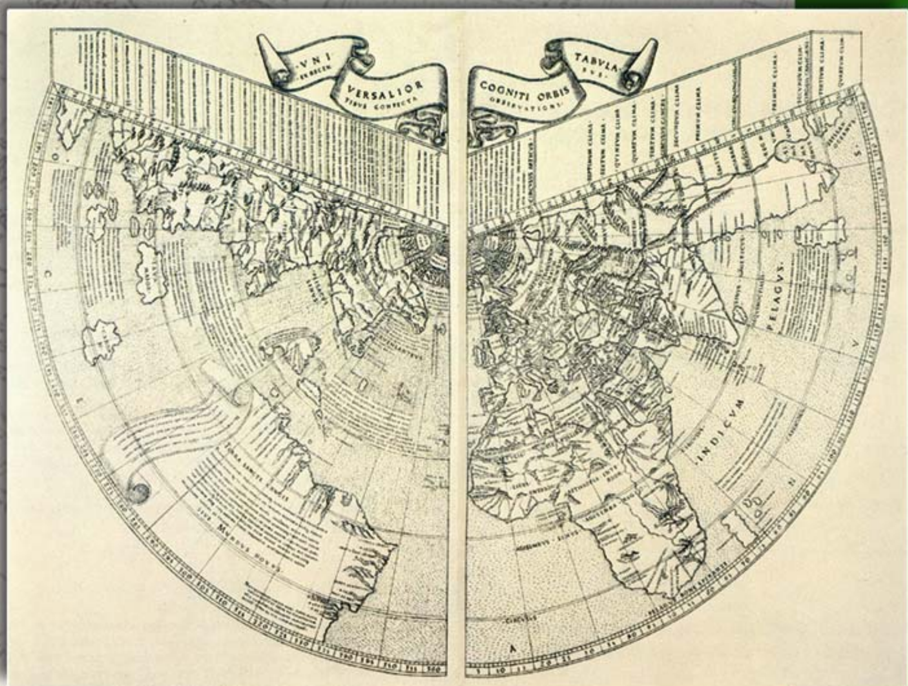
APAT
Agenzia per la protezione dell'ambiente
e per i servizi tecnici

CAMBIAMENTI CLIMATICI
CONFERENZA NAZIONALE 2007

RAPPORTI

Italian Greenhouse Gas Inventory 1990 - 2005

National Inventory Report 2007



76 / 2007

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National Inventory Report 2007

Daniela Romano, Antonella Bernetti, Rocío D. Cóndor, Mario Contaldi,
Riccardo De Lauretis, Eleonora Di Cristofaro, Barbara Gonella, Marina Vitullo

APAT - Agency for Environmental Protection and Technical Services

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Premessa

Nell'ambito degli strumenti e delle politiche per fronteggiare i cambiamenti climatici un ruolo fondamentale è svolto dal monitoraggio delle emissioni dei gas climalteranti.

A garantire questa funzione, in Italia, è l'APAT su incarico del Ministero dell'Ambiente attraverso Direttiva Ministeriale e relativa convenzione.

L'APAT, infatti, realizza ogni anno l'inventario nazionale delle emissioni in atmosfera, che è strumento indispensabile di verifica degli impegni assunti a livello internazionale sulla protezione dell'ambiente atmosferico, come la Convenzione Quadro sui Cambiamenti Climatici (UNFCCC), il Protocollo di Kyoto, la Convenzione di Ginevra sull'inquinamento atmosferico transfrontaliero (UNECE-CLRTAP), le Direttive europee sulla limitazione delle emissioni.
In particolare, ogni Paese che partecipa alla Convenzione sui Cambiamenti Climatici, oltre a fornire annualmente l'inventario nazionale delle emissioni dei gas serra secondo i formati richiesti, deve documentare in uno specifico documento, il *National Inventory Report*, le metodologie di stima unitamente ad una spiegazione degli andamenti osservati.

Il *National Inventory Report* facilita i processi internazionali di verifica cui le stime ufficiali di emissione dei gas serra sono sottoposte. In particolare, viene esaminata la rispondenza alle proprietà di trasparenza, consistenza, comparabilità, completezza e accuratezza nella realizzazione, qualità richieste esplicitamente dalla Convenzione suddetta. L'inventario delle emissioni è, in realtà, sottoposto ogni anno ad un esame da parte di un organismo nominato dal Segretariato della Convenzione che analizza tutto il materiale presentato dal Paese e ne verifica in dettaglio le qualità su enunciate. Senza tali requisiti l'Italia sarebbe esclusa dalla partecipazione ai meccanismi flessibili previsti dallo stesso Protocollo come il mercato delle quote di emissioni, il trasferimento delle tecnologie (TT), l'implementazione di progetti con i paesi in via di sviluppo (CDM) e l'implementazione di progetti congiunti con i paesi delle economie in transizione (JI).

In particolare, il rapporto "Italian Greenhouse Gas Inventory 1990-2005. National Inventory Report 2007" descrive la comunicazione annuale italiana dell'inventario delle emissioni dei gas serra dal 1990 al 2005.

Il documento è uno strumento fondamentale per la pianificazione e l'attuazione di efficaci politiche ambientali e fornisce alle istituzioni centrali e periferiche un adeguato contributo conoscitivo sulle problematiche inerenti ai cambiamenti climatici a livello settoriale.

Nuove politiche ed interventi a livello nazionale ed internazionale saranno, infatti, indispensabili per garantire nel futuro il rispetto degli obiettivi del Protocollo di Kyoto, dal momento che, come emerge dal rapporto, le emissioni totali dei gas serra (espressi in termini di CO_2 equivalente) sono aumentate, dal 1990 al 2005, di circa il 12.1% a fronte di un impegno nazionale di riduzione pari al 6,5% entro il periodo 2008-2012.

Giancarlo Viglione
Commissario Straordinario APAT

Contents

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.
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 through 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.
As a Party to the Convention and the Kyoto Protocol, Italy is committed to develop, publish and regularly update national emission inventories of greenhouse gases (GHGs) as well as formulate and implement programmes to reduce these emissions.
In order to establish compliance with national and international commitments, the national GHG emission inventory is compiled and communicated annually by the Agency for Environmental Protection and Technical Services (APAT) to the competent institutions, after endorsement by the Ministry for the Environment, Land and Sea. 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. As a whole, 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 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 2007, including the update for the year 2005 and the revision of the entire time series 1990-2004.
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).
This report, the CRF files and other related documents are available on website at the address http://www.sinanet.apat.it/it/sinanet/serie_storiche_emissioni.

The official inventory submissions can also be found at the UNFCCC website http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/3929.php.

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, land use change and forestry, increased by 12.1% between 1990 and 2005 (from 517 to 580 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 85.1% of total emissions in CO_2 equivalent in 2005, showed an increase by 13.5% between 1990 and 2005. In the energy sector, specifically, emissions in 2005 were 14.5% greater than in 1990.

CH_4 and N_2O emissions were equal to 6.9% and 7.0%, respectively, of the total CO_2 equivalent greenhouse gas emissions in 2005. CH_4 emissions showed a decrease by 4.4% from 1990 to 2005, while N_2O increased by 6.2%.

Other greenhouse gases, HFCs, PFCs and SF_6, ranged from 0.1% 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 1990-2005, expressed in CO_2 equivalent terms, by substance and category.

GHG Emissions	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 equivalent (Gg)															
Net CO_2 emissions/removals	354,790	332,953	336,482	345,103	322,516	342,380	332,996	344,362	358,470	355,927	366,170	359,431	357,133	374,370	386,088	383,195
CO_2 emissions (without LULUCF)	434,782	434,226	433,893	427,711	420,709	445,712	439,195	443,434	454,391	459,386	463,607	469,298	471,144	486,618	490,933	493,372
CH_4 emissions (including CH_4 from LULUCF)	41,712	42,909	42,304	42,693	43,272	44,086	44,139	44,526	44,236	44,272	44,367	43,331	41,744	41,089	39,911	39,756
CH4 emissions (excluding CH_4 from LULUCF)	41,569	42,872	42,243	42,542	43,212	44,058	44,116	44,452	44,150	44,230	44,280	43,276	41,713	41,024	39,876	39,721
N_2O emissions (including N_2O from LULUCF)	38,040	39,002	38,443	39,009	38,168	38,813	38,547	39,824	39,969	40,740	41,111	41,234	40,701	40,408	42,564	40,498
N_2O emissions (excluding N_2O from LULUCF)	38,009	38,998	38,437	38,954	38,061	38,730	38,544	39,796	39,800	40,508	40,881	41,228	40,698	40,401	41,694	40,366
HFCs	351	355	359	355	482	671	450	756	1,182	1,524	1,986	2,550	3,100	3,796	4,515	5,267
PFCs	1,808	1,452	850	707	477	491	243	252	270	258	346	451	424	498	350	361
SF_6	333	356	358	370	416	601	683	729	605	405	493	795	738	465	492	460
Total (including LULUCF)	437,033	417,027	418,795	428,238	405,331	427,042	417,058	430,449	444,733	443,125	454,473	447,792	443,840	460,625	473,920	469,538
Total (excluding LULUCF)	516,851	518,260	516,139	510,640	503,357	530,264	523,232	529,418	540,399	546,311	551,594	557,598	557,816	572,802	577,859	579,548

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 equivalent (Gg)															
Energy	419,419	419,276	418,590	415,280	409,178	432,500	428,442	432,728	444,091	449,172	452,772	457,442	459,394	474,122	477,769	480,114
Industrial Processes	36,544	36,165	35,572	32,736	31,399	34,590	31,556	32,032	32,490	32,889	34,959	36,993	37,002	38,154	40,631	40,792
Solvent and Other Product Use	2,394	2,334	2,334	2,293	2,216	2,180	2,279	2,280	2,367	2,348	2,285	2,211	2,219	2,167	2,114	2,098
Agriculture	40,577	41,372	40,863	41,163	40,641	40,349	40,097	41,150	40,418	40,795	39,939	39,428	38,250	38,099	37,892	37,214
Land Use, Land-Use Change and Forestry	-79,818	-101,233	-97,344	-82,402	-98,026	-103,222	-106,174	-98,970	-95,666	-103,185	-97,121	-109,806	-113,977	-112,177	-103,940	-110,010
Waste	17,916	19,112	18,780	19,168	19,922	20,646	20,858	21,228	21,033	21,106	21,638	21,524	20,952	20,260	19,453	19,330
Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table ES.1. Total greenhouse gas emissions and removals in CO_2 equivalent (Gg CO_2 eq.)

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

The energy sector is the largest contributor to national total GHG emissions with a share, in 2005, of 82.8%. Emissions from this sector increased by about 14.5% from 1990 to 2005. Substances with the highest increase rates were CO_2, whose levels increased by 14.7% from 1990 to 2005 and accounts for 97% of the total in the energy sector, and N_2O which showed an increase of 53% but its share out of the total is only 2%; CH_4, on the other hand, showed a decrease of 19.3% from 1990 to 2005 but it is not relevant on total emissions, accounting only for 1%. Specifically, in terms of total CO_2 equivalent, the most significant increase was observed in the sectors of transport, other sectors and in the energy industries, about 26.5%, 21.8% and 19.1% from 1990 to 2005, respectively. These sectors, altogether, account for 81% of total energy emissions.

For the industrial processes sector, emissions showed a total increase of 11.6% from the base year to 2005. Specifically, by substance, CO_2 emissions account for 66% and showed a decrease by about 1.4%, due to opposite trends, specifically an increase of the mineral sector production and the decrease of chemical and metal production emissions. CH_4 decreased by 40.8%, but it accounts only for 0.2%, while N_2O, whose levels share 19% of total industrial emissions, grew by 16.2%. A considerable increase was observed in F-gas emissions (about 144.4%), which level on total emissions is 15%.

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 12.4% from 1990 to 2005. The reduction is mainly to be attributed to a decrease by 17.4% in CO_2 emissions, which account for 63% of the sector. As regards CO_2, the most significant reduction affected the paint application sector (-19%), which accounts for 52%; emissions from other use of solvents in related activities, such as domestic solvent use other than painting, printing industries, vehicle dewaxing, which account for 43%, decreased of about 1%. Emissions from metal degreasing and dry cleaning activities, also decreased (-64.2%) but account for only 5%.
The level of N_2O emissions, on the other hand, did not show a significant variation from 1990 to 2005.

For agriculture, emissions refer to CH_4 and N_2O levels, which account for 42% and 58% of the sector, respectively. The decrease observed in the total emissions (-8.3%) was mostly due to the decrease of CH_4 emissions from enteric fermentation (-10.9%), which account for 29%, and to a minor decrease from manure management (-7.4%), which accounts for 18% of the sectoral emissions.

Finally, emissions from the waste sector increased by 7.9% from 1990 to 2005 due to the increase in the emissions from solid waste disposal (8.6%), which account for 75% of waste emissions and from waste-water handling, which increased of about 12.2% and account for 22% of the total. The most important greenhouse gas in this sector is CH_4 which accounts for 88% of the sectoral emissions and shows an increase of 10.6% from 1990 to 2005. N_2O levels increased by 7.8%, whereas CO_2 decreased by 69.2%; these gases account for 11% and 1%, respectively.
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	2005
	CO_2 equivalent (Gg)															
1A. Energy: fuel combustion	**408,682**	**408,666**	**407,992**	**404,624**	**398,860**	**422,481**	**418,677**	**422,793**	**434,198**	**440,198**	**443,751**	**448,886**	**451,194**	**465,431**	**469,921**	**472,287**
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	147,770	150,930	157,781	158,592	157,732	159,877
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	86,116	81,960
CO_2: 3. Transport	101,461	104,331	108,652	110,378	110,205	112,005	113,188	114,912	118,723	119,994	120,458	122,761	124,883	126,202	128,353	126,891
CO_2: 4. Other Sectors	76,508	82,070	78,632	78,308	69,151	75,920	77,766	75,099	78,055	82,620	78,471	81,252	78,464	85,018	87,204	92,969
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	1,198
CH_4	1,424	1,495	1,558	1,557	1,617	1,661	1,658	1,680	1,646	1,685	1,587	1,464	1,343	1,354	1,463	1,405
N_2O	5,221	5,183	5,262	5,281	5,360	5,664	5,802	5,973	6,330	6,591	6,770	6,987	7,300	7,599	7,963	7,988
1B2. Energy: fugitives from oil & gas	**10,737**	**10,611**	**10,598**	**10,656**	**10,318**	**10,019**	**9,765**	**9,935**	**9,893**	**8,975**	**9,021**	**8,556**	**8,200**	**8,691**	**7,848**	**7,827**
CO_2	3,341	3,265	3,212	3,380	3,226	3,174	3,035	3,243	3,119	2,404	2,585	2,440	2,261	2,834	2,152	2,112
CH_4	7,395	7,345	7,385	7,275	7,091	6,843	6,728	6,691	6,773	6,569	6,434	6,115	5,938	5,855	5,694	5,713
N_2O	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2. Industrial processes	**36,544**	**36,165**	**35,572**	**32,736**	**31,399**	**34,590**	**31,556**	**32,032**	**32,490**	**32,889**	**34,959**	**36,993**	**37,002**	**38,154**	**40,631**	**40,792**
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	26,879
CH_4	108	104	101	102	106	113	63	68	65	64	63	59	57	58	61	64
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	7,760
HFCs	351	355	359	355	482	671	450	756	1,182	1,524	1,986	2,550	3,100	3,796	4,515	5,267
PFCs	1,808	1,452	850	707	477	491	243	252	270	258	346	451	424	498	350	361
SF_6	333	356	358	370	416	601	683	729	605	405	493	795	738	465	492	460
3. Solvent and other product use	**2,394**	**2,334**	**2,334**	**2,293**	**2,216**	**2,180**	**2,279**	**2,280**	**2,367**	**2,348**	**2,285**	**2,211**	**2,219**	**2,167**	**2,114**	**2,098**
CO_2	1,598	1,585	1,587	1,535	1,469	1,424	1,379	1,379	1,328	1,331	1,274	1,295	1,306	1,310	1,315	1,320
N_2O	796	750	748	758	747	756	901	901	1,039	1,017	1,011	915	913	857	799	777
4. Agriculture	**40,577**	**41,372**	**40,863**	**41,163**	**40,641**	**40,349**	**40,097**	**41,150**	**40,418**	**40,795**	**39,939**	**39,428**	**38,250**	**38,099**	**37,892**	**37,214**
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	10,836	10,852
CH_4: Manure management	3,462	3,461	3,332	3,325	3,220	3,286	3,295	3,281	3,317	3,349	3,278	3,336	3,263	3,252	3,156	3,150
CH_4: Rice Cultivation	1,562	1,493	1,551	1,627	1,664	1,657	1,623	1,615	1,533	1,497	1,382	1,382	1,420	1,462	1,510	1,464
CH_4: Field Burning of Agricultural Residues	13	14	14	13	13	13	13	12	14	13	12	11	13	11	14	13
N_2O: Manure management	3,921	3,915	3,749	3,713	3,700	3,782	3,824	3,857	3,936	3,995	3,862	4,063	3,847	3,816	3,731	3,688
N_2O: Agriculture soils	19,437	20,037	20,143	20,538	19,990	19,341	19,016	20,004	19,324	19,509	19,238	18,967	18,673	18,500	18,643	18,042
N_2O: Field Burning of Agricultural Residues	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5A. Land-use change and forestry	**-79,818**	**-101,233**	**-97,344**	**-82,402**	**-98,026**	**-103,222**	**-106,174**	**-98,970**	**-95,666**	**-103,185**	**-97,121**	**-109,806**	**-113,977**	**-112,177**	**-103,940**	**-110,010**
CO_2	-79,992	-101,273	-97,410	-82,608	-98,193	-103,332	-106,198	-99,072	-95,921	-103,459	-97,437	-109,867	-114,011	-112,248	-104,844	-110,176
CH_4	143	37	60	151	61	27	22	74	86	42	87	55	31	65	35	34
N_2O	31	4	6	55	106	83	2	28	169	232	230	6	3	7	870	132
6. Waste	**17,916**	**19,112**	**18,780**	**19,168**	**19,922**	**20,646**	**20,858**	**21,228**	**21,033**	**21,106**	**21,638**	**21,524**	**20,952**	**20,260**	**19,453**	**19,330**
CO_2	537	562	562	521	524	483	472	508	504	393	202	222	245	216	199	165
CH_4	15,427	16,513	16,231	16,701	17,450	18,220	18,414	18,728	18,511	18,625	19,359	19,242	18,650	17,976	17,144	17,060
N_2O	1,952	2,037	1,986	1,946	1,948	1,943	1,972	1,992	2,017	2,087	2,078	2,060	2,057	2,068	2,110	2,104
TOTAL EMISSIONS (with LULUCF)	**437,033**	**417,027**	**418,795**	**428,238**	**405,331**	**427,042**	**417,058**	**430,449**	**444,733**	**443,125**	**454,473**	**447,792**	**443,840**	**460,625**	**473,920**	**469,538**
TOTAL EMISSIONS (without LULUCF)	**516,851**	**518,260**	**516,139**	**510,640**	**503,357**	**530,264**	**523,232**	**529,418**	**540,399**	**546,311**	**551,594**	**557,598**	**557,816**	**572,802**	**577,859**	**579,548**

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

ES.4. Other information

In Table ES.3 NO_X, CO, NMVOC and SO_2 emission trends from 1990 to 2005 are summarised. All gases showed a significant reduction in 2005 as compared to 1990 levels. The highest reduction is observed for SO_2 (-76.7%), while CO and NO_X emissions reduced by about 46.4% and 42.6% respectively, NMVOC levels showed a decrease by 39%.

Indirect greenhouse gases and SO_2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Gg																
NO_X	1,941	2,000	2,019	1,919	1,840	1,808	1,732	1,654	1,553	1,453	1,373	1,351	1,258	1,249	1,192	1,114
CO	7,123	7,462	7,652	7,560	7,377	7,155	6,858	6,576	6,161	5,879	5,128	5,062	4,455	4,356	4,191	3,818
NMVOC	1,977	2,045	2,125	2,087	2,030	2,002	1,949	1,878	1,772	1,683	1,496	1,425	1,331	1,291	1,260	1,207
SO_2	1,794	1,677	1,578	1,477	1,388	1,320	1,210	1,133	997	899	755	704	622	525	494	417

Table ES.3. Total emissions of indirect greenhouse gases and SO_2 (1990-2005) (Gg)

Sommario (*Italian*)

Nel documento "Italian Greenhouse Gas Inventory 1990-2005. National Inventory Report 2007" 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 (UNFCCC), del protocollo di Kyoto 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 principali, *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 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.

La serie storica nazionale delle emissioni è anche disponibile sul sito web all'indirizzo 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 2005, si evidenzia che le emissioni nazionali totali dei sei gas serra, espresse in CO_2 equivalente, sono aumentate del 12.1% nel 2005 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'85.1% del totale e risultano nel 2005 superiori del 13.5% rispetto al 1990, mentre le emissioni relative al solo settore energetico sono aumentate del 14.5%. Le emissioni di metano e di protossido di azoto sono pari rispettivamente a circa il 6.9% e 7% del totale e presentano andamenti in diminuzione per il metano (-4.4%) e in aumento (+6.2%), per il protossido di azoto. Gli altri gas serra, HFC, PFC and SF_6, hanno un peso complessivo sul totale delle emissioni che varia tra lo 0.1% e l'1%; le emissioni degli HFC evidenziano una forte crescita, mentre le emissioni di PFC decrescono e quelle di SF_6 mostrano un minore incremento. Sebbene al momento tali variazioni non risultino determinanti ai fini del conseguimento degli obiettivi di riduzione delle emissioni, la significatività del trend degli HFC potrebbe renderli 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. More recently, the scientific knowledge on climate change has firmed up considerably by the IPCC Fourth Assessment Report on global warming which states that “Warming of the climate system is unequivocal… There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities… Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations”. 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.
On 11/12/1997, Parties to the Convention adopted the Kyoto Protocol, which establishes emission reduction objectives for Annex B Parties (i.e. industrialised countries and countries with economy in transition) in the period 2008-2012. 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 the base 1990 levels.
Italy ratified the Kyoto Protocol on 1st June 2002 through law no.120 of 01/06/2002. The ratification law prescribes also the preparation of a National Action Plan to reduce greenhouse gas emission, 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 on 16th February 2005.
As a Party to the Convention and the Kyoto Protocol, Italy is committed to develop, publish and regularly update national emission inventories as well as formulate and implement programmes to reduce these emissions.
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).
The 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.
The submission also provides for detailed information on emission figures and estimation methodologies, including all basic data needed to carry out final estimates, in the annual National Inventory Report, in order to improve the transparency, consistency, comparability, accuracy and completeness of the inventory.

As follows, 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 2005 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 2007 submission, including the entire time series 1990-2004.
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, the national inventory reports and other related documents are available at the address http://www.sinanet.apat.it/it/sinanet/serie_storiche_emissioni .
The official inventory submissions can also be found at the UNFCCC website http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/3929.php.

1.2 Description of the institutional arrangement for inventory preparation

Italy has developed a national inventory system, National System, which includes all institutional, legal and procedural arrangements for estimating emissions and removals of greenhouse gases and for reporting and archiving inventory information.
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 Italian National System is fully described in the document 'National Greenhouse Gas Inventory System in Italy' (APAT, 2006[a]); a summary picture is reported herebelow.
The Agency for Environmental Protection and Technical Services (APAT) is in charge of the development and compilation of the national emission inventory on the basis of a Ministerial Directive issued on 14th April 2005 regarding the general functions and priority activities of the Agency. The issue of a specific Legislative Decree is under examination. The Italian Atmospheric Emission Inventory and the Italian Greenhouse Gas Inventory are compiled and maintained by the Agency for Environmental Protection and Technical Services which is the technical body responsible for data submission. A specific unit of the Agency is responsible for the inventory compilation in the framework of both the Convention on Climate Change and the Convention on Long Range Transboundary Air Pollution. The whole inventory is compiled by the 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.
APAT has been designated as single national entity with overall responsibility for the national emission inventory by the Ministry for the Environment, Land and Sea and bears the responsibility for the general administration of the inventory, co-ordinates participation in reviews, publishes and archives the inventory results. The Italian greenhouse gas inventory is 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, Land and Sea.
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.
Different institutions are responsible for statistical basic data and data publication, which are primary to APAT for carrying out emission estimates. These institutions are part of the National Statistical System (Sistan), which provides national official statistics, and therefore are asked periodically to update statistics; moreover, the National Statistical System ensures the homogeneity of the methods used for official statistics data through a coordination plan, involving the entire public administration at central, regional and local levels.
The National Statistical System is coordinated by the Italian National Institute of Statistics (ISTAT) whereas other bodies, joining 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 Italian statistical system was instituted on 6th September 1989 by the Legislative Decree n. 322/89, which established guiding principles and criteria for reforming public statistics. This decree addresses to all public statistical bodies and agencies which provide official statistics both at local, national and international level in order to assure homogeneity of the methods and comparability of the results. To this end, a national statistical plan which defines surveys, data elaborations and project studies for a three-year period shall be draw up and updated annually, as established in the Decree n. 322/89. The procedures to be followed with relation to the annual fulfilment as well as the forms to be filled in for census, data elaborations and projects, and how to deal with sensitive information are also defined.
The plan is deliberated by the Committee for addressing and coordinating statistical information (Comstat) and forwarded to the Commission for the assurance of statistical information; the Commission adopts the plan after endorsement of the Guarantor of the privacy of personal data. Finally, the plan is approved by a Prime Ministerial Decree after consideration of the Interministerial Committee for economic planning (Cipe). The latest Prime Ministerial Decree, which approved the three-year plan for 2005-2007, was issued on 8th September 2005. The statistical information and results deriving from the completion of the plan are of public domain and the system is responsible for wide circulation.
Ministries, public agencies and other bodies are obliged to provide the data and information specified in the annual statistical plan; the same obligations regard the private entities. All the data are protected by the principles of statistical disclosure control and can be distributed and

communicated only at aggregate level even though microdata can circulate among the subjects of the Statistical System.

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

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

The national emission inventory itself is a Sistan product.

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 Economic Development Activities (MSE) in the National Energy Balance (BEN), statistics on industrial and agricultural production published by the National Institute of Statistics (ISTAT), statistics on transportation provided by the Ministry of Transportation (MINT), and data supplied directly by the relevant professional associations.
Emission factors and methodologies used in the estimation process are consistent with the 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. 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.
The collection of data in the framework of the European Emissions Trading Scheme has also yielded considerable impovements in the inventory estimates of the relative sectors; in fact, these data are used in the check and improvement of national emissions factors as well as of the activity data level.
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 of the inventory preparation takes over annually. In addition to a new year, the entire time series from 1990 onwards is checked and revised during the annual compilation of the inventory in order to meet the requirements of transparency, consistency, comparability, completeness and accuracy 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.
In particular, recalculations are elaborated on account of changes in the methodologies used to carry out emission estimates, changes due to different allocation of emissions as compared to previous submissions and changes due to error corrections. The inventory may also be expanded by including categories not previously estimated if sufficient information on activity data and suitable emission factors have been identified and collected.
Information on the major recalculations is provided every year in the sectoral and general chapters of the national inventory reports; detailed explanations of recalculations are also given compiling the relevant CRF tables.

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. 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 at the address http://www.sinanet.apat.it/it/sinanet/serie_storiche_emissioni.

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 Economic Development Major national electricity producers
1A2 Manufacturing Industries and Construction	Fuel use	Energy Balance - Ministry of Economic Development Major National Industry Corporation
1A3 Transport	Fuel use Number of vehicles Aircraft landing and take-off cycles and maritime activities	Energy Balance - Ministry of Economic Development Statistical Yearbooks - National Statistical System Statistical Yearbooks - Ministry of Transportation
1A4 Residential-public-commercial sector	Fuel use	Energy Balance - Ministry of Economic Development
1B Fugitive Emissions from Fuel	Amount of fuel treated, stored, distributed	Energy Balance - Ministry of Economic Development Statistical Yearbooks - Ministry of Transportation Major National Industry Corporation
2 Industrial Processes	Production data	National Statistical Yearbooks- National Institute of Statistics International Statistical Yearbooks-UN Sectoral Industrial Associations
3 Solvent and Other Product Use	Amount of solvent use	National Environmental Publications - Sectoral Industrial Associations International Statistical Yearbooks - UN
4 Agriculture	Agricultural surfaces Production data Number of animals Fertiliser consumption	Agriculture Statistical Yearbooks - National Institute of Statistics Sectoral Agriculture Associations
5 Land Use, Land Use Change and Forestry	Forest and soil surfaces Amount of biomass Biomass burnt Biomass growth	Statistical Yearbooks - National Institute of Statistics State Forestry Corps National and Regional Forestry Inventory Universities and Research Institutes
6 Waste	Amount of waste	National Waste Cadastre - Agency for Environmental Protection and 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	**D,M,T1,T2,T3**	**CS,D**	**D,M,T1,T2,T3**	**CR,CS,D**	**D,M,T1,T2,T3**	**CR,CS,D**						
A. Fuel Combustion	D,M,T1,T2,T3	CS	D,M,T1,T2,T3	CR,CS,D	D,M,T1,T2,T3	CR,CS,D						
1. Energy Industries	T3	CS	T3	CR,D	T3	CR,D						
2. Manufacturing Industries and Construction	T2	CS	T2	CR,D	T2	CR,D						
3. Transport	D,M,T1,T2	CS	D,M,T1,T2	CR,CS	D,M,T1,T2	CR,CS						
4. Other Sectors	T2	CS	T2	CR	T2	CR						
5. Other	T2	CS	T2	CR	T2	CR						
B. Fugitive Emissions from Fuels	T1,T2	CS,D	T1,T2	CR,CS,D	NA	NA						
1. Solid Fuels	NA	NA	T1	CR,CS,D	NA	NA						
2. Oil and Natural Gas	T1,T2	CS,D	T1,T2	CS,D	NA	NA						
2. Industrial Processes	**D,T2**	**CR,CS,D,PS**	**D**	**CR,CS,PS**	**D**	**D,PS**	**CS,T2**	**CS,D,PS**	**CS,T2**	**D,PS**	**CS,D,T3**	**CS,PS**
A. Mineral Products	D,T2	CS,D,PS	NA	NA	NA	NA						
B. Chemical Industry	D	CR,PS	D	CR,CS,PS	D	D,PS					NA	NA
C. Metal Production	D	CR,CS,PS	D	CR,CS,PS	NA	NA	NA	NA	T2	D,PS	D	PS
D. Other Production	NA	NA										
E. Production of Halocarbons and SF_6									NA	NA	NA	NA
F. Consumption of Halocarbons and SF_6							CS,T2	CS,D,PS	CS	PS	CS,T3	CS,PS
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**CR,CS**	**CR,CS**			**CS**	**CS**						
4. Agriculture			**D,T1,T2**	**CS,D**	**D,T1,T2**	**CS,D**						
A. Enteric Fermentation			T1,T2	CS,D								
B. Manure Management			T1,T2	CS,D	T1,T2	CS,D						
C. Rice Cultivation			T2	CS								
D. Agricultural Soils			NA	NA	D	CS,D						
E. Prescribed Burning of Savannas			NA	NA	NA	NA						
F. Field Burning of Agricultural Residues			D	CS,D	D	CS,D						
G. Other			NA	NA	NA	NA						
5. Land Use, Land-Use Change and Forestry	**T1,T2**	**CS,D**	**T1**	**D**	**T1**	**D**						
A. Forest Land	T1,T2	CS,D	T1	D	T1	D						
B. Cropland	T1	D	NA	NA	T1	D						
C. Grassland	NA	NA	NA	NA	NA	NA						
D. Wetlands	NA	NA	NA	NA	NA	NA						
E. Settlements	T1	D	NA	NA	NA	NA						
F. Other Land	NA	NA	NA	NA	NA	NA						
G. Other			NA	NA	NA	NA						
6. Waste	**D**	**CS**	**CS,D,T2**	**CR,CS,D**	**D**	**CR,CS,D**						
A. Solid Waste Disposal on Land	NA	NA	T2	CS								
B. Waste-water Handling			D	D	D	CR,D						
C. Waste Incineration	D	CS	D	CR,D	D	CS						
D. Other	NA	NA	CS	CS	NA	NA						
7. Other (as specified in Summary 1.A)	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

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) **CR** (CORINAIR)

RA (Reference Approach) **T2** (IPCC Tier 2) **CS** (Country Specific)

T1 (IPCC Tier 1) **T3** (IPCC Tier 3) **OTH** (Other)

If using more than one method within one source category, list all the relevant methods. Explanations regarding country-specific methods, other methods or any modifications to the default IPCC methods, as well as information

Use the following notation keys to specify the emission factor used:

D (IPCC default) **CS** (Country Specific) **OTH** (Other)

CR (CORINAIR) **PS** (Plant Specific)

Where a mix of emission factors has been used, list all the methods in the relevant cells and give further explanations in the documentation box. Also use the documentation box to explain the use of notation OTH.

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 by the Ministry of Economic Development. Additional information for electricity production is provided by the major national electricity producers and by the major national industry corporation. On the other hand, basic information for road transport, maritime and aviation, such as the number of vehicles, harbour statistics and aircraft landing and take-off cycles are provided in statistical yearbooks published both by the National Institute of Statistics and the Ministry of Transportation. Other data are communicated by different category associations.

The analysis of data from the Italian Emission Trading Scheme database is used to develop country-specific emission factors and check activity data levels.

For the industrial sector the annual production data are provided by national and international statistical yearbooks. Emission data collected through the National Pollutant Emission Register (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 for the Environment, Land and Sea and to

the European Commission within October of the current year for data referring to the previous year. These data are not always directly used for the compilation of the inventory because industries communicate figures only if they exceed specific thresholds; furthermore, basic data such as fuel consumption are not supplied and production data are not split by product but 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.
Both for energy and industrial processes, emissions of large industrial point sources are registered individually; communication also takes place in the framework of the European Directive on Large Combustion Plants, based upon detailed information such as fuel consumption. Other small plants communicate their emissions which are also considered individually.
For the other sectors, i.e. for solvents, the amount of solvent use is provided by environmental publications of sector industries and specific associations as well as international statistics.
For agriculture, annual production data and number of animals are provided by the National Institute of Statistics and other sectoral associations.
For land use, land use change and forestry, forest and soil surfaces are provided by the National Institute of Statistics while statistics on forest fires are supplied by the State Forestry Corps.
For waste, the main activity data are provided by the Agency for Environmental Protection and 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 Environmental Protection and Technical Services. The inventory is composed by spreadsheets to calculate emission estimates; activity data and emission factors as well as methodologies are referenced to their data sources. A ‘reference’ database has also been developed to increase the transparency of the inventory.

1.5 Brief description of key categories

A key category analysis of the Italian inventory is 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). According to these guidelines, 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 to the last submitted inventory; a key category analysis has also been carried out for the base year emission levels.

For the base year, 18 sources were individuated according to the Tier 1 approach, whereas 21 sources were carried out by the Tier 2. Including the LULUCF categories in the analysis, 24 categories were selected jointly by the Tier 1 and the Tier 2. The description of these sources is shown in the Table 1.3 and Table1.4.

Key categories (excluding the LULUCF sector)	
CO_2 stationary combustion liquid fuels	L
CO_2 stationary combustion solid fuels	L
CO_2 stationary combustion gaseous fuels	L
CO_2 Mobile combustion: Road Vehicles	L
CO_2 Fugitive emissions from Oil and Gas Operations	L
CH_4 Fugitive emissions from Oil and Gas Operations	L
CO_2 Cement production	L
N_2O stationary combustion	L
N_2O Adipic Acid	L
CH_4 Enteric Fermentation in Domestic Livestock	L
Direct N_2O Agricultural Soils	L
Indirect N_2O from Nitrogen used in agriculture	L
N_2O Manure Management	L
CH_4 Manure Management	L
CH_4 from Solid waste Disposal Sites	L
N_2O Mobile combustion: Road Vehicles	L2
CO_2 Emissions from solvent use	L2
N_2O Emissions from solvent use	L2
N_2O from animal production	L2
CH_4 Emissions from Wastewater Handling	L2
N_2O Emissions from Wastewater Handling	L2
CO_2 Iron and steel production	L1
CO_2 Limestone and dolomite use	L1
CO_2 Mobile combustion: Waterborne Navigation	L1

L1 = level key category by Tier 1
L2 = level key category by Tier 2
L = level key category by Tier 1 and Tier 2

Table 1.3 Key categories by the IPCC Tier 1 and Tier 2 approaches (L=Level). Base year

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

L1 = level key category by Tier 1
L2 = level key category by Tier 2
L = level key category by Tier 1 and Tier 2

Table 1.4 Key categories by the IPCC Tier 1 and Tier 2 approaches (L=Level). Base year

Applying the category analysis to the 2005 inventory, without considering the LULUCF sector, 26 key categories were totally individuated, both at level and trend. Results are reported in Table 1.5.

Key categories (excluding the LULUCF sector)	
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
N_2O Mobile combustion: Road Vehicles	L, T
CH_4 Fugitive emissions from Oil and Gas Operations	L, T
HFC, PFC substitutes for ODS	L, T
CH_4 Enteric Fermentation in Domestic Livestock	L, T
Direct N_2O Agricultural Soils	L, T
Indirect N_2O from Nitrogen used in agriculture	L, T
CO_2 Cement production	L, T2
N_2O Manure Management	L, T2
CH_4 Manure Management	L, T2
CH_4 from Solid waste Disposal Sites	L, T2
CO_2 Fugitive emissions from Oil and Gas Operations	L2, T
CO_2 Emissions from solvent use	L2, T2
N_2O from animal production	L2, T2
CH_4 Emissions from Wastewater Handling	L2, T2
N_2O Emissions from Wastewater Handling	L2, T2
N_2O stationary combustion	L
N_2O Adipic Acid	L
CO_2 Mobile combustion: Waterborne Navigation	L1
N_2O Emissions from solvent use	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 1.5 Key categories by the IPCC Tier 1 and Tier 2 approaches (L=Level, T=Trend). Year 2005

If considering emissions and removals from the LULUCF sector, 29 key categories were individuated as reported in Table 1.6.
There are no additional categories as compared to the previous analysis expect for those referring to the LULUCF sector.

Key categories (including the LULUCF sector)	
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
N_2O Mobile combustion: Road Vehicles	L, T
HFC, PFC substitutes for ODS	L, T
CH_4 Enteric Fermentation in Domestic Livestock	L, T
CH_4 from Solid waste Disposal Sites	L, T
Direct N_2O Agricultural Soils	L, T
Indirect N_2O from Nitrogen used in agriculture	L, T
CO_2 Forest land remaining Forest land	L, T
CO_2 Cropland remaining Cropland	L, T
CO_2 Land converted to Forest Land	L, T
N_2O Manure Management	L, T2
CH_4 Fugitive emissions from Oil and Gas Operations	L, 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

CH_4 Manure Management	L2, T2
CO_2 Land converted to Settlements	L2, T2
CH_4 Emissions from Wastewater Handling	L2, T2
N_2O stationary combustion	L
CO_2 Cement production	L
N_2O Adipic Acid	L1
CO_2 Mobile combustion: Waterborne Navigation	L1
N_2O from animal production	L2
CO_2 Land converted to Cropland	T2
N_2O Emissions from Wastewater Handling	T2
CO_2 Iron and steel production	T1
CO_2 Ammonia production	T1
PFC Aluminium production	T1
CO_2 Fugitive emissions from Oil and Gas Operations	T1

Table 1.6 Key categories by the IPCC Tier 1 and Tier 2 approaches (L=Level, T=Trend). Year 2005.

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

APAT has elaborated an inventory QA/QC plan which describes specific QC procedures to be implemented during the inventory development process, facilitates the overall QA procedures to be conducted, to the extent possible, on the entire inventory and establishes quality objectives.
Particularly, an inventory QA/QC procedures manual (APAT, 2006 [b]) has been drawn up which describes QA/QC procedures and verification activities to be followed during the inventory compilation and helps in the inventory improvement. Furthermore, specific QA/QC procedures and different verification activities implemented thoroughly the current inventory compilation, as part of the estimation process, are figured out in the annual QA/QC plan (APAT, 2005; APAT, 2006 [c]; APAT, 2007 [a]).
Quality control checks and quality assurance procedures together with some verification activities are applied both to the national inventory as a whole and at sectoral level. Future planned improvements are prepared for each sector, by the relevant inventory compiler; each expert identifies areas for sectoral improvement based on his own knowledge and in response to inventory UNFCCC reviews and other kind of processes.
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.

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. Checklists compiled annually by the inventory experts are collected by the QA/QC coordinator and registred in the 'reference' database.
General QC procedures also include data and documentation gathering. Specifically, the inventory analyst for a source category maintains a complete and separate project archive for that source category; the archive includes all the materials needed to develop the inventory for that year and is maintained in a transparent manner

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 has been the development of a 'reference' database. After each reporting cycle, all database files, spreadsheets and official submissions are archived as 'read-only' mode in a master computer.

Quality assurance procedures regard some verification activities of the inventory as a whole and at sectoral level.
Feedbacks for the Italian inventory derive from communication of data to different institutions and/or at local level. For instance, the communication of the inventory to the European Community result in a pre-check of the GHG values before the submission to the UNFCCC and relevant inconsistencies may be highlighted.

Even though official independent and public reviews prior to the Italian inventory submission are not implemented yet, emission figures are subjected to a process of re-examination once the inventory, the inventory related publications and the national inventory reports are posted on website, specifically www.apat.gov.it, and from the communication of data to different institutions and/or at local level.
Moreover, the inventory is presented to a Technical Committee on Emissions (CTE), coordinated by the Ministry for the Environment, Land and Sea, where all the relevant Ministries and local authorities are represented; within this task emission figures and results are shared and discussed.
Expert peer reviews of the national inventory also occur annually within the UNFCCC process, whose results and suggestions can provide valuable feedback on areas where the inventory should be improved. 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).
Moreover, at European level, voluntary reviews of the European inventory are undertaken by experts from different Member States for critical sectoral categories.

The only official review, apart from those by the UNFCCC, was performed by Ecofys, in 2000, 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. 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 preparation of environmental reports where data are needed at different aggregation levels or refer to different contexts, such as environmental and economic accountings, is also a check for emission trends. At national level, for instance, emission time series are reported in the Environmental Data Yearbooks published by the Agency. Emission data are also published by the Ministry for the Environment, Land and Sea in the Reports on the State of the Environment and the National Communications as well as in the Demonstrable Progress report. Moreover, figures are communicated to the National Institute of Statistics to be published in the relevant Environmental Statistics Yearbooks as well as used in the framework of the EUROSTAT NAMEA Project.
At European level, APAT also reports on indicators meeting the requirements of Article 3 (1)(j) of Decision N° 280/2004/EC. In particular, Member States shall submit figures on specified priority indicators and should submit information on additional priority and supplementary indicators for the period 1990 to the last submitted year and forecasts for some specified years. The national

trends of these indicators are explained in the report ‘Carbon Dioxide Intensity Indicators’ (APAT, 2007 [b]).

Comparisons between national activity data and data from international databases are usually carried out in order to find out the main differences and an explanation to them. Emission intensity indicators among countries (e.g. emissions per capita, industrial emissions per unit of added value, transport emissions per car, emissions from power generation per kWh of electricity produced, emissions from dairy ruminants per tonne of milk produced) can also be useful to provide a preliminary check and verification of the order of magnitude of the emissions. This is carried out at European and international level by considering the annual reports compiled by the EC and the UNFCCC as well as related documentation available from international databases and outcome of relevant workshops.

Additional comparisons between emission estimates from industrial sectors and those published by the industry itself in the Environmental reports are carried out annually in order to assess the quality and the uncertainty of the estimates.

The quality of the inventory has also improved by the organization and participation in sector specific workshops. 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 European emissions trading scheme in the national greenhouse gas inventories. Previous workshops addressed methodologies to estimate emissions from the agriculture and LULUCF sectors, involving the Joint Research Centre, from the waste sector, involving the European Topic Center on Resource and Waste Management, as well as from international bunkers, involving the International Energy Agency and EUROCONTROL. Presentations and documentation of the workshops are available on the website at the address: http://air-climate.eionet.europa.eu/meetings/past_html.

A national conference on the Italian emission inventory was organized by APAT in October 2006. Methodologies used to carry out national figures and results of time series from 1990 to 2004 were presented detailing explanations for each sector. More than one hundred participants from national and local authorities, Ministries, Industry, Universities and Research organizations attended the two days meeting.

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 sectors) which involve, on a voluntary basis, different institutions, local agencies and industrial associations cooperating for improving activity data and emission factors accuracy.

In addition to these panels, APAT participates in technical working groups within the National Statistical System (Sistan). These groups, named *Circoli di qualità* and coordinated by the National Institute of Statistics, are constituted by both producers and users of statistical information with the aim of improving and monitoring statistical information in specific sectors such as transport, industry, agriculture, forest and fishing. These activities should improve the quality and details of basic data, as well as enable a more organized and timely communication.

Other specific activities relating to improvements of the inventory and QA/QC practises carried out in the last year were:

- *Energy – Industrial processes*. 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*. 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 IPCC Good Practice and overcoming the underestimation of CH4 emissions.
- *Agriculture*. 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 available from the Italian manufacturers and the Italian Association of Aerosol Producers as well as other relevant associations.
- *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.
- *European Pollutant Emission Register*. Data from the Italian pollutant emission register from some industrial sectors were used as a check and comparison with the estimates carried out at national level. This specifically regards the production of non-ferrous metals, chemical productions such as nitric and sulphuric acid, and the production of iron and steel.

A summary of all the main QA/QC activies over the past years which ensure the continous improvement of the inventory is presented in the document 'Quality Assurance/Quality Control plan for the Italian Emission Inventory. Year 2007' (APAT, 2007 [a]).

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

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

After each reporting cycle, all database files, spreadsheets and electronic documents are archived as 'read-only' mode.
A 'reference' database is also compiled every year to increase the transparency of the inventory. This database consists of a number of records that references all documentation used during the inventory compilation, for each sector and submission year, the link to the electronically available documents and the place where they are stored as well as internal documentation on QA/QC procedures.

1.7 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 described 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 estimates, for the 2005 total emission figures without LULUCF, an uncertainty of 3.2% in the combined GWP total emissions, whereas for the trend between 1990 and 2005 the analysis assesses 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 2005, whereas the uncertainty for the trend is estimated to be 7.7%.

The assessment of uncertainty has also been applied to the base year emission levels. The results show an uncertainty of 3.5% in the combined GWP total emissions, excluding emissions and removals from LULUCF, whereas it increases to 7.2% including the LULUCF sector.

QC procedures are also undertaken on the calculations of uncertainties in order to confirm the correctness of the estimates and that there is sufficient documentation to duplicate the analysis. The assumptions on which uncertainty estimations are based are documented for each category. Figures used to draw up uncertainty analysis are checked both with the relevant analyst experts and literature references and are consistent with the IPCC Good Practice Guidance (IPCC, 2000; IPCC, 2003).

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.

Sources and sinks not estimated (NE)[1]			
GHG	Sector[2]	Source/sink category [2]	Explanation
Carbon	5 LULUCF	5.E.1 Settlements remaining Settlements	Up to now there is a lack of data concerning urban tree formations. Therefore it is not possible to give estimates on the C stock changes in living biomass
Carbon	5 LULUCF	5.E.1 Settlements remaining Settlements	Up to now there is a lack of data concerning urban tree formations. Therefore it is not possible to give estimates on the C stock changes in living biomass
Carbon	5 LULUCF	5.E.1 Settlements remaining Settlements	Up to now there is a lack of data concerning urban tree formations. Therefore it is not possible to give estimates on the C stock changes in dead organic matter
Carbon	5 LULUCF	5.E.2.2 Cropland converted to Settlements	Up to now there are no sufficient data for estimating C stock changes in dead organic matter.
Carbon	5 LULUCF	5.E.2.3 Grassland converted to Settlements	Up to now there are no sufficient data for estimating C stock changes in dead organic matter.
Carbon	5 LULUCF	5.E.1 Settlements remaining Settlements	Up to now there is a lack of data concerning urban tree formations. Therefore it is not possible to give estimates on the C stock changes in soils
CH4	1 Energy	1.AA.2.D Pulp, Paper and Print	Emissions have not been estimated because fuel data are not available
CH4	1 Energy	1.C2 Multilateral Operations	Information and statistical data are not available
CO2	1 Energy	1.AA.2.D Pulp, Paper and Print	Emissions have not been estimated because fuel data are not available
CO2	1 Energy	1.C2 Multilateral Operations	Information and statistical data are not available
N2O	1 Energy	1.AA.2.D Pulp, Paper and Print	Emissions have not been estimated because fuel data are not available
N2O	1 Energy	1.C2 Multilateral Operations	Information and statistical data are not available
N2O	3 Solvent and Other Product Use	3.D.4 Other Use of N2O	No information is available on other use of N2O

Table 1.7 Source and sinks not estimated in the 2005 inventory

Details are reported in Table 1.7 and Table 1.8. Sectoral and background tables of CRF sheets are complete as far as the details of basic information are available. For instance, multilateral operations emissions are not estimated because no activity data are available; pulp, paper and print emissions from the combustion of biomass are not estimated because no data on this use is available. There is no information on other use of N_2O for solvent and other product use except for the emissions reported.

Allocation of emissions is not consistent with the IPCC Guidelines only where there is no data available to split the information. For istance, for fugitive emissions, CO_2 and 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 other leakage emissions are included in distribution emission estimates. N_2O emissions from from oil and natural gas exploration and refining and storage activities are reported under 1.B.2.c oil flaring. Further investigation will be carried out closely with industry about these figures. 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.

Sources and sinks reported elsewhere (IE)[3]				
GHG	**Source/sink category**	**Allocation as per IPCC Guidelines**	**Allocation used by the Party**	**Explanation**
CH4	1.B.2.A.1 Exploration	1.B.2.A.1	1.B.2.A.2	Emissions are included in 1.B.2.A.2 Production
CH4	1.B.2.B.1 Exploration	1.B.2.B.1	1.B.2.B.2	Emissions are included in 1.B.2.B.2 Production
CH4	1.B.2.B.5.1 at industrial plants and power stations			Emissions are reported under the respective sectors where they occurr
CH4	1.B.2.B.5.2 in residential and commercial sectors			Emissions are reported under the respective sectors where they occurr
CH4	1.B.2.C.1.1 Oil	1.B.2.C.1.1	1.B.2.A.2	Emissions are included in 1.B.2.A.2 Oil production
CH4	1.B.2.C.1.2 Gas	1.B.2.C.1.2	1.B.2.B.2	Emissions are included in 1.B.2.B.2 Gas production
CH4	1.B.2.C.2.2 Gas	1.B.2.C.2.2	1.B.2.B.2	Emissions are included in 1.B.2.B.2 Gas production
CH4	2.C.1.4 Coke	2.C.1.4	1.B.1.b	CH4 emission from coke production are fugitive emissions due to the door leakage during the solid transformation and are reported under the 1.B.1.b category, fugitive emissions from solid fuel.
CH4	6.B.1 Industrial Wastewater			Emissions are reported under 6.B.1 Indutrial Wastewater/Wastewater
CH4	1.AA.3.B Road Transportation			Emissions from biodiesel are included in liquid fuel - gasoil/diesel category
CO2	1.B.2.A.1 Exploration	1.B.2.A.1	1.B.2.A.2	Emissions are included in 1.B.2.A.2 Oil Production
CO2	1.B.2.B.1 Exploration	1.B.2.B.1	1.B.2.B.2	Emissions are included in 1.B.2.B.2 Gas Production
CO2	1.B.2.B.5.1 at industrial plants and power stations			Emissions are reported under the respective sectors where they occurr
CO2	1.B.2.B.5.2 in residential and commercial sectors			Emissions are reported under the respective sectors where they occurr
CO2	1.B.2.C.1.1 Oil	1.B.2.C.1.1	1.B.2.A.2	Emission are included in 1.B.2.A.2 Oil Production
CO2	1.B.2.C.1.2 Gas	1.B.2.C.1.2	1.B.2.B.2	Emissions are included in 1.B.2.B.2 Gas production
CO2	1.B.2.C.2.2 Gas	1.B.2.C.2.2	1.B.2.B.2	Emissions are included in 1.B.2.B.2 Gas production
CO2	2.A.4.2 Soda Ash Use			Emission from soda ash use are included in other processes (glass, paper,etc).
CO2	5.A.1 Forest Land remaining Forest Land	5.A.1. - 5(V) - Biomass Burning - Wildfires	5.A.1 Carbon stock change	CO2 emissions due to wildfires in forest land remaining forest land are included in table 5.A.1, Carbon stock change in living biomass, Losses
N2O	1.B.2.A.1 Exploration	1.B.2.A.1	1.B.2.c.2	Emissions are included in 1.B.2.c.2 oil flaring
N2O	1.B.2.A.4 Refining / Storage	1.B.2.A.4	1.B.2.C.2	Emissions are included in 1.B.2.c.2 oil flaring
N2O	6.B.1 Industrial Wastewater			Emissions are reported under 6.B.1 Industrial Wastewater/Wastewater
N2O	6.B.2.1 Domestic and Commercial (w/o human sewage)	6.B.2.1 Domestic and commercial/Wastewater	6.B.2.2 Human sewage	
N2O	6.B.2.1 Domestic and Commercial (w/o human sewage)	6.B.2.1 Domestic and commercial/Sludge	6.B.2.2 Human sewage	
N2O	1.AA.3.B Road Transportation			Emissions from biodiesel are included in liquid fuel - gasoil/diesel category
SF6	2.F.7 Semiconductor Manufacture			Data are included in new manufactured products
SF6	2.F.7 Semiconductor Manufacture			Data are included in new manufactured products
SF6	2.F.7 Semiconductor Manufacture			Emissions are included in emissions from manufacturing
SF6	2.F.7 Semiconductor Manufacture			Emissions are included in emissions from manufacturing

Table 1.8 Source and sinks reported elsewhere in the 2005 inventory

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 1990-2005 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 emissions and removals from LULUCF, have increased by 12.1% between 1990 and 2005, varying from 517 to 580 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 85.1% of total emissions in CO_2 equivalent, shows an increase by 13.5% between 1990 and 2005. In the energy sector, in particular, emissions in 2005 are 14.5% greater than in 1990.

CH_4 and N_2O emissions are equal, respectively, to 6.9% and 7.0% of the total CO_2 equivalent greenhouse gas emissions. CH_4 emissions have decreased by 4.4% from 1990 to 2005, while N_2O has increased by 6.2%.

Other greenhouse gases, HFCs, PFCs and SF_6, range from 0.1% to 1% of total emissions; HFCs emissions show a strong increase, while PFCs emissions show a decrease and SF_6 emissions show a lighter increase. Although at present, variations in these gases are not relevant to reaching the emission reduction objectives, the meaningful increasing trend of HFCs will make them even more important in next years.

Figure 2.1 illustrates the national trend of greenhouse gases for 1990-2005, expressed in CO_2 equivalent terms and by substance; total emissions do not include emissions and removals from land use, land use change and forestry.

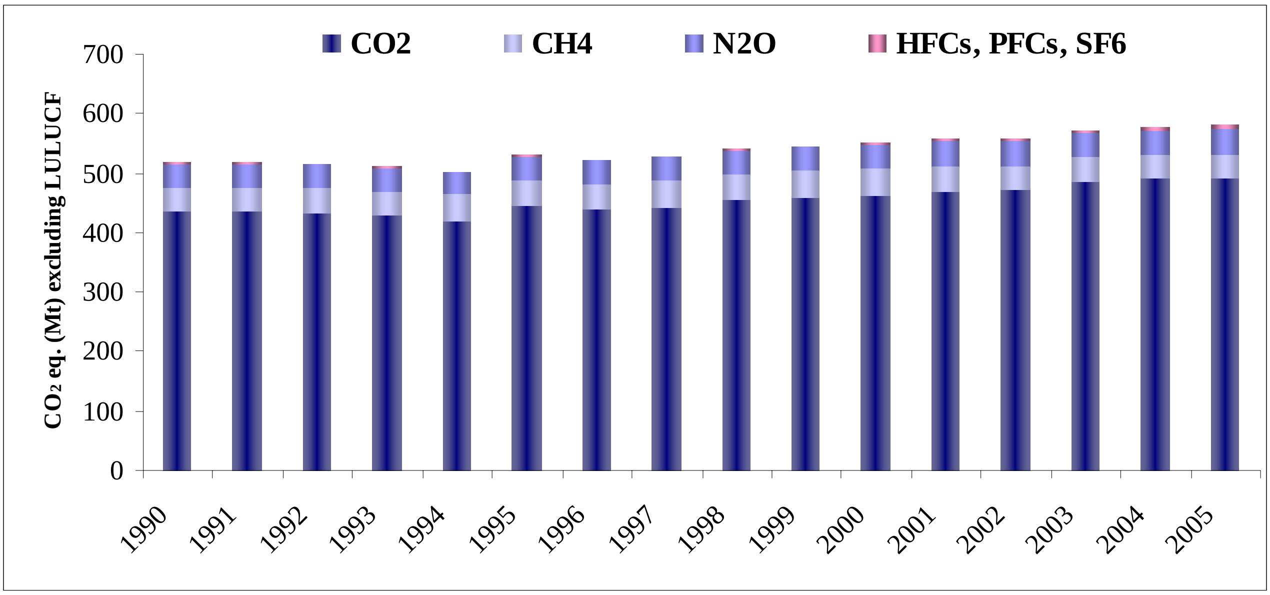

Figure 2.1 National greenhouse gas emissions from 1990 to 2005 (without LULUCF) (Mt CO_2 eq.)

The share of the different sectors in terms of total emissions remains nearly unvaried over the period 1990-2005. Specifically for the year 2005, the greatest part of the total greenhouse gas emissions is to be attributed to the energy sector, with a percentage of 82.8%, followed by industrial

processes, accounting for 7% of total emissions, agriculture, contributing with 6.4%, waste (3.3%) and use of solvents (0.4%).
Considering total greenhouse gas emissions with emissions and removals from LULUCF, the energy sector accounts, in 2005, for 70% of total emissions and removals, as absolute weight, followed by the LULUCF sector which contributes with 16%.
Figure 2.2 shows total greenhouse gas emissions and removals subdivided by sector.

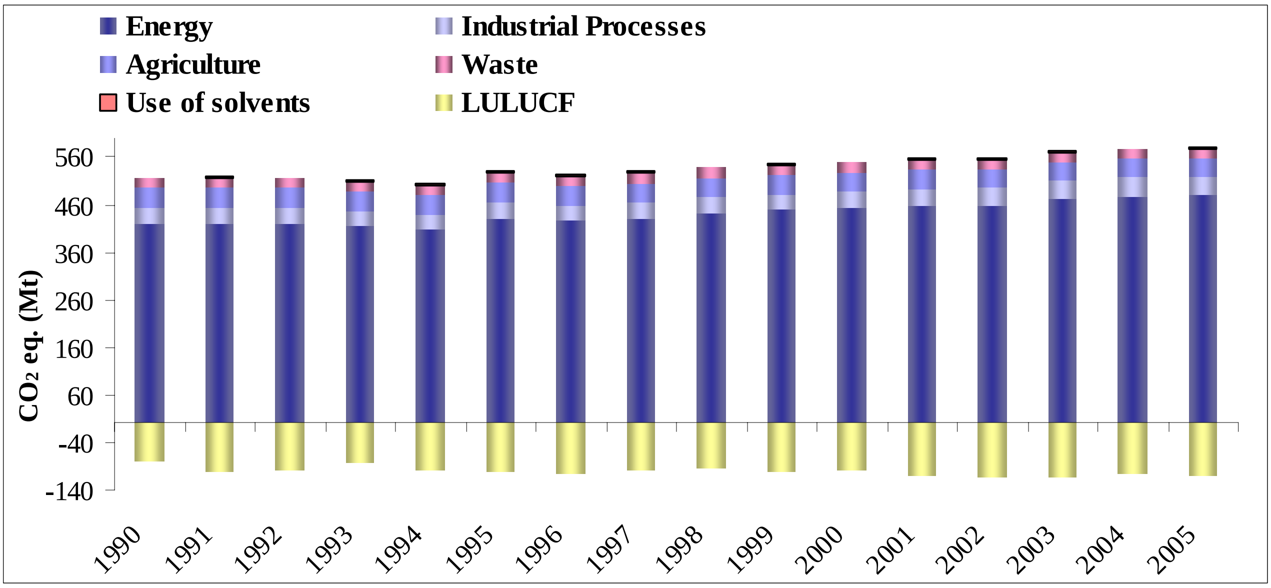

Figure 2.2 Greenhouse gas emissions and removals from 1990 to 2005 by sector (Mt CO_2 eq.)

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 13.5% from 1990 to 2005, ranging from 435 to 493 million tons.
The most relevant emissions derive from the energy industries (32%) and transportation (26%). Non-industrial combustion accounts for 19% and manufacturing and construction industries for 17%, 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.

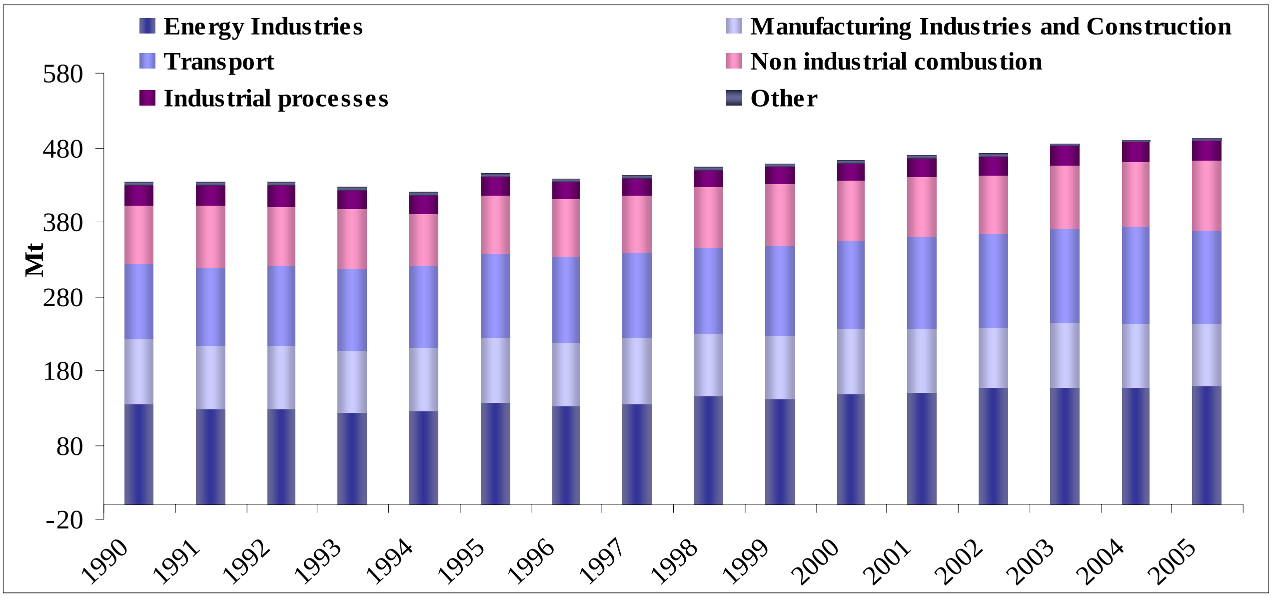

Figure 2.3 National CO_2 emissions by sector from 1990 to 2005 (Mt)

The main sectors responsible for the increase of CO_2 emissions are transport and energy industries; in particular, emissions from transport have increased by 25.1% from 1990 to 2005 while those from energy industries increased by 19.2%. Non industrial combustion emissions have raised by 21.4%; emissions from industrial processes and manufacturing industries and construction show a decrease of about 1.4% and 7.8% respectively, emissions in the ‘Other’ sector, mostly fugitive emissions from oil and natural gas and emissions from solvent and other product use, reduced by 34.3%.

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

- Gross Domestic Product (GDP) at market prices as of 2000 (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.

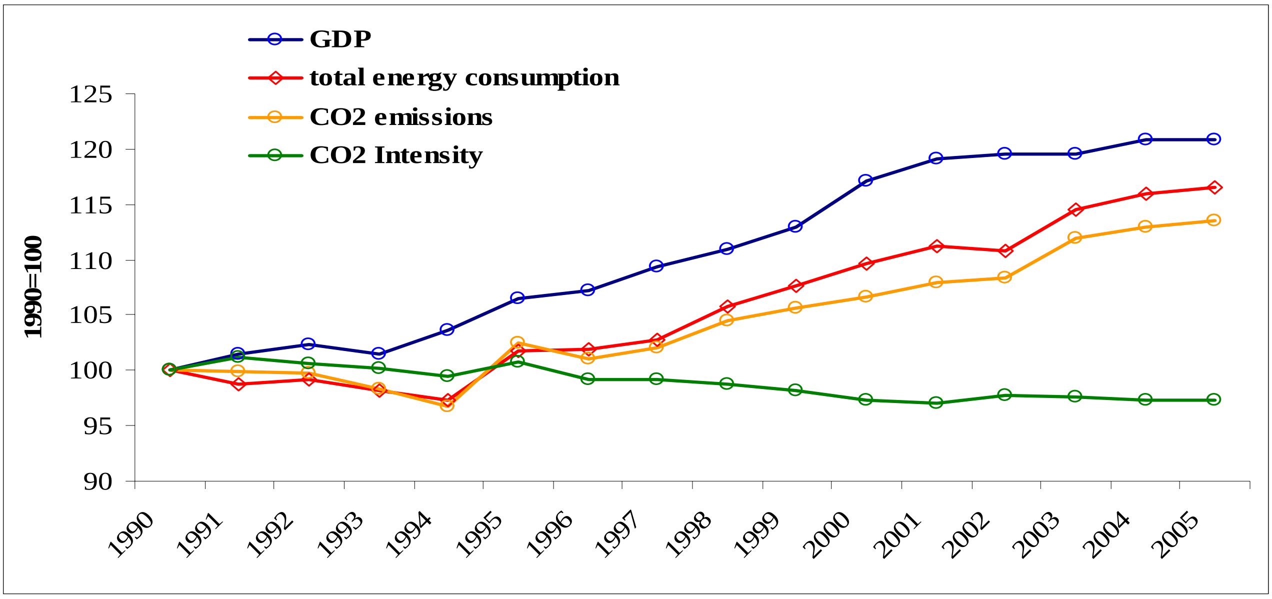

Figure 2.4 Energy-related and economic indicators and CO_2 emissions

2.2.2 Methane emissions

Methane emissions in 2005 represent 6.9% of total greenhouse gases, equal to 39.7 Mt in CO_2 equivalent, and show a decrease of approximately 1.8 Mt as compared to 1990 levels.
CH_4 emissions, in 2005, are mainly originated from waste sector which accounts for 42.9% of total methane emissions, as well as to agricultural sector (39%) 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, 10.6% 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 10.1% as compared to 1990.
In terms of CH_4 emissions in the energy sector, the reduction (-19.3%) 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.

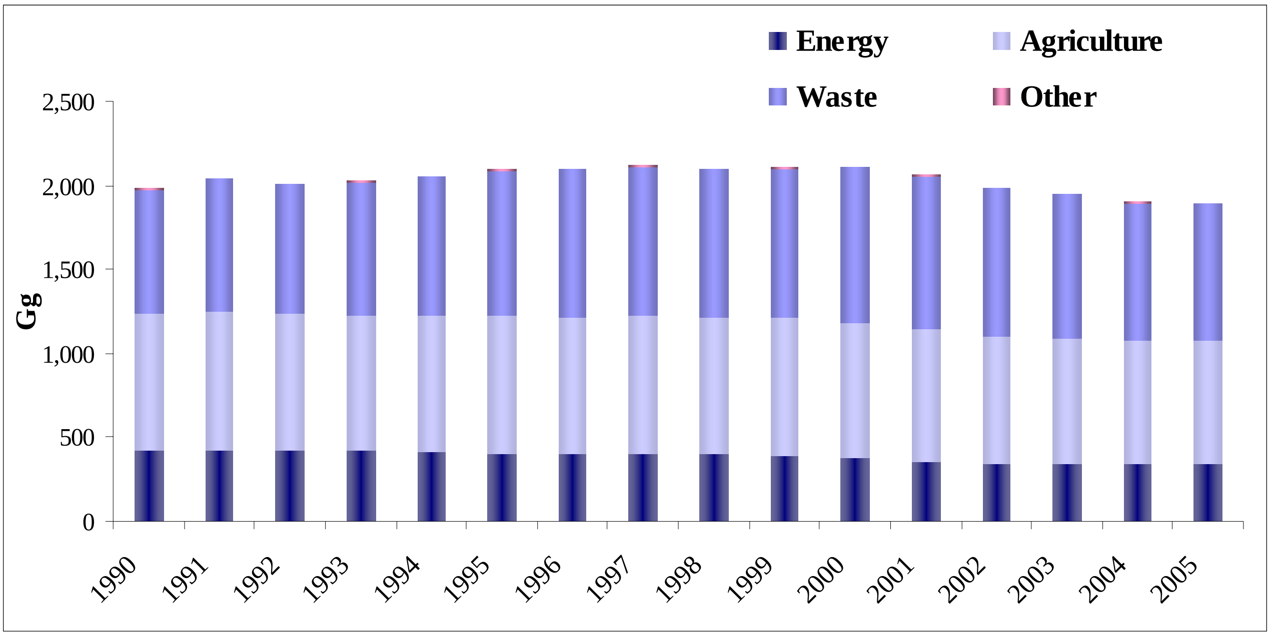

Figure 2.5 National CH_4 emissions by sector from 1990 to 2005 (Gg)

2.2.3 Nitrous oxide emissions

In 2005 nitrous oxide emissions represent 7% of total greenhouse gases, with a growth rate of 6.2% between 1990 and 2005, from 38.01 to 40.37 Mt CO_2 equivalent.
The major source of N_2O emissions is the agricultural sector (53.8%), 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 7% during the period 1990-2005.
Emissions in the energy-use sector (20% of the total) show an increase by approximately 53% from 1990 to 2005; this growth can be traced primarily to the road transport sector and it 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 19.2% 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.

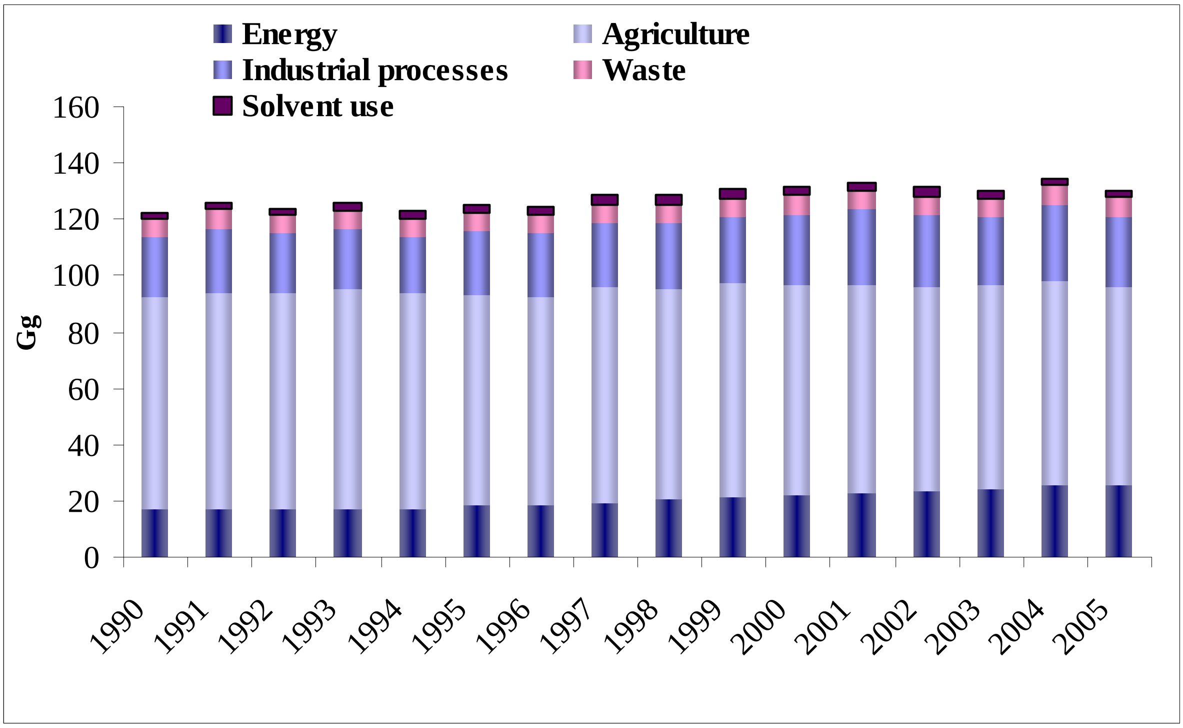

Figure 2.6 National N_2O emissions by sector from 1990 to 2005 (Gg)

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. Taken altogether, the emissions of fluorinated gases represent 1.05% of total greenhouse gases in CO_2 equivalent in 2005, and they show an increase of 144.4% between 1990 and 2005. This increase is the result of different features for different gases.

HFCs, for instance, have increased considerably from 1990 to 2005, from 0.4 to 5.3 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 80% from 1990 to 2005. The level of these emissions in 2005 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 0.5 Mt in CO_2 equivalent in 2005, with an increase of 38.2% as compared to 1990 levels. Out of the SF_6 emissions, 18% can be traced to the use of gas in magnesium foundries, 69% 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.

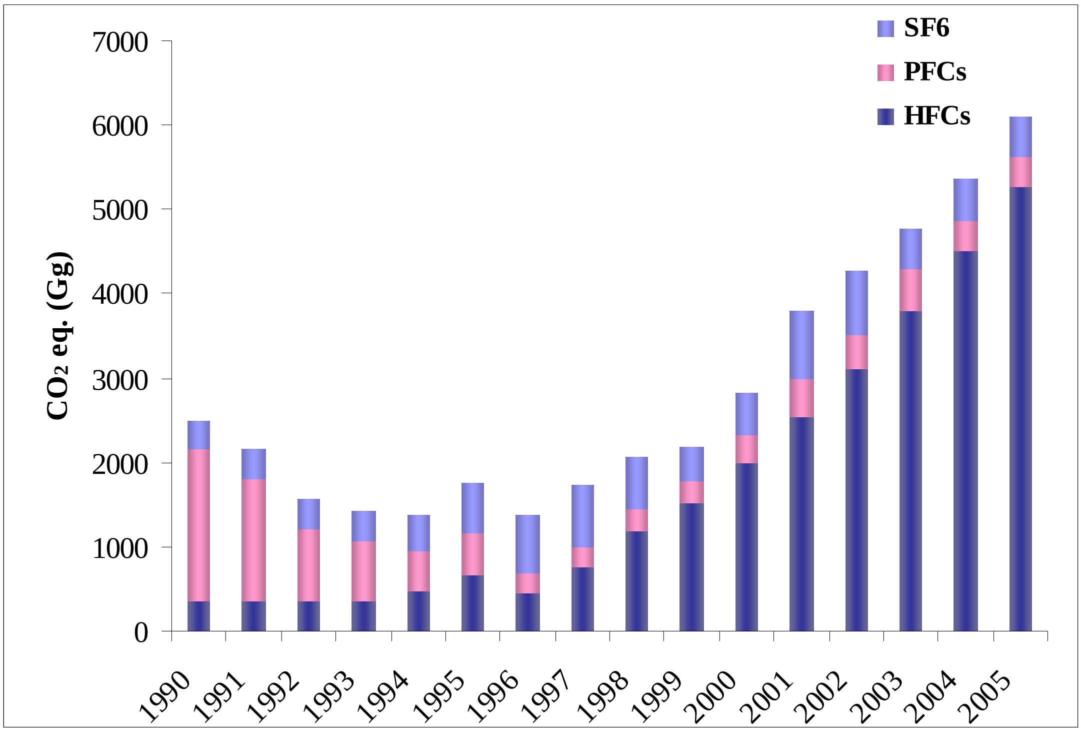

Figure 2.7 National emissions of fluorinated gases by sector from 1990 to 2005 (Gg CO_2 eq.)

2.3 Description and interpretation of emission trends by source

2.3.1 Energy

Emissions from the energy sector account for 82.8% of total national greenhouse gas emissions, excluding LULUCF.
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	2005
Gg CO_2 eq.																
Total emissions	**419419**	**419276**	**418590**	**415280**	**409178**	**432500**	**428442**	**432728**	**444091**	**449172**	**452772**	**457442**	**459394**	**474122**	**477769**	**480114**
Fuel Combustion (Sectoral Approach)	408682	408666	407992	404624	398860	422481	418677	422793	434198	440198	443751	448886	451194	465431	469921	472287
Energy Industries	134791	129078	128958	123508	126161	138663	134146	135905	146306	142354	148415	151583	158457	159282	158445	160592
Manufacturing Industries and Construction	90607	87640	85955	86305	87067	89371	87117	90201	84305	88017	89454	86730	82709	87656	87794	83645
Transport	103952	106890	111332	113153	113130	115128	116506	118370	122480	123999	124498	126813	129200	130616	133007	131502
Other Sectors	78218	83789	80391	80126	70965	77811	79670	77024	80015	84674	80534	83395	80506	87176	89494	95256
Other	1114	1269	1355	1533	1537	1507	1238	1292	1092	1154	851	365	322	701	1180	1291
Fugitive Emissions from Fuels	10737	10611	10598	10656	10318	10019	9765	9935	9893	8975	9021	8556	8200	8691	7848	7827
Solid Fuels	122	112	112	82	71	65	60	60	55	53	73	81	78	95	64	69
Oil and Natural Gas	10615	10499	10486	10574	10247	9954	9705	9876	9837	8922	8947	8475	8122	8596	7784	7758

Table 2.1 Total emissions in CO_2 equivalent from the energy sector by source (1990-2005) (Gg CO_2 eq.)

An upward trend is noted from 1990 to 2005. Substances with the highest increase rate are CO_2, whose levels have increased by 14.7% from 1990 to 2005 and account for 97% of the total, and N_2O which shows an increase of 53% but its share out of the total is only 2%; CH_4, on the other

hand, shows a decrease of 19.3% from 1990 to 2005 but this is not relevant on total emissions, accounting only for 1%.
Totally emissions from this sector increase by 14.5% from 1990 to 2005.
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, in the other sectors and in the energy industries sectors, about 26.5%, 21.8% and 19.1%, respectively, from 1990 to 2005; these sectors, altogether, account for 81% of total emissions.

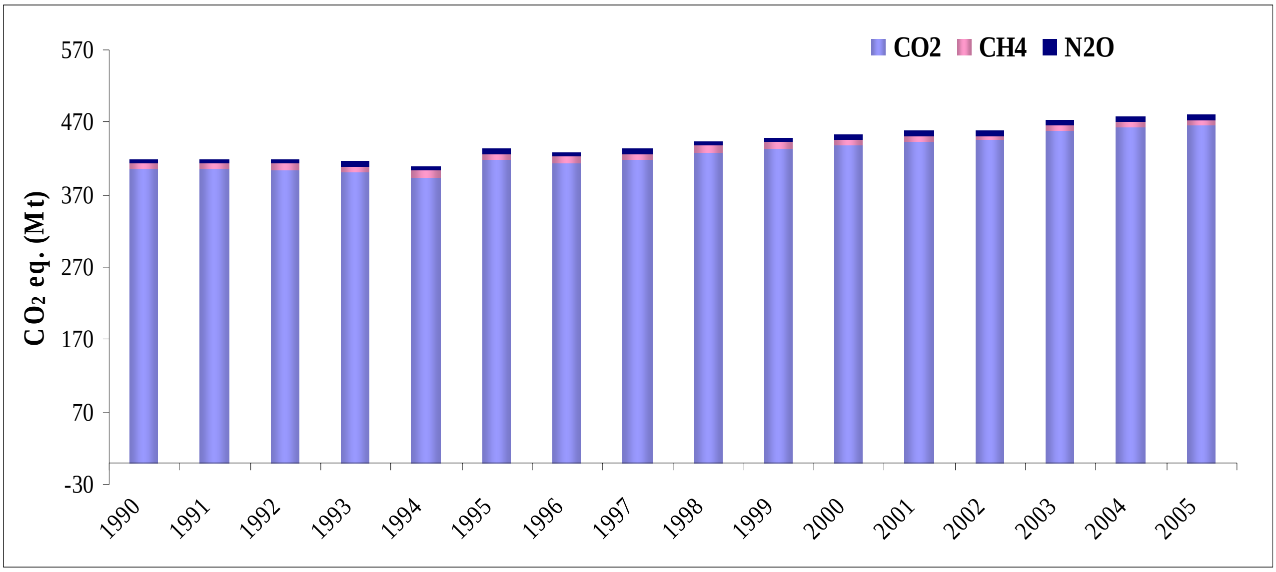

Figure 2.8 Trend of total emissions in CO_2 equivalent from the energy sector by gas (1990-2005) (Mt CO_2 eq.)

2.3.2 Industrial processes

Emissions from industrial processes account for 7% of total national greenhouse gas emissions, excluding LULUCF.
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 11.6%, from the base year to 2005. Taking into account emissions by substance, CO_2 level decreased by 1.4%, while N_2O level increased by 16.2%; these two substances account altogether for about 85% of the total emissions from industrial processes. The increase in emissions is mostly due to an increase in the mineral products category (13.3%), for the increase in production figures especially for cement and lime. The increase in the chemical industry (1.9%) is due to adipic acid production. On the other hand, emissions from metal production decreased by 57.6% mostly for the different materials used in the pig iron and steel production processes.
A considerable increase is observed in F-gas emissions (144.4%), whose share on total emissions is 15%.
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	2005
Gg CO_2 eq.																
Total emissions	**36544**	**36165**	**35572**	**32736**	**31399**	**34590**	**31556**	**32032**	**32490**	**32889**	**34959**	**36993**	**37002**	**38154**	**40631**	**40792**
CO_2	27268	26827	27360	24488	23607	25474	23092	23165	23219	23336	24153	24906	24782	25780	26770	26879
CH_4	108	104	101	102	106	113	63	68	65	64	63	59	57	58	61	64
N_2O	6676	7071	6544	6712	6311	7239	7025	7063	7148	7303	7918	8232	7902	7557	8443	7760
HFCs	351	355	359	355	482	671	450	756	1182	1524	1986	2550	3100	3796	4515	5267
PFCs	1808	1452	850	707	477	491	243	252	270	258	346	451	424	498	350	361
SF_6	333	356	358	370	416	601	683	729	605	405	493	795	738	465	492	460

Table 2.2 Total emissions in CO_2 equivalent from the industrial processes sector by gas (1990-2005)

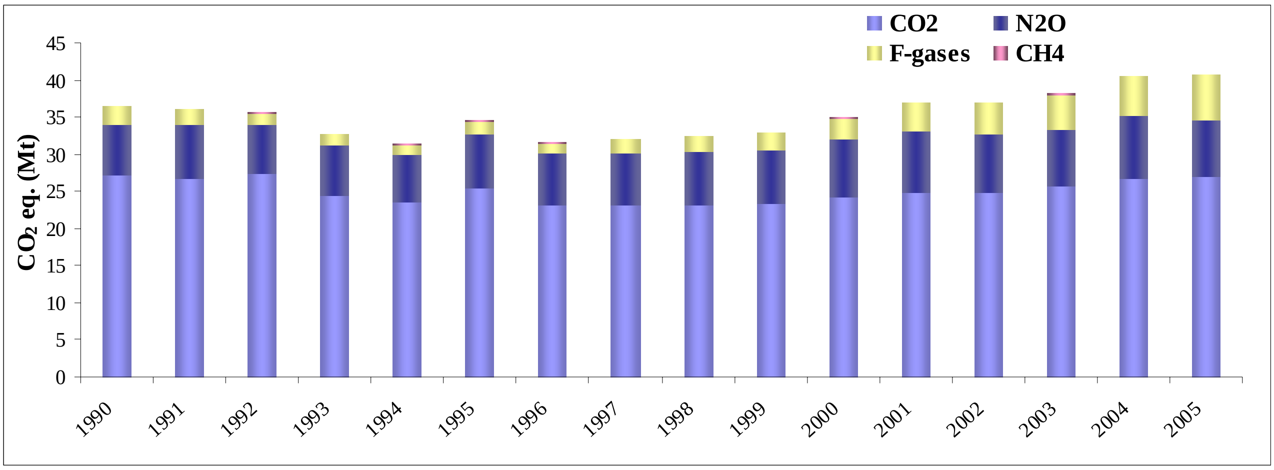

Figure 2.9 Trend of total emissions in CO_2 equivalent from industrial processes by gas (1990-2005) (Mt CO_2 eq.)

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 63% out of the total; a decrease by 12.4% is noted from this sector from 1990 to 2005, which is to be attributed to different sources. As regards CO_2, emission levels from paint application sector, which accounts for 52% of total CO_2 emissions from this sector, decreased by 19%; emissions from other use of solvents in related activities, such as domestic solvent use other than painting, printing industries, vehicle dewaxing, which account for 43% of the total, show a decrease of 1%. Finally, emissions from metal degreasing and dry cleaning activities, decreased by 64.2% but they account for only 5% of the total.
In 2005, solvent use is responsible for 0.4% of the total CO_2 emissions (excluding LULUCF) and 39% of the total NMVOC emissions, and represents the main source of anthropogenic NMVOC national emissions.
The N_2O emissions, in 2005, 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 about equal to 85% and 95%, 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.

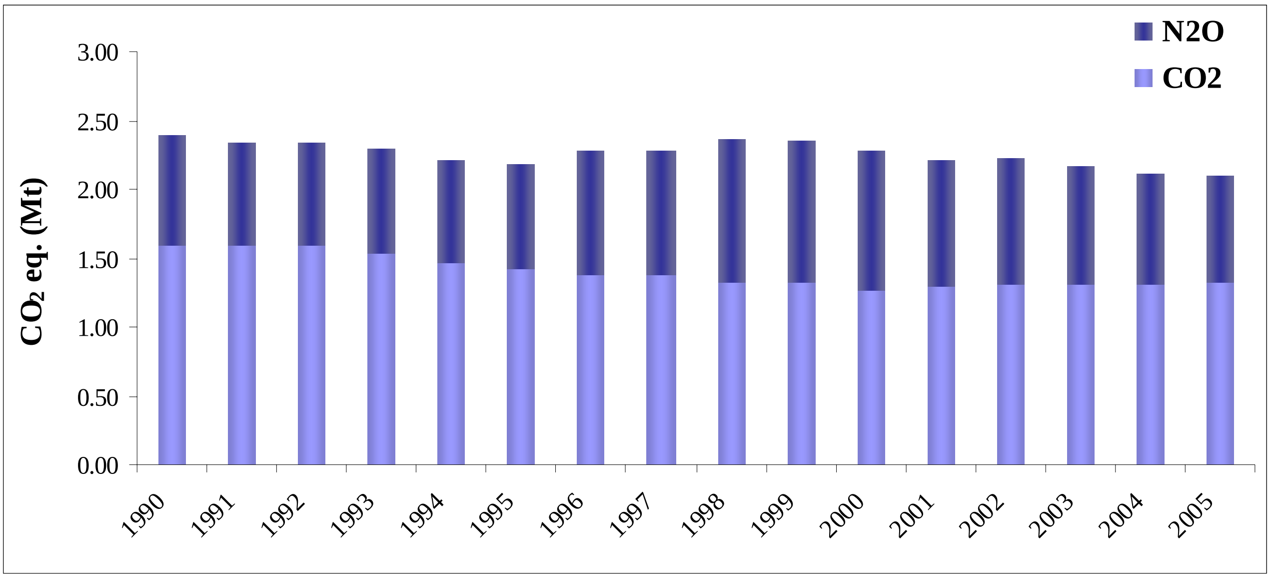

Figure 2.10 Trend of total emissions in CO_2 equivalent from the solvent and other product use sector (1990-2005) (Mt CO_2 eq.)

2.3.4 Agriculture

Emissions from the agriculture sector account for 6.4% of total national greenhouse gas emissions, excluding LULUCF.
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	2005
Gg CO_2 eq																
Total emissions	**40577**	**41372**	**40863**	**41163**	**40641**	**40349**	**40097**	**41150**	**40418**	**40795**	**39939**	**39428**	**38250**	**38099**	**37892**	**37214**
Enteric Fermentation	12178	12448	12070	11943	12050	12266	12322	12376	12291	12428	12165	11666	11029	11055	10836	10852
Manure Management	7383	7376	7081	7038	6920	7068	7119	7138	7253	7344	7140	7398	7110	7067	6886	6838
Rice Cultivation	1562	1493	1551	1627	1664	1657	1623	1615	1533	1497	1382	1382	1420	1462	1510	1464
Agricultural Soils	19437	20037	20143	20538	19990	19341	19016	20004	19324	19509	19238	18967	18673	18500	18643	18042
Field Burning of Agricultural Residues	17	19	18	17	18	17	18	16	18	17	16	15	17	15	18	17

Table 2.3 Total emissions in CO_2 equivalent from the agricultural sector by source (1990-2005) (Gg CO_2 eq.)

Emissions refer to CH_4 and N_2O levels, which account for 42% and 58% of the total emission of the sector, respectively. The decrease observed in the total emissions (-8.3%) is mostly due to the decrease of CH_4 emissions from enteric fermentation (-10.9%) which account for 29% of the total emissions. Detailed comments can be found in the specific chapter.

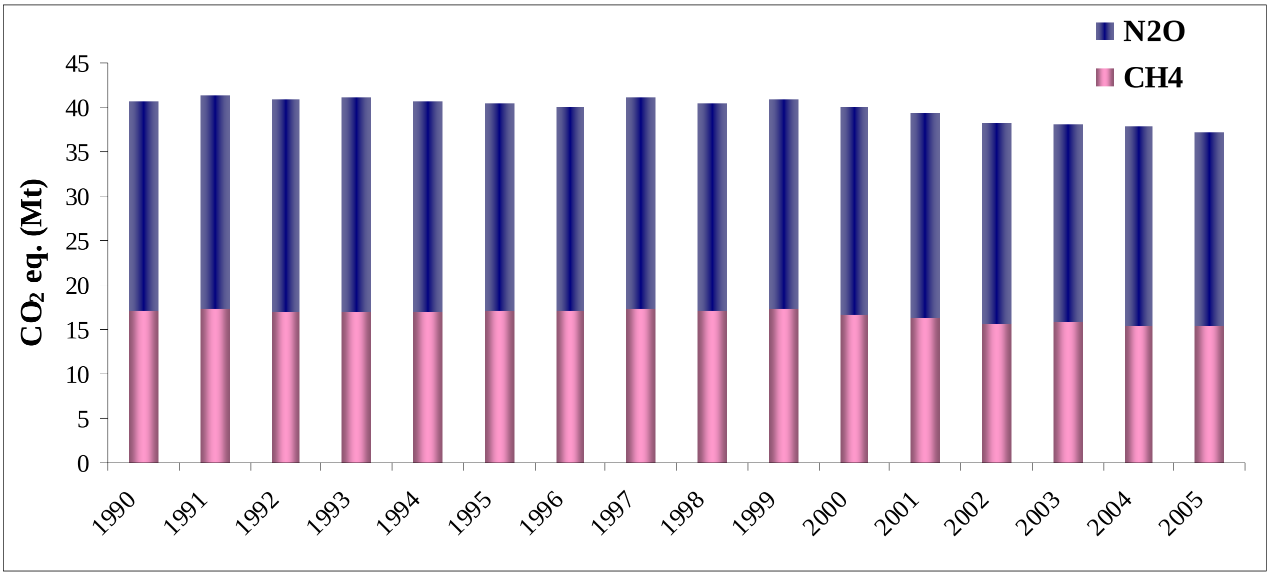

Figure 2.11 Trend of total emissions in CO_2 equivalent from agriculture (1990-2005) (Mt CO_2 eq.)

2.3.5 LULUCF

Emissions from the LULUCF 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	2005
	Gg CO_2 eq															
Total emissions - removals	**-79818**	**-101233**	**-97344**	**-82402**	**-98026**	**-103222**	**-106174**	**-98970**	**-95666**	**-103185**	**-97121**	**-109806**	**-113977**	**-112177**	**-103940**	**-110010**
Forest Land	-59068	-80830	-77150	-62616	-79005	-84389	-87332	-79906	-77792	-85539	-79416	-88034	-94529	-84601	-92508	-92289
Cropland	-22030	-21919	-21677	-21067	-20301	-20113	-19821	-20344	-19154	-18926	-18985	-20611	-20469	-19681	-12712	-19001
Settlements	1280	2527	2531	1280	1280	1280	2572	1280	1280	1280	1280	2559	2560	2559	1280	1280
Grassland	0	-1011	-1048	0	0	0	-1593	0	0	0	0	-3721	-1538	-10454	0	0
Wetlands	0	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	0
Other	0	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 (1990-2005) (Gg CO_2 eq.)

Total removals, in CO_2 equivalent, show an increase of 37.8%, from the base year to 2005.
CO_2 accounts for more than 99% to total emissions and removals of the sector: in the period 1990–2005 CO_2 removals increased by 37.7%, mostly because of the increase of forest areas.
Further details for LULUCF emissions and removals can be found in the specific chapter.

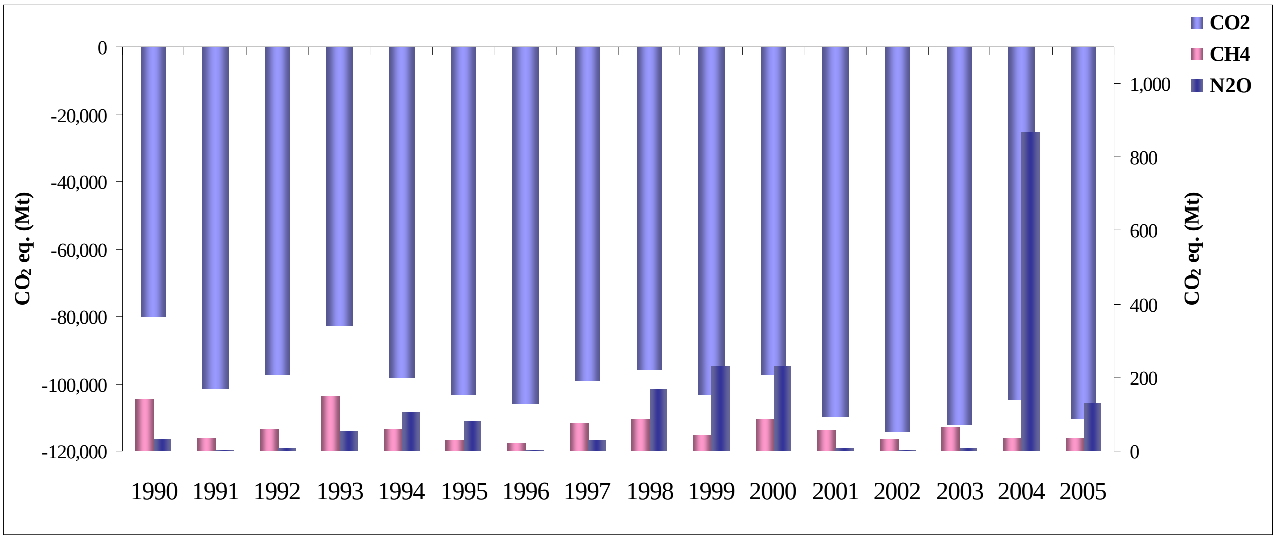

Figure 2.12 Trend of total emissions and removals in CO_2 equivalent from LULUCF (1990-2005) (Mt CO_2 eq.)

2.3.6 Waste

Emissions from the waste sector account for 3.3% of total national greenhouse gas emissions, excluding LULUCF.
Emissions from the waste sector are shown in Table 2.5 and Figure 2.13.
Total emissions in CO_2 equivalent increased by 7.9% from 1990 to 2005. The increase is due to the increase in emissions from solid waste disposal (8.6%) due to the increase of waste production, which accounts for 75% of the total, as well as from waste-water handling (12.2%), which accounts for 22% of the total .
Considering emissions by gas, the most important greenhouse gas is CH_4 which accounts for 88% of the total and shows an increase of 10.6% from 1990 to 2005. N_2O levels have increased by 7.8% while CO_2 decreased by 69.2%; these gases account for 11% 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	2005
Gg CO_2 eq																
Total emissions	**17916**	**19112**	**18780**	**19168**	**19922**	**20646**	**20858**	**21228**	**21033**	**21106**	**21638**	**21524**	**20952**	**20260**	**19453**	**19330**
Solid Waste Disposal on Land	13298	14154	13876	14255	15006	15754	15969	16203	16007	16059	16824	16662	16067	15402	14490	14437
Waste-water Handling	3832	3934	3974	3997	4021	4007	4077	4104	4154	4210	4248	4243	4254	4250	4274	4299
Waste Incineration	785	1025	930	916	895	884	811	920	871	836	564	617	627	604	686	590
Other	0	0	0	0	0	0	0	1	1	2	2	3	3	4	4	4

Table 2.5 Total emissions in CO_2 equivalent from the waste sector by source (1990-2005) (Gg CO_2 eq.)

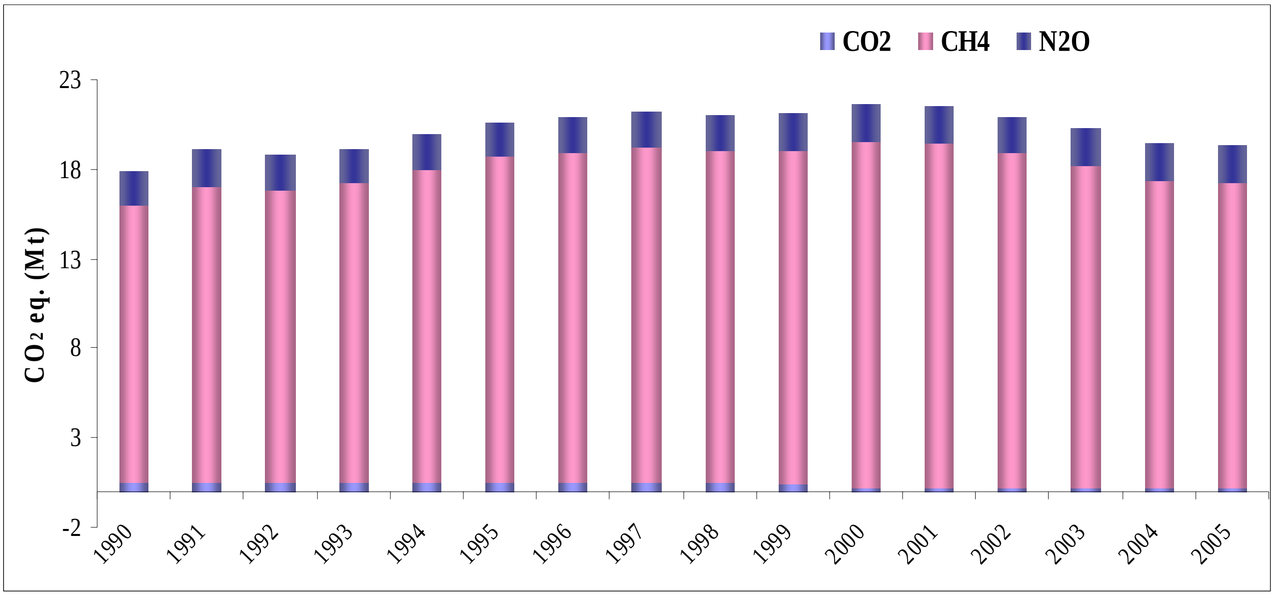

Figure 2.13 Trend of total emissions in CO_2 equivalent from waste (1990-2005) (Mt CO_2 eq.)

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 2005 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	2005
	kt															
NO_X	1,941	2,000	2,019	1,919	1,840	1,808	1,732	1,654	1,553	1,453	1,373	1,351	1,258	1,249	1,192	1,114
CO	7,123	7,462	7,652	7,560	7,377	7,155	6,858	6,576	6,161	5,879	5,128	5,062	4,455	4,356	4,191	3,818
NMVOC	1,977	2,045	2,125	2,087	2,030	2,002	1,949	1,878	1,772	1,683	1,496	1,425	1,331	1,291	1,260	1,207
SO_2	1,794	1,677	1,578	1,477	1,388	1,320	1,210	1,133	997	899	755	704	622	525	494	417

Table 2.6 Total emissions for indirect greenhouse gases and SO_2 (1990-2005) (kt)

All gases show a significant reduction in 2005 as compared to 1990 levels. The highest reduction is observed for SO_2 (-76.7%), CO levels have reduced by 46.4%, while NO_X and NMVOC show a decrease by 42.6% and 39%, 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.

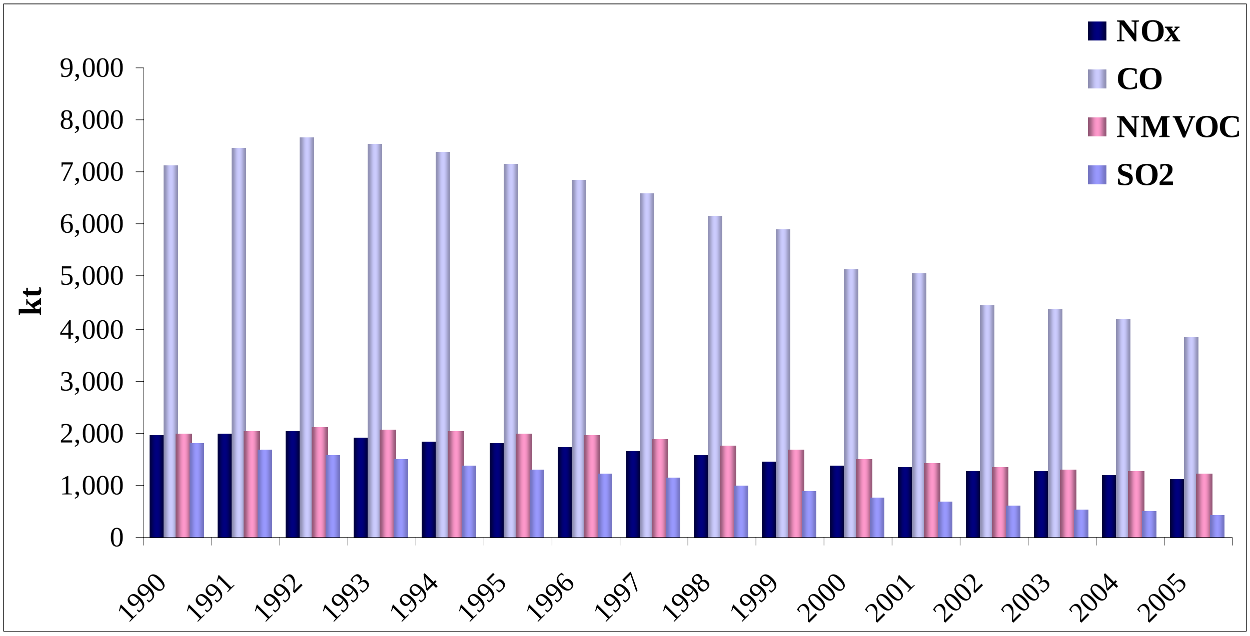

Figure 2.14 Trend of total emissions for indirect greenhouse gases and SO_2 (1990-2005) (kt)

Chapter 3: ENERGY [CRF sector 1]

3.1 Introduction

The aim of this section is to describe in detail the methodology used to estimate emissions from fuel combustion for energy. These sources correspond to IPCC Tables 1A.
The national 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 2005 inventory has identified 10 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 10) 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 (MSE, 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 Terna database (Terna, 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 2005, 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 three key sources (n. 4, 6, and 8) 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,T	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	L1,T1	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 Fugitive emissions from Oil and Gas Operations	L2,T	3.11	Table 3.28
10	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 ((MSE, 2006 [a])), Terna (Terna, 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, MSE) publishes annually energy balances (MSE, 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 2005 data is attached, the full time series is available on 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 2005, 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 MSE 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 Terna (Terna, 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 2005, 96% of the total amount of waste incinerated is treated in plants with energy recovery system.
In the previous submission 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 1990-2004 and every subsector. The following table shows the percentage differences between the 2007 and 2006 submissions for the total energy sector and by gas.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
								%							
Energy	***-0.01***	***-0.01***	***-0.01***	***-0.01***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***-0.01***	***0.03***	***0.22***
CO2	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.04	0.22
CH4	0.00	0.00	-0.02	0.00	-0.01	0.06	-0.04	-0.20	-0.07	-0.12	-0.13	-0.01	-0.10	-0.18	-0.05
N2O	-0.02	-0.02	-0.02	-0.02	-0.01	-0.18	-0.12	-0.14	0.03	0.05	0.05	-0.02	-0.25	0.10	0.38

Table 3.1 Emission recalculations in the energy sector 1990-2004 (%)

Recalculations for the years 1990-1994 are due to a revision in the distribution between the energy and waste sectors of emissions from the waste incineration facilities, on the basis of the updated information on the facilities with the energy recovery in 1990. Recalculations in 2004 are due to the update of the 2004 National Energy Balance, especially regarding natural gas and coal fuel consumptions. Other minor recalculation regards CH_4 and N_2O emissions from 1995 to 2004 due to an update of biomass fuel consumption to avoid double counting.
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 (Terna), 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 Terna for the years from 2000 to 2005. The detailed list is confidential and only the

output of the simulation model used to calculate emissions for the years 2004 and 2005 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	2005
national coal	58	-	96	Solids	Solids	Solids	Solids	Solids	Solids
imported coal	10,724	8,216	8,378	9,633	11,445	13,088	14,252	17,031	16,253
lignite	1,501	380	62						
Natural gas, m^3	9,731	11,277	19,766	22,334	21,930	22,362	25,534	28,768	30,544
BOF(steel conve	509	633	536	Coal	Coal	Coal	Coal	Coal	Coal
Blast furnace ga	6,804	6,428	8,611	gases	gases	gases	gases	gases	gases
Coke gas, m^3	693	540	660	8,690	9,785	10,034	10,479	10,640	12,104
Light distillate	5	6	12	oil	oil	oil	oil	oil	oil
Diesel oil	303	184	560	products	products	products	products	products	products
Heavy fuel oil	21,798	25,355	17,511	19,352	17,186	17,694	14,993	10,522	7,941
Refinery gas	211	378	409						
Petroleum coke	186	189	216						
Orimulsion	-	-	1,688						
Gases from cher	444	803	1,155	Others	Others	Others	Others	Others	Others
Tar	2	-	-			m^3=769	m^3=857	m^3=955	m^3=978
Heat recovered f	146	3	-			kt=10,686	kt=12,588	kt=15,031	kt=15,460
Other fuels	344	697	1,819	5,153	9,175				

Source: Terna, 2006

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

Both BEN and Terna 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 Terna data arises from the following reasons:

- BEN data are prepared on the basis of Terna reports to IEA, so both data sets come from the same source;
- Before being published in the BEN, Terna 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 Terna 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 Terna 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/Terna data are detailed by primary fuel for the last two years: 2004 and 2005. For previous years see NIR 2006.
The other two statistical publications quoted before, UP (UP, several years) and ENI (ENI, several years), have direct access to fuel consumption data from the associated companies, but both rely on Terna 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.
In response to the review process of the Initial report of the Kyoto Protocol and of the 2006 submission under the Convention, N_2O and CH_4 stationary combustion emission factors have been revised for the whole time series, both for the 2006 and 2007 submission, taking in account default IPCC (IPCC, 1997; IPCC, 2000) and CORINAIR emission factors (EMEP/CORINAIR, 2005).
The energy data used for the years 2004 and 2005 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, in the 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 2005. 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	308,381	6,489	23,778
Solid fuels	425,016	10,810	39,610
Natural gas	1,001,567	15,427	56,527
Refinery gases	19,894	599	2,194
Coal gases	10,187	131	478
Biomass	42,502	1,774	6,499
Other fuels (incl.waste)	41,998	582	2,131
Total	**1,849,545**	**34,038**	**124,718**
Industrial producers (Table 1.A.1, a-b-c) and auto-producers, to table "1.A.2 Manufacturing Industries "			
Liquid fuels	3,027	71	262
Solid fuels	4	0	0
Natural gas	56,819	875	3,207
Refinery gases	3,531	106	389
Other refinery products	65,886	1,442	5,283
Coal gases	43,181	3,417	12,519
Biomass			
Other fuels (incl.waste)	478	12	45
Total	**172,925**	**5,924**	**21,705**
General total	**2,022,469**	**39,962**	**146,423**

Table 3.3 Power sector, Energy/CO_2 emissions in CRF format, year 2005

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	2005
Total electricity produced (gross)	216.9	241.5	276.6	279.0	284.4	293.9	303.3	303.7
Total CO_2 emitted, Mt	128.5	135.7	140.5	138.3	145.4	148.1	146.0	146.4
g CO_2 / kwh of gross thermo-electric production	720	693	645	640	641	624	609	596
g CO_2 / kwh of total gross production	592	562	508	496	511	504	481	482

Table 3.4 Time series of CO_2 emissions from electricity production

3.4.2 Refineries

The consumption data used come from BEN (MSE, 2006 [a]), the same data are also reported by UP (UP, several years).
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 2005 is reported, with energy and emission data. In Table 3.6 GHG emissions in the years 1990, 1995, 2000-2005 are reported.

	Consumption, TJ			CO_2 emissions, kt		
REFINERIES	Petroleum coke	Ref. gas	Liquid fuels	Petroleum coke	Ref. gas	Liquid fuels
			24100			1748
	40978	118491	92137	4088	7356	6978
TOTAL			275706			20170

Table 3.5 Refineries, CO_2 emission calculation, year 2005

	1990	1995	2000	2001	2002	2003	2004	2005
CO_2 emissions, Mt	18.3	18.8	17.6	19.8	18.8	18.7	18.6	20.2
CH_4 emissions, kt	0.88	0.72	0.63	0.76	0.74	0.73	0.73	0.79
N_2O emissions, kt	0.99	1.03	0.73	0.84	0.78	0.73	0.77	0.85
Refinery, total, Mt C	18.7	19.2	17.9	20.1	19.1	18.9	18.9	20.5

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) 2005 average	56.438	2.02 (sm^3)	2.325
Solid fuels			
Steam coal, 2005 average	93.196	2.423	3.899
"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 , 2005 average	76.700	3.163	3.209
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, 2000-05	71.145	3.109	2.977
Gas oil, 1990-99	73.274	3.127	3.066
Gas oil, engines, test data, 2000-05	73.153	3.138	3.061
Gas oil, heating, test data, 2000-05	73.693	1.410	3.083
LPG, 1990-99, IPCC	62.392	2.872	2.610
LPG, test data, 2000-05	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	2005
CO_2 emissions, kt	80,658	76,419	81,116	78,472	75,659	78,618	79,398	76,328
CH_4 emissions, t	14,936	14,730	14,342	14,217	13,710	13,954	14,508	14,188
N_2O emissions, t	3,325	2,678	3,264	3,204	3,147	3,323	3,321	3,196
Industry, total, kt CC	82,002	77,559	82,429	79,764	76,962	79,941	80,733	77,617

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	2005
CO_2 stationary combustion liquid fuels	kt	155,077	105,797
CO_2 stationary combustion solid fuels	kt	59,395	65,092
CO_2 stationary combustion gaseous fuels	kt	85,065	163,917
CH_4 stationary combustion	t	645	796
N_2O stationary combustion	t	3,434	3,893

Table 3.9 Stationary combustion, GHG emissions in 1990 and 2005

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	2005
CO_2	Mt	101.5	112.0	120.5	122.8	124.9	126.2	128.4	126.9
CH_4	Mt	0.77	0.95	0.84	0.72	0.65	0.62	0.66	0.61
N_2O	Mt	1.72	2.17	3.20	3.34	3.67	3.79	4.00	4.01
Total, Mt CO_2 eq.	Mt	104.0	115.1	124.5	126.8	129.2	130.6	133.0	131.5

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 (MSE, 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, several years) and the Italian civil aviation in the national aviation statistics yearbooks (ENAC/MINT, 2006);

(iii) Total consumption for military aviation is given in the petrochemical bulletin (MSE, 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 2005 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	2005
Domestic flights	186,446	199,585	319,963	303,354	315,010	325,179	313,171	311,218
International flights	139,733	184,233	303,747	315,736	293,365	325,755	343,052	363,140

Source: ISTAT, several years; ENAC/MINT, 2006

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	1.58	647.6
International LTO	kg/LTO	0.354	0.3	10.84	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	15.04	1.241	0.546	-
Aircraft Military [a]	kg/t fuel	0.4	0.2	15.8	126	3.6	-

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	2005
						kt						
Domestic LTO	132	135	151	163	177	205	218	208	216	226	217	216
International LTO	123	162	181	196	213	236	267	277	258	286	301	319
Domestic cruise	387	414	464	502	546	629	664	630	654	675	650	646
International cruise	1,215	1,662	1,773	1,797	1,952	2,140	2,279	2,015	2,003	2,330	2,320	2,457

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	2005
CO_2	kt	1,597	1,691	1,894	2,047	2,228	2,570	2,716	2,580	2,677	2,772	2,668	2,652
CH_4	t	50	53	60	65	70	81	85	81	79	87	83	83
N_2O	t	37	40	45	48	53	61	64	61	60	65	63	62

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 (MSE, 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 (MSE, 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, 2000-05[b]	71.145	3.109
Gas oil, 1990-'99, IPCC OECD[a]	73.274	3.127
Gas oil, engines, test data, 2000-05[b]	73.153	3.137
LPG, 1990-'99, IPCC[a]	62.392	2.872
LPG, test data, 2000-05[b]	64.936	2.994
Natural gas (dry) 2005	56.438	-
Fuel oil , 2005 average	76.700	-

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	3,218,872	55,933,296
070101	PC Hway	gasoline	2,648,648	47,984,939
070101	PC Hway	lpg	318,159	5,229,115
070102	PC rur	diesel	4,532,273	94,929,416
070102	PC rur	gasoline	3,751,296	86,883,345
070102	PC rur	lpg	313,852	6,972,153
070103	PC urb	diesel	1,975,142	24,703,092
070103	PC urb	gasoline	5,239,344	58,139,868
070103	PC urb	lpg	397,401	5,229,115
070201	LDV Hway	diesel	1,103,526	10,520,805
070201	LDV Hway	gasoline	49,880	738,136
070202	LDV rur	diesel	1,764,794	28,932,212
070202	LDV rur	gasoline	137,295	2,029,875
070203	LDV urb	diesel	1,453,769	13,151,006
070203	LDV urb	gasoline	145,943	922,670
070301	HDV Hway	diesel	4,737,814	20,417,944
070301	HDV Hway	gasoline	971	5,883
070302	HDV rur	diesel	2,714,047	13,922,366
070302	HDV rur	gasoline	2,647	17,649
070303	HDV urb	diesel	1,502,004	4,789,133
070303	HDV urb	gasoline	1,324	5,883
070400	mopeds	gasoline	510,945	16,170,647
070501	Moto Hway	gasoline	47,796	1,372,208
070502	Moto rur	gasoline	260,420	9,605,456
070503	Moto urb	gasoline	494,223	16,466,495
Total				525,072,706

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 2005

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	2005
CO_2	kt	93,616	104,153	110,311	113,019	115,119	116,351	118,389	117,042
CH_4	kt	743	915	805	680	616	584	622	571
N_2O	kt	1,605	2,062	3,072	3,217	3,546	3,674	3,877	3,891

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, several years). 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, several years).
In the following Tables 3.20, 3.21 and 3.22 detailed data on the relevant vehicles in the circulating fleet between 1990 and 2005 are reported, subdivided according to the main emission regulations that applied when the vehicle was sold.

	1990	**1995**	**2000**	**2005**
Older than 20 years, PRE ECE	0.005	0.007		
1972 -1977, ECE 15.00/.01	0.142	0.017	0.009	
1978 -1986, ECE 15.02/.03	0.277	0.178	0.039	0.009
1987 -1989, ECE 15.04	0.159	0.103	0.061	0.018

	1990	1995	2000	2005
1990 - 1992, ECE 15.04	0.417	0.388	0.264	0.137
91/441/EC, from 1/1/93, euro 1	0.000	0.308	0.218	0.158
94/12/ EC, from 1-1-97 , euro 2		0.000	0.410	0.280
98/69/EC, from 1/1/2001, euro 3 / 4				0.397
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	2005
Older than 15 years, PRE ECE	0.006			
1972 -1977, ECE 15.00/.01	0.008	0.009		
1978 -1985, ECE 15.02/.03	0.248	0.103	0.009	0.006
1985-1989, ECE 15.04	0.359	0.285	0.053	0.006
1990 - 1992, ECE 15.04	0.378	0.390	0.109	0.026
91/441/EC, from 1/1/93, euro 1	0.000	0.213	0.127	0.041
94/12/ EC, from 1-1-97 , euro 2			0.702	0.200
98/69/EC, from 1/1/2001, euro 3/4				0.720
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	2005
pre -1985	0.60	0.32	0.18	0.06
1985-1989, Dir 88/77/EWG	0.29	0.26	0.17	0.06
1990 - 1992	0.11	0.21	0.14	0.06
1/gen/93 - 31/dic/95		0.10	0.07	0.05
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	0.27
from 1/1/2001, Dir. 99/96, euro III				0.38
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, several years) 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	2005
All passenger vehicles, total mileage (10^9 veh-km/y)	339	394	426	450	454	447
Car fleet (10^6)	27.7	31	32.9	34.3	34.9	35
Goods transport, total mileage (10^9 veh-km/y)	60.6	61	62.4	71.4	75.5	76.2
Truck fleet (10^6), including LDV	3	3.3	3.7	4.4	4.5	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 (MSE, 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	2005
Estimates of fuels used for domestic travels	778	706	802	843	888	859	875	871	851	867	882	868
Estimate of fuel in harbours (dom+int ships)	748	693	794	824	868	844	864	860	841	856	871	857
Estimate of fuel in international Bunkers	1,398	1,286	911	975	982	982	1,224	1,389	1,591	1,784	1,910	1,977
CO_2 Mobile combustion: Waterborne Navigation	5,401	5,095	5,726	5,936	6,219	6,072	6,201	6,194	6,064	6,162	6,229	6,143

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 (MSE, 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 1990-2005 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 (MSE, 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 2005 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	11325.4	3788.9	2792.2	4744.3
% of total input		33.45%	24.65%	41.89%
% of net input			37.05%	62.95%

Table 3.25 Other non energy uses, year 2005

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	591	576	281	-266			0.8137
Refinery gas	226	119	902	-795			0.8549
Virgin naphtha	5,662	0	0	5,662			0.8703
Gasoline	1,071	2,068	0	-997			0.8467
Kerosene	883	590	0	293			0.8485
Gas oil	1,085	164	0	922			0.8569
Fuel oil	611	201	452	-42			0.8678
Petroleum coke	0	0	0	0			0.955
Others (feedstock)	151	71	112	-31			0.8368
Losses			0	0			0.8368
Natural gas	1,045	0	1,046	-1			0.747
total	11,325	3,789	2,792	4,744	42%	63%	

Table 3.26 Petrochemical, detailed data from MSE, year 2005 (MSE, 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	3,598	40.19	0.8841	144.6
lubricants	1,286	40.19	0.8038	51.7
recovered lubricant oils	0	40.19	0.8038	0.0
paraffin	64	40.19	0.8368	2.6
others (benzene, others)	837	40.19	0.8368	33.6
Totals	5,785			232.5

Table 3.27 Other non energy uses, year 2005, MSE 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 1.6% out of the total emissions in the energy sector. Both CH_4 and CO_2 emissions show a reduction from 1990 to 2005 by 23% and 37%, respectively.
The decrease of CO_2 fugitive emissions is driven by the reduction in crude oil losses in refineries. Emissions are balanced with the amount of crude oil losses reported in the national Energy Balance (MSE, 2006 [a]). 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	2005
CO_2																
Oil and natural gas	3,341	3,265	3,212	3,380	3,226	3,174	3,035	3,243	3,119	2,404	2,585	2,440	2,261	2,834	2,152	2,112
CH_4																
Solid fuels	122	112	112	82	71	65	60	60	55	53	73	81	78	95	64	69
Oil and natural gas	7,273	7,233	7,273	7,193	7,020	6,779	6,668	6,631	6,717	6,516	6,361	6,034	5,860	5,761	5,630	5,644
N_2O																
Oil and natural gas	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 3.28 Fugitive emissions from oil and gas 1990-2005 (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 (L2,T)

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, both Tier 1 and Tier 2 approaches, and level assessment with Tier 2. The uncertainty in methane, N_2O 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 (MSE, 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 and emissions from the production of oil and natural gas. These last one have been estimated from the 2006 submission because of new information available reported by operators on their environmental reports. Emissions in refineries have been estimated on the basis of activity data published in the National Energy Balance (MSE, 2006 [a]) or supplied by industry (UP, several years) and operators especially in the framework of the European emissions trading scheme. Emissions occurring in production of oil and gas have been calculated on the basis of activity data published in the National Energy Balance (MSE, 2006 [a]), data published by industry (UP, several years) and data supplied by operators and emission factors published on the IPCC Good Practice Guidance (IPCC, 2000).

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 (MSE, 2006 [a]) and by industry (UP, several years), 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, 2007), length of pipelines distinct by low, medium and high pressure and by type, iron, grey iron, steel or polyethylene pipelines (AEEG, 2006), natural gas losses reported in the national energy balance (MSE, 2006 [a]) and methane emissions reported by operators in their environmental reports (ENI, 2007; EDISON, several years); 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, 2007; Riva, 1997). More detailed on the methodology used and on the basic information collected from operators are reported in a technical paper (Contaldi, 1999).

In response to the review process of the Initial Report under the Kyoto Protocol and of the 2006 submission under the Convention, N_2O emissions from flaring in oil and gas production have been estimated on the basis of activity production data and emission factors reported in the IPCC GPG (IPCC, 2000). They amount for the whole time series at less than 1 kilotons of CO_2 equivalent.

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.
CO_2 and CH_4 fugitive emissions from oil exploration are included in those from production because no detailed information is available. N_2O emissions from flaring in oil exploration and in refining activities are reported under oil flaring. Emissions from transport and distribution of oil result as not occurring. CO_2 and CH_4 emissions from gas exploration are also included in those from production while CH_4 emissions from other leakage are included in distribution emission estimates. Further investigation will be carried out with industry about these figures.
CO_2 and 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.
CO_2 and CH_4 emissions from gas flaring are also included in production under 1.B.2.b.
A summary of the completeness of CO_2, CH_4 and N_2O fugitive emissions is shown in the following Table 3.29.

1.B. 2.a. Oil		
i. Exploration	CO_2,CH_4	Included in 1.B.2.a production
i. Exploration	N_2O	Included in 1.B.2.c oil flaring
iv. Refining	N_2O	Included in 1.B.2.c oil flaring
1.B.2.b. Natural Gas		
i. Exploration	CO_2,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	CO_2,CH_4	Included in 1.B.2.a production
ii. Gas	CO_2,CH_4	Included in 1.B.2.b production

Table 3.29 Completeness of CO_2 CH_4 and N_2O 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 2005 industrial processes account for 5.4% of CO_2 emissions, 0.2% of CH_4, 19.2% of N_2O, 100% of PFCs, HFCs and SF_6. In term of CO_2 equivalent, industrial processes share 7 % 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 2005, while CO_2 emissions from chemical and metal industry reduced sharply.

GAS/SUBSOURCE	1990	1995	2000	2001	2002	2003	2004	2005
CO_2 (Gg)								
2A. Mineral Products	21,100	20,768	21,266	22,096	22,089	22,986	23,832	23,908
2B. Chemical Industry	2,186	1,223	1,062	1,034	1,082	1,243	1,328	1,317
2C. Metal Production	3,983	3,483	1,826	1,776	1,612	1,551	1,611	1,654
CH_4 (Gg)								
2B. Chemical Industry	2.45	2.65	0.40	0.33	0.33	0.31	0.33	0.33
2C. Metal Production	2.71	2.71	2.61	2.50	2.38	2.45	2.57	2.72
N_2O (Gg)								
2B. Chemical Industry	21.54	23.35	25.54	26.55	25.49	24.38	27.24	25.03
HFCs (Gg CO_2 eq.)	351	671	1,986	2,550	3,100	3,796	4,515	5,267
PFCs (Gg CO_2 eq.)	1,808	491	346	451	424	498	350	361
SF_6 (Gg CO_2 eq.)	333	601	493	795	738	465	492	460

Table 4.1 Trend in greenhouse gas emissions from the industrial process sector, 1990-2005 (Gg)

Six 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)
2C	CO_2	Emissions from iron and steel production	Key (T1)
2B	CO_2	Emissions from ammonia production	Key (T1)
2C	PFC	Emissions from aluminium production	Key (T1)

CO_2 emissions from cement 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. 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 3.6% of the total national emissions.
CO_2 emissions also occur from processes where lime is produced and account for 0.54% of the total national emissions, while CO_2 emissions due to the limestone and dolomite use account for 0.52% of the total national emissions.
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 sector.
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 from this sector (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, 2006) 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 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 and checked with the industrial association (CAGEMA, 2005). Specifically, in 2005 the implied emission factor is equal to 798 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; ANDIL, several years; ASSOPIASTRELLE, 2004; ASSOPIASTRELLE, several years) and they have been supplied in the framework of the European emissions 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 emissions 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. Uncertainty level for activity data is an expert judgement, taking in account the basic source of information, while the uncertainty level for emission factors is equal to the maximum level reported in the IPCC Good Practice Guidance (IPCC, 2000) for the cement production.
In Tables 4.2 and 4.3, the production of mineral products and CO_2 emission trend is reported.

ACTIVITY DATA	**1990**	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Cement production (decarbonizing)	29,786	28,778	29,816	30,893	30,770	32,077	33,049	33,122
Glass (decarbonizing)	3,779	4,259	4,930	5,014	4,811	5,141	5,178	5,150
Lime (decarbonizing)	2,583	2,873	2,760	2,958	2,951	3,174	3,357	3,349
Limestone and dolomite use	5,397	4,907	4,843	5,014	5,240	5,359	5,714	5,792
Soda ash production and use	610	1,070	1,000	1,000	918	847	870	915

Table 4.2 Production of mineral products, 1990 – 2005 (kt)

CO_2 EMISSIONS	**1990**	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Cement production (decarbonizing)	16,084	15,540	16,101	16,682	16,616	17,322	17,846	17,886
Glass (decarbonizing)	416	468	549	549	521	524	528	525
Lime (decarbonizing)	2,042	2,279	2,185	2,358	2,365	2,540	2,686	2,674
Limestone and dolomite use	2,375	2,159	2,131	2,206	2,306	2,358	2,514	2,548
Soda ash production and use	183	321	300	300	281	242	258	275

Table 4.3 CO_2 emissions from mineral products, 1990 – 2005 (Gg)

Emission trends are related to the production, which are in particular increasing for cement, 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

No recalculations have been done.

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, several years). Specifically, for N_2O, adipic acid is a key source at level assessment, both with the Tier 1 and Tier 2 approach. These emissions account for 15.0% of total N_2O emissions in 2005. CO_2 emissions from this source are also estimated.
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.
N_2O emissions from caprolactame production are released by 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 emissions are not relevant.

4.3.2. Methodological issues

Italian production figures and emission estimates for adipic acid have been provided by the process operator (Radici Chimica, several years) 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, from 1990 to 2003. 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. From the end of 2005 the abatement technology is fully operative; the average emission factor in 2005 is equal to 0.26 kg N_2O/kg adipic acid produced.
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 factor, equal to 1.175 t CO_2/t ammonia production, has 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 2002-2005 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), 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, several years). The N_2O average emission factors are calculated 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 2005 respectively.
N_2O emissions from caprolactame have been estimated on the basis of 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 and CH_4 emissions from carbon black production process have been estimated on the basis of information supplied by the Italian production plants in the framework of the EPER registry and the European emissions trading scheme. In 1996 the existing plants changed the production technology; it caused a reduction of CH_4, NMVOC, NO_x, SO_x and PM_{10} emissions. In 2005, the CO_2 implied emission factor is equal to 2.55 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 by 10.4%, for each activity, as combination of uncertainties equal to 3% and 10% for activity data and emission factors, respectively.
In Tables 4.4 and 4.5, the production of chemical industry, including non-key sources, and CO_2, CH_4 and N_2O emission trends are reported.
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.

ACTIVITY DATA	1990	1995	2000	2001	2002	2003	2004	2005
Adipic acid	49	64	71	75	74	69	78	75
Ammonia	1,455	592	414	430	474	578	648	607
Caprolactame	120	120	111	91	78	7	-	-
Carbon black	184	208	221	208	209	210	219	214
Ethylene	1,466	1,807	1,771	1,662	1,687	1,530	1,698	1,721
Ethylene oxide	61	54	13	5	-	-	-	-
Nitric acid	1,037	588	556	527	542	539	616	572
Propylene	774	693	690	653	1,035	931	996	1,037
Styrene	365	484	613	563	487	545	542	520
Titanium dioxide	58	69	72	60	69	66	70	60

Table 4.4 Production of chemical industry, 1990 – 2005 (kt)

EMISSIONS	1990	1995	2000	2001	2002	2003	2004	2005
CO_2 (Gg)								
Ammonia	1,709.63	695.60	486.19	505.46	557.53	679.57	747.55	705.18
Carbon black	422.05	477.48	508.83	479.30	460.43	489.89	506.62	548.22
Titanium dioxide	52.80	48.11	64.70	47.00	61.60	72.00	72.00	62.01
Adipic acid	1.33	1.72	1.93	2.03	2.00	1.86	1.56	1.50
CH_4 (Gg)								
Carbon black	1.84	2.08	0.11	0.10	0.10	0.10	0.10	0.10
Ethylene	0.12	0.15	0.15	0.14	0.14	0.13	0.14	0.15
Propylene	0.07	0.06	0.06	0.06	0.09	0.08	0.08	0.09
Styrene	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ethylene oxide	0.42	0.37	0.09	0.03	-	-	-	-
N_2O (Gg)								
Nitric acid	6.73	4.22	4.09	3.94	3.27	3.67	5.82	5.44
Adipic acid	14.77	19.09	21.42	22.59	22.20	20.70	21.41	19.59
Caprolactame	0.04	0.04	0.03	0.03	0.02	-	-	-

Table 4.5 CO_2, CH_4 and N_2O emissions from chemical industry, 1990 – 2005 (Gg)

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

No recalculations have been done.

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. CH_4 emissions from coke production are fugitive emissions during solid fuel transformation and have been reported under 1B1b.
The share of CO_2 emissions from metal production accounts, in the year 2005, for 0.34% of the national total CO_2 emissions, and 6.15% of the total CO_2 from industrial processes.

The share of CH_4 emissions is, in the year 2005, equal to 0.14% 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 nearly 3% (0.03% of the national total greenhouse gas emissions) in the year 2005.

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 and the European emissions trading scheme, and supplied by industry (FEDERACCIAI, several years) 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 2005 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 emissions 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 0.021 t CO_2/t steel production, from 1990 to 2005, 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; in Annex 3, the energy and carbon balance in the iron and steel sector, with detailed explanation, is reported.
CH_4 emissions from steel production 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 national statistics (ENIRISORSE, several years; ASSOMET, several years) and 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. 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 provided by industrial association (ENIRISORSE, several years; ASSOMET, 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, several years). 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, CH_4 and F-gas from metal 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.
In Table 4.11 the emission trend of F-gases per compound from metal production is given.

EMISSIONS	1990	1995	2000	2001	2002	2003	2004	2005
CO_2 (Gg)								
Iron and steel	3,124	2,898	1,225	1,239	1,187	1,125	1,179	1,221
Aluminium production	359	276	294	291	295	297	303	303
Ferroalloys	499	310	307	247	129	129	129	129
CH_4 (Gg)								
Pig iron	2.13	2.10	2.02	1.89	1.75	1.82	1.90	2.05
Steel	0.58	0.60	0.59	0.61	0.62	0.63	0.67	0.67
PFC (Gg CO_2 eq.)								
Aluminium production	1,673	298	199	234	199	268	157	181
SF_6 (Gg)								
Magnesium foundries	-	-	0.0072	0.0188	0.0167	0.0057	0.0039	0.0035

Table 4.10 CO_2, CH_4 and F-gas emissions from metal production, 1990 – 2005 (Gg)

COMPOUND	1990	1995	2000	2001	2002	2003	2004	2005
				Gg CO_2 eq.				
CF_4 (PFC-14)	1,289.2	235.8	168.1	198.1	168.1	226.4	133.1	153.0
C_2F_6 (PFC-16)	384.1	61.7	30.6	36.0	30.6	41.2	24.2	27.8
Total PFC emissions from aluminium production	*1,673.4*	*297.5*	*198.7*	*234.1*	*198.6*	*267.6*	*157.3*	*180.8*
Total SF_6 emissions from magnesium foundries	0.0	0.0	172.1	449.9	400.1	135.2	94.3	84.7
Total F-gas emissions from metal production	1,673.4	297.5	370.8	684.0	598.7	402.8	251.5	265.5

Table 4.11 Actual F-gas emissions per compound from metal production in Gg CO_2 equivalent, 1990 – 2005

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). 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; from 2004 C_2F_6 values calculated with Tier 1 rise up.

COMPOUND	1990	1991	1992	1995	1996	1997	2000	2001	2002	2003	2004	2005
Tier 1												
CF_4 (t)	198.3	155.0	85.7	36.3	18.4	18.8	19.0	18.8	19.0	19.1	19.5	19.6
C_2F_6 (t)	41.8	33.7	17.2	6.7	3.1	3.2	3.2	3.2	3.2	3.3	3.3	3.3
Tier 1 and Tier 2												

COMPOUND	1990	1991	1992	1995	1996	1997	2000	2001	2002	2003	2004	2005
CF_4 (t)	198.3	155.0	85.7	36.3	18.4	18.8	25.9	30.5	25.9	34.8	20.5	23.5
C_2F_6 (t)	41.8	33.7	17.2	6.7	3.1	3.2	3.3	3.9	3.3	4.5	2.6	3.0

Table 4.12 Comparison between PFC emissions from aluminium production in tonnes, calculated with only the Tier 1 methodology and with both the Tier 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. In this framework, primary aluminium production supplied by national statistics (ENIRISORSE, several years; ASSOMET, several years,) and the only national producer ALCOA (ALCOA, several years), in addition with data reported in a site-specific study (Sotacarbo, 2004) have been checked, in order to avoid the use of different time series. Moreover, emissions from magnesium foundries have been checked with those reported in EPER registry.

4.4.5. Source-specific recalculations

No recalculations have been done.

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, “By-product emissions” and “Fugitive emissions”, identified as non-key sources. Within by-product emissions, HFC-23

emissions are released from HCFC-22 manufacture, as well as C_2F_6, CF_4 and HFC 143a are released from the production of CFC 115, SF_6 and HFC 134a, respectively.
The share of F-gas emissions 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 2005; the share in the national total greenhouse gas emissions was 0.12% in the base-year and 0.003% in 2005.

4.6.2. Methodological issues

For source category ”By-product emissions”, the IPCC Tier 2 method is used, based on plant-level data communicated by the national producer (Solvay, several years).
Also for source category “Fugitive emissions”, emission estimates are based on plant-level data communicated by the national producer (Solvay, several years).

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 4.13 an overview of the emissions from production of halocarbons and SF_6 is given for the 1990-2005 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-125 and HFC-134a have been cut in 1999 thanks to a rationalisation in the new production facility located in Porto Marghera, whereas HFC-143 released as by-products from the production of HFC-134a has been recovered and commercialised.

COMPOUND	**1990**	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
				Gg CO_2 eq.				
HFC 23	351.0	351.0	0.0	0.0	0.0	0.0	0.0	0.0
HFC 143a	0.0	22.8	3.8	3.8	0.0	3.8	3.8	4.2
CF_4	97.5	97.5	0.0	0.0	0.0	0.0	0.0	0.0
PFC C2÷C3	36.8	36.8	0.0	0.0	0.0	0.0	0.0	0.0
Total F-gas by product emissions	*485.3*	*508.1*	*3.8*	*3.8*	*0.0*	*3.8*	*3.8*	*4.2*
HFC 125	0.0	28.0	2.8	5.6	5.6	11.2	2.8	3.4
HFC 134a	0.0	39.0	15.6	15.6	15.6	7.8	11.7	12.6
HFC 227ea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SF_6	119.5	119.5	0.0	0.0	0.0	0.0	0.0	0.0
Total F-gas fugitive emissions	*119.5*	*186.5*	*18.4*	*21.2*	*21.2*	*19.0*	*14.5*	*16.0*
Total F-gas emissions from production of halocarbons and SF_6	604.8	694.6	22.2	25.0	21.2	22.8	18.3	20.2

Table 4.13 Actual emissions of F-gases per compound from production of halocarbons and SF_6 in Gg CO_2 equivalent, 1990 – 2005

4.6.4. Source-specific QA/QC and verification

This source category is covered by the general QA/QC procedures. Where information is available, emissions from production of halocarbons and SF_6 have been checked with data reported to the national EPER registry.

4.6.5. Source-specific recalculations

More specific information has been supplied by Solvay Solexis in order to better define emissions that are released as by-product or as fugitive emissions. As a consequence, data have been reallocated between “By-product emissions” and “Fugitive emissions”.

4.6.6. Source-specific planned improvements

No further improvements are planned.

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. Potential emissions are also reported in this section. The share of F-gas emissions from the consumption of halocarbons and SF_6 in the national total of F-gases was 8.6% in the base-year 1990 and 95.3% in 2005; the share in the national total greenhouse gas emissions was 0.04% in the base-year and 1% in 2005.

4.7.2. Methodological issues

The methods used to calculate F-gas emissions 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 mobile air conditioning equipment the national motor company and the agent’s union of foreign motor-cars vehicles have provided the yearly consumptions (FIAT, several years; IVECO, several years; UNRAE, several years; CNH, several years); pharmaceutical industry has provided aerosols/metered dose inhaler data (Sanofi Aventis, several years; Boehringer Ingelheim, several years; Chiesi Farmaceutici, several years; GSK, several years; Lusofarmaco, several years; Menarini, several years); the semiconductor manufacturing industry has supplied consumption data for four national plants (ST Microelectronics, several years; MICRON, several years); 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, several years). Additional data on SF_6 used in high voltage gas-insulated transmission lines have been supplied by the main energy distribution companies (ACEA, 2004; AEM, several years; EDISON, 2006; ENDESA, 2004; ENDESA, several years [a] and [b]; ENEL, several years).
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, several years; ST Microelectronics, several years; MICRON, several years). As regard PFC potential emissions, since no production occurs in Italy, export has been reasonably assumed negligible, whereas import correspond to consumption of PFCs by semiconductor manufactures, that use these substances.

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 4.14 an overview of the emissions from consumption of halocarbons and SF_6 is given for the 1990-2005 period, per compound. In Table 4.15 an overview of the potential emissions is given for the 1990-2005 period, per compound.

COMPOUND	**1990**	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
				Gg CO_2 eq.				
HFC 23	0.00	1.58	7.09	8.60	10.29	12.16	14.26	16.96
HFC 32	0.00	0.00	52.64	80.86	113.66	150.60	191.26	235.27
HFC 125	0.00	1.85	371.52	564.85	791.25	1,048.04	1,332.75	1,643.17
HFC 134a	0.00	224.33	1,128.57	1,302.26	1,448.76	1,591.21	1,735.51	1,888.80
HFC 143a	0.00	2.74	206.29	308.60	430.22	570.18	727.55	901.48
Total HFC emissions from refrigeration and air conditioning equipment	*0.00*	*230.49*	*1,766.11*	*2,265.17*	*2,794.17*	*3,372.19*	*4,001.34*	*4,685.68*
HFC 134a emissions from foam blowing	0.00	0.00	64.18	88.01	118.80	158.62	210.20	234.09
HFC 227ea emissions from fire extinguishers	0.00	0.00	19.64	26.51	35.82	47.44	61.26	79.95
HFC 134a emissions from aerosols/metered dose inhalers	0.00	0.00	108.37	137.62	123.71	186.21	215.21	240.16
Total HFC emissions from ODS substitutes	*0.00*	*0.00*	*192.18*	*252.15*	*278.33*	*392.27*	*486.67*	*554.20*
HFC 23	0.00	0.00	5.12	7.42	6.19	8.57	8.83	7.19
HFC 134a	0.00	0.00	0.05	0.01	0.00	0.00	0.00	0.00
CF_4	0.00	24.43	64.81	107.81	106.17	117.11	111.67	84.89
C_2F_6	0.00	34.57	81.98	99.12	108.01	97.68	68.00	81.22
C_3F_8	0.00	0.00	0.00	8.98	10.16	13.18	11.74	4.29
C_4F_8	0.00	0.00	0.37	1.20	0.77	2.04	1.33	10.02
SF_6	0.00	0.00	20.91	49.40	53.30	60.46	69.88	57.16
Total PFC, HFC, SF_6 *emissions from semiconductor manufacturing*	*0.00*	*59.00*	*173.25*	*273.93*	*284.59*	*299.04*	*271.44*	*244.77*
SF_6 emissions from electrical equipment	*213.42*	*481.95*	*300.44*	*295.66*	*284.27*	*269.02*	*327.43*	*318.31*

COMPOUND	1990	1995	2000	2001	2002	2003	2004	2005
Total F-gas emissions from consumption of halocarbons and SF_6	213.42	771.45	2,431.99	3,086.91	3,641.37	4,332.52	5,086.88	5,802.95

Table 4.14 Actual F-gas emissions per compound from the consumption of halocarbons and SF_6 in Gg CO_2 equivalent, 1990-2005

COMPOUND	1990	1995	2000	2001	2002	2003	2004	2005
				Gg CO_2 eq.				
HFC 32	0.00	0.00	10.40	3.25	-5.20	29.25	70.20	31.85
HFC 125	0.00	148.40	268.80	1,671.60	803.60	-123.20	2,200.80	1,131.20
HFC 134a	0.00	1,739.40	2,107.30	4,371.90	2,960.10	4,551.30	4,308.20	5,575.70
HFC 143a	0.00	11.40	68.40	258.40	79.80	547.20	972.80	801.80
HFC 227ea	0.00	0.00	72.50	133.40	89.90	0.00	0.00	0.00
Total HFC potential emissions	*0.00*	*1,899.20*	*2,527.40*	*6,438.55*	*3,928.20*	*5,004.55*	*7,552.00*	*7,540.55*
CF_4	0.00	0.00	55.77	158.57	167.43	183.92	186.08	148.86
C_2F_6	0.00	0.00	65.50	147.94	164.54	133.97	114.71	111.45
C_3F_8	0.00	0.00	0.00	33.89	36.85	46.99	40.26	17.92
C_4F_8	0.00	0.00	0.52	4.64	2.61	6.09	5.44	28.96
Total PFC potential emissions	*0.00*	*0.00*	*121.80*	*345.03*	*371.43*	*370.98*	*346.49*	*307.19*
SF_6	*3,752.30*	*3,675.82*	*3,919.60*	*5,903.30*	*3,689.20*	*3,211.20*	*2,943.24*	*1,541.84*
Total F-gas potential emissions	3,752.30	5,575.02	6,568.80	12,686.88	7,988.83	8,586.73	10,841.73	9,389.58

Table 4.15 Potential F-gas emissions per compound from the consumption of halocarbons and SF_6, in Gg CO_2 equivalent, 1990 – 2005

4.7.4. Source-specific QA/QC and verification

This source category is covered by the general QA/QC procedures. Where information is available, emissions from production of halocarbons and SF_6 have been checked with data reported to the national EPER registry.

4.7.5. Source-specific recalculations

In Table 4.16 the comparison between total estimation recalculated and previous estimation of the sector is given in percentages from 1990 to 2004, for each gas. Only percentages different from zero have been reported.
In order to update the government's strategy to achieve Italy's emissions reduction target under the Kyoto Protocol, emission projections for 2010 and 2020 have been carried out; in this framework, updated projections regarding consumption of ODS substitutes have been supplied by industry (Solvay, 2007) which has also lead to a revision of data from 1996 to 2005 for some substances.
Due to this updated information supplied by industry, C_3F_8 emissions from semiconductor manufacturing have been estimated.
Other minor modifications have regarded emissions from electrical equipments.

4.7.6. Source-specific planned improvements

Further investigation on fire extinguishers sector is planned.

COMPOUND	1996	1997	1998	1999	2000	2001	2002	2003	2004
HFC 23	6.86%	13.41%	20.12%	27.16%	34.63%	42.61%	51.18%	60.39%	70.31%
HFC 32				38.48%	4.60%	-13.18%	-22.53%	-34.50%	-43.29%
HFC 125				20.12%	-2.66%	-15.91%	-23.15%	-31.39%	-37.83%
HFC 134a				1.92%	-0.72%	-4.61%	-8.70%	-8.61%	-6.37%
HFC 143a				-0.80%	-12.20%	-19.04%	-22.69%	-24.74%	-26.14%
Total HFC emissions from refrigeration and air conditioning equipment	0.04%	0.07%	0.08%	4.90%	-2.37%	-10.01%	-16.00%	-20.91%	-24.90%
HFC 134a emissions from foam blowing				25.84%	56.17%	92.67%	130.13%	174.91%	228.85%
HFC 227ea emissions from fire extinguishers						-7.04%	-8.03%	-6.71%	-4.51%
HFC 134a emissions from aerosols/metered dose inhalers									
Total HFC emissions from ODS substitutes				7.09%	13.65%	19.04%	29.89%	33.08%	41.77%
HFC 23									-10.40%
HFC 134a									
CF_4									-17.09%
C_2F_6									-39.46%
C_3F_8						100.00%	100.00%	100.00%	100.00%
C_4F_8						-89.42%			-43.38%
SF_6									0.50%
Total PFC, HFC, SF_6 *emissions from semiconductor manufacturing*						-0.41%	3.70%	4.61%	-17.43%
SF_6 emissions from electrical equipment						-0.13%	-0.24%	-7.22%	-25.35%
Total F-gas emissions from consumption of halocarbons and SF_6	**0.02%**	**0.03%**	**0.05%**	**3.78%**	**-0.81%**	**-6.46%**	**-11.19%**	**-15.62%**	**-20.99%**

Table 4.16 Comparison between recalculated and previous F-gas emissions from the consumption of halocarbons and SF_6 per gas in percentage, 1990-2004

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 2005, solvent use is responsible for 0.27% of the total CO_2 emissions and 39.4% of total NMVOC emissions, and represents the second source of anthropogenic NMVOC national emissions.
N_2O emissions, in 2005, represent 1.93% 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 2000, 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	2000	2001	2002	2003	2004	2005
NMVOC (Gg)								
3A. Paint application	270.79	252.60	226.07	229.60	226.37	221.65	221.30	219.41
3B. Degreasing and dry cleaning	56.66	34.12	26.40	25.70	25.02	24.36	23.72	20.28
3C. Chemical products	59.54	59.00	60.96	58.37	57.83	54.48	53.00	52.37
3D. Other	185.23	170.13	156.21	160.19	167.61	174.23	176.91	183.94
CO_2 (Gg)								
3A. Paint application	844.07	787.35	704.65	715.67	705.61	690.88	689.79	683.92
3B. Degreasing and dry cleaning	176.62	106.34	82.27	80.09	77.98	75.93	73.94	63.20
3D. Other	577.36	530.29	486.90	499.31	522.44	543.07	551.42	573.34
N_2O (Gg)								
3D. Other (use of N2O for anaesthesia and aerosol cans)	2.57	2.44	3.26	2.95	2.95	2.76	2.58	2.51

Table 5.1 Trend in NMVOC, CO_2 and N_2O emissions from the solvent use sector, 1990 – 2005 (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, several years), solvent use in dry cleaning (ENEA/USLRMA, 1995), solvent use in textile finishing and in the tanning industries (TECHNE, 1998; Regione Toscana, 2001; Regione Campania, 2005; GIADA 2006). Basic information from industry on percentage reduction of solvent content in paints and other products has been applied to EMEP/CORINAIR emission factors in order to evaluate the reduction in emissions during the considered period.
Emissions from domestic solvent use have been calculated using a detailed methodology, based on VOC content per type of consumer product.
As regards household and car care products, information on VOC content and activity data has been supplied by the Sectoral Association of the Italian Federation of the Chemical Industry (Assocasa, several years) and by the Italian Association of Aerosol Producers (AIA, several years [a] and [b]).
As regards cosmetics and toiletries, basic data have been supplied by the Italian Association of Aerosol Producers too (AIA, several years [a] and [b]) and by 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 2005 (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 2005 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 2005 with respect to 1990 by sub-sectors.

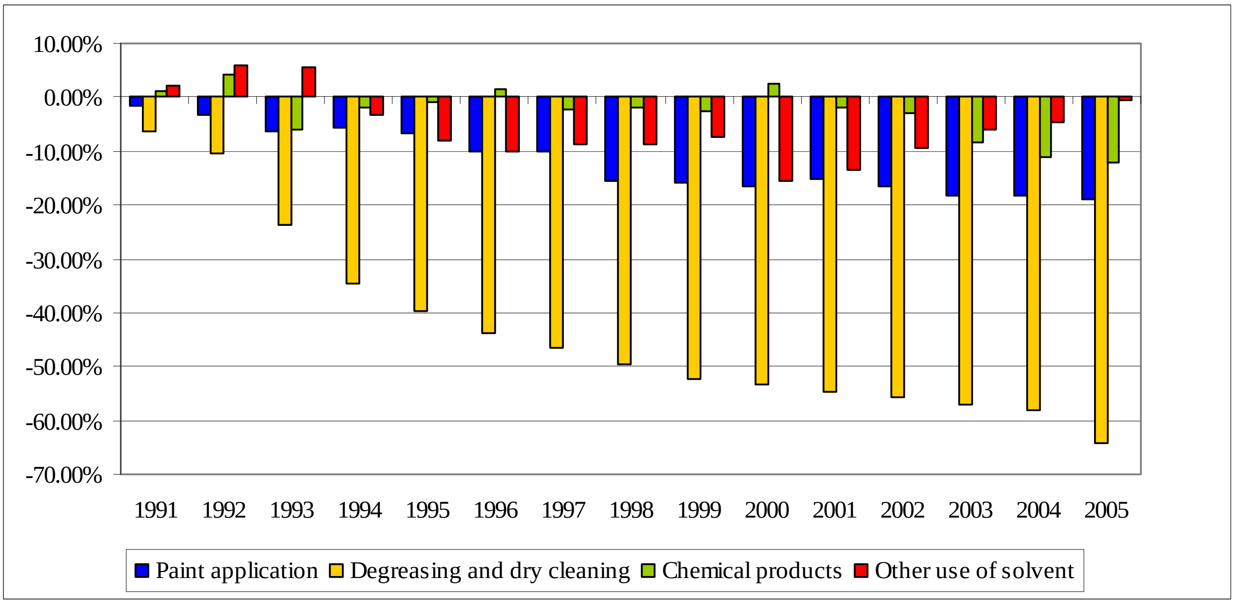

Figure 5.1 Trend of NMVOC emissions from 1991 to 2005 as compared to 1990 (%)

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, several years) 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.

5.7 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 2004, for NMVOC.
Modifications have regarded the update of activity data supplied by new statistics in particular referring to Polyurethane processing (revision of activity data 2000-2004), Pharmaceutical products manufacturing (revision of 2004 activity data), Paints manufacturing (revision of 2004 activity data), Leather tanning (revision of 2004 activity data), Fat edible and non edible oil extraction (revision of activity data 1990-2004) and Domestic Solvent Use (revision of 2003 and 2004 activity data).
Moreover, a revision of emission factor for Glues manufacturing and Application of glues and adhesives has been done, due to an error reported in the worksheet. Emission factor regarding the olive oil extraction activity has been modified due to national techniques which use less solvent due to the fact of the main production of natural olive oil in Italy.
No changing in methodology has been done.

GAS/SUBSOURCE	1990	1991	1992	1995	1996	1997	2000	2001	2002	2003	2004
NMVOC											
3A. Paint application	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3B. Degreasing and dry cleaning	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3C. Chemical products	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.28%	-0.35%	-0.28%	0.71%	1.02%
3D. Other	0.00%	-0.58%	-0.51%	-0.40%	-0.91%	-0.78%	-2.58%	-2.00%	-1.95%	-2.16%	-1.80%

Table 5.2 Differences in percentages between NMVOC emissions from the sector reported in the updated time series and the 2006 submission

Chapter 6: AGRICULTURE [CRF sector 4]

6.1 Overview of sector

In this chapter information on the estimation of greenhouse gas (GHG) emissions from the Agriculture sector, as reported under the IPCC Category 4 in the Common Reporting Format[1] (CRF), is given. Emissions from enteric fermentation (4A), manure management (4B), rice cultivation (4C), agriculture soils (4D) and field burning of agriculture residues (4F) are included in this sector. Methane (CH_4) and nitrous oxide (N_2O) emissions are estimated and reported. 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.

To provide information of the characteristics from the agriculture sector in Italy, data from the Farm Structure Survey 2005 are reported. At the end of 2005, about 1.38 million agricultural holdings has an economic size of at least 1 European Size Unit (ESU[2]), among these holdings (EUROSTAT, 2007):

- 64% made use of less than one AWU[3], while 12% made use of 2 or more AWUs;
- 67% used less than 5 ha agricultural area, while 1% used 100 ha or more;
- 19% were holdings of the type specialist olives, 15% specialist cereals, oil seed and protein crops, 12% specialist vineyards, 10% were engaged in mixed cropping and 10% were general field cropping;
- 50% of their agricultural area was situated in less favoured or mountain areas;
- 3% were organic farms;
- 25% were producing mainly for their own consumption;
- 15% benefited from direct investment aid.

6.1.1 Emission trends

Emission trends per gas

In 2005, 6.4% of the Italian GHG emissions without emissions and removals from LULUCF (7.9% in 1990) originated from the agriculture sector, the third source of emissions, after energy (82.8%) and industrial processes (7.0%) sectors. For the agriculture sector, the trend of GHGs from 1990 to 2005 shows a decrease of 8.3% due to reduction in activity data such as the number of animals and cultivated surface/crop production (see Figure 6.1). CH_4 and N_2O emissions have decreased by 10.1% and 7.0%, respectively (see Table 6.1). In 2005, the agriculture sector has been dominant national sources for CH_4 and N_2O emissions, sharing 39.0% and 53.8%, respectively.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
									Gg CO_2 eq.							
CH_4	17,215	17,416	16,967	16,908	16,948	17,222	17,253	17,285	17,154	17,287	16,836	16,395	15,725	15,780	15,515	15,480
N_2O	23,362	23,956	23,896	24,255	23,694	23,127	22,844	23,865	23,264	23,508	23,103	23,033	22,524	22,319	22,378	21,734
Total	**40,577**	**41,372**	**40,863**	**41,163**	**40,641**	**40,349**	**40,097**	**41,150**	**40,418**	**40,795**	**39,939**	**39,428**	**38,250**	**38,099**	**37,892**	**37,214**

Table 6.1 Emissions of GHG and trends from 1990 to 2005 for the Agriculture sector (Gg CO_2 eq.)

[1] http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/3929.php
[2] 1 ESU is equal to 1200 euros
[3] Annual work unit (AWU) is equivalent to a worker employed on a full time basis for one year. In Italy it is 1800 hours (225 working days of 8 working hours per day).

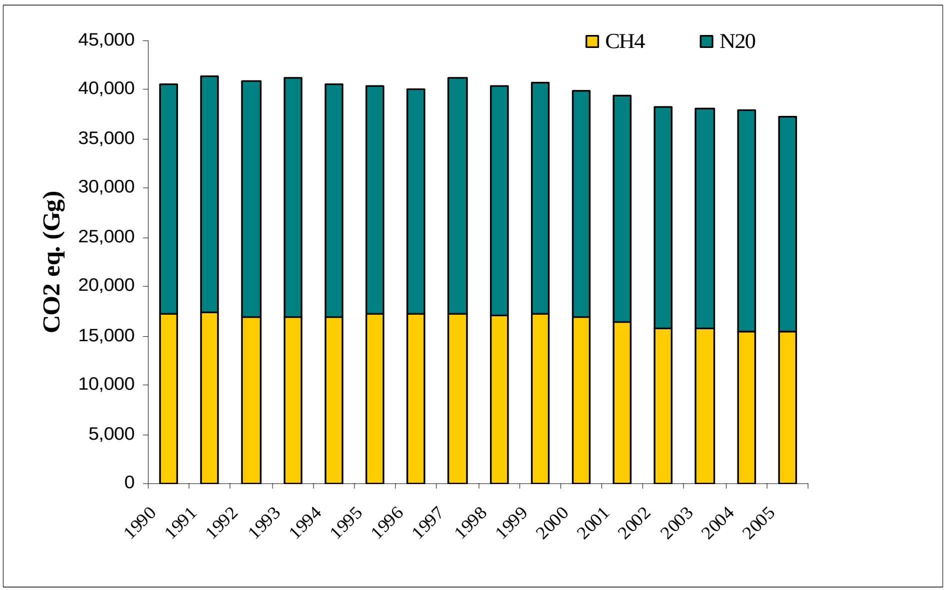

Figure 6.1 Trend of GHG emissions for the Agriculture sector from 1990 to 2005 (Gg CO_2 eq.)

Emission trends per sector

In Table 6.2, total GHG emissions and trends by sub categories from 1990 to 2005 are presented. CH_4 emissions from enteric fermentation (4A) and N_2O emissions from direct agriculture soils (4D), are the most relevant source categories in this sector. In 2005, their individual shares, in national GHG emissions without LULUCF, were 1.9% and 1.6%, respectively.

Year	Methane emissions (Gg)				Total	Nitrous oxide emissions (Gg)			Total
	4A	4B	4C	4F		4B	4D	4F	
1990	579.89	164.86	74.39	0.62	819.75	12.65	62.70	0.013	75.36
1991	592.76	164.82	71.09	0.68	829.35	12.63	64.64	0.014	77.28
1992	574.76	158.67	73.86	0.66	807.95	12.09	64.98	0.014	77.08
1993	568.70	158.32	77.48	0.64	805.14	11.98	66.25	0.013	78.24
1994	573.83	153.34	79.22	0.64	807.03	11.93	64.48	0.013	76.43
1995	584.11	156.48	78.90	0.62	820.11	12.20	62.39	0.013	74.60
1996	586.77	156.90	77.27	0.64	821.59	12.34	61.34	0.013	73.69
1997	589.35	156.26	76.91	0.57	823.10	12.44	64.53	0.012	76.98
1998	585.29	157.94	72.99	0.64	816.87	12.70	62.33	0.013	75.04
1999	591.80	159.48	71.27	0.62	823.18	12.89	62.93	0.013	75.83
2000	579.26	156.10	65.80	0.58	801.73	12.46	62.06	0.012	74.53
2001	555.54	158.85	65.80	0.53	780.72	13.11	61.18	0.011	74.30
2002	525.21	155.39	67.63	0.60	748.82	12.41	60.24	0.013	72.66
2003	526.44	154.84	69.60	0.55	751.42	12.31	59.68	0.012	72.00
2004	515.98	150.26	71.88	0.67	738.80	12.03	60.14	0.014	72.19
2005	516.77	150.00	69.74	0.62	737.13	11.90	58.20	0.013	70.11

Table 6.2 Total GHG emissions and trend from 1990 to 2005 for the Agriculture sector (Gg)

6.1.2 Key sources

In 2005, CH_4 from enteric fermentation, N_2O and CH_4 from manure management, and N_2O from agricultural soils, both direct and indirect emissions were ranked among the top-10 level key sources with the Tier 2 analysis, including the uncertainty (L2). N_2O from agricultural soils, both direct and indirect emissions, and CH_4 enteric fermentation are ranked among the top-10 level key sources with the Tier 2 analysis, including the uncertainty (T2). In the following box, with a level and/or trend assessment (*IPCC Tier 1 and Tier 2 approaches*), key and non-key sources from the agriculture sector are shown.

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, T2)
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

6.1.3 Activities

Emission factors used for the preparation of the national inventory try to reflect Italian characteristics of the agriculture sector; hence, outputs from national research studies have been considered. However, activity data mainly comes from the National Institute of Statistics[4] (ISTAT). National and international references used for the preparation of the agriculture inventory are stored every year in the *National References Database.*

Improvements are described in the Italian Quality Assurance/Quality Control plan for the agriculture sector (APAT, 2007). Since 2006 submission, results from the MeditAIRaneo project have been included in the preparation of the emission inventory. Besides, we expect further improvements from two conventions signed between APAT and the Ministry for the Environment, Land and Sea.

For the preparation of this chapter, we have followed recommendations from the last review process (UNFCCC, 2005). Moreover, we have kept consistent methodologies for the preparation of national inventories under the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and the United Nations Framework Convention on Climate Change (UNFCCC). In this framework, we have implemented synergies among international conventions and European directives when preparing national inventories (Cóndor and De Lauretis, 2007; Cóndor, 2006).

6.1.4 Agricultural statistics

The Italian National Statistical System (SISTAN[5]) revises every year the National Statistical Plan that covers three years and includes the system of agricultural statistics among others. In this framework, the Agriculture, Forestry and Fishing Quality Panel has been established under coordination of the Agriculture service from ISTAT, then, those who produce and use agricultural statistics (mainly public institutions) meet every year in order to monitor and improve national statistics. Among those producing statistics, ISTAT plays a major role in the agricultural sector collecting comprehensive data through different surveys as reported by Greco and Martino (2001):

[4] http://www.istat.it/agricoltura/
[5] SISTAN, *Sistema Statistico Nazionale* (http://www.sistan.it/)

- Structural surveys (Farm Structure Survey, survey on economic results of the farm, survey on the production means)
- Conjunctural surveys[6] (survey on the area and production of the cultivation, livestock number, milk production, slaughter, etc.)
- General Agricultural Census[7], done each 10 years (1990, 2000, 2010)

Detailed information on the agriculture sector is found each two years in the Farm Structure Survey – FSS [8,9] (ISTAT, 2006[a]). Main agricultural statistics sources, which are used for the preparation of the agriculture emission inventory are available online, as reported the following box:

Main activity data sources used for the Agriculture emission inventory

Agricultural statistics	Time series	Web site
Livestock number	Table 6.3; 6.4; 6.7	http://www.istat.it/agricoltura/datiagri/consistenza/
Milk production	Table 6.3	http://www.istat.it/agricoltura/datiagri/latte/
Fertilizers	Table 6.31	http://www.istat.it/agricoltura/datiagri/mezzipro/
Crops production/surface	Table 6.27; 6.33; 6.34	http://www.istat.it/agricoltura/datiagri/coltivazioni/

6.2. Enteric fermentation (4A)

6.2.1. Source category description

Methane is produced as a by-product of enteric fermentation, which is a digestive process where carbohydrates are degraded by microorganisms into simple molecules.
Methane emissions from enteric fermentation are a major key source, both in terms of level and trend for Tier 1 and Tier 2 approaches. 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 IPCC guidelines. In 2005, CH_4 emissions from this category were 516.77 Gg, which represent 70.1% of CH_4 emissions for the agriculture sector (70.7% in 1990) and 27.3 % for national CH_4 emissions (29.3% in 1990). Methane emissions from this source mainly consist of cattle emissions: dairy cattle (207.95 Gg) and non-dairy cattle (204.62 Gg); these sub-categories sources represented 40.2% (42.3% in 1990) and 39.6% (40.2% in 1990), respectively, of total enteric fermentation emissions.

6.2.2. Methodological issues

Methane emissions from enteric fermentation are estimated by defining an emission factor for each livestock category, which is multiplied by the population of the same category. Data for each livestock category is collected from ISTAT (several years [a], [b], [c], [f]; ISTAT, 1991; 2007[a]). Livestock categories provided by ISTAT are classified according to the type of production, slaughter or breeding, and the age of animals. In Table 6.20, activity data for all livestock categories are shown. In the following box, different livestock categories and source of information are showed. In order to have a consistent time series, it was necessary to reconstruct the number of some animal categories, with information available from other official sources such as FAO (2007) and UNA (2007).

[6] http://www.istat.it/agricoltura/datiagri/
[7] http://www.census.istat.it/
[8] Indagine sulla struttura e produzione delle aziende agricole (SPA), survey carried out every two years in agricultural farms.
[9] http://www.istat.it/salastampa/comunicati/non_calendario/20061227_00/

Activity data for the different livestock categories

Livestock category	Source
Cattle	ISTAT
Buffalo	ISTAT
Sheep	ISTAT
Goat	ISTAT
Horses	ISTAT/FAO(a)
Mules and asses	ISTAT/FAO(a)
Swine	ISTAT
Poultry	ISTAT/UNA(b)
Rabbit	ISTAT(c)

(a) reconstruction of a consistent time series
(b) For 1990 data from the census and reconstruction for brood-rabbits and other rabbits based on meat production
(c) For 1990 data from the census and reconstruction based a production index

Dairy cattle

Methane emissions from enteric fermentation for dairy cattle are estimated using Tier 2 approach, as suggested in the Good Practice Guidance (IPCC, 2000). Feeding characteristics are described in a national publication (CRPA, 2004[a]) and have been discussed in a specific working group, in the framework of the MeditAIRaneo project (CRPA, 2006[a]; CRPA, 2005). Parameters used for the calculation of the emission factor are presented in the following box:

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

Parameters	Value	Reference
Average weight (kg)	602.7	CRPA, 2006
Coefficient NEm (dairy cattle)	0.335	NRC, 2001; IPCC, 2000
Pasture (%)	5	CRPA, 2006[a]; ISTAT, 2003
Weight gain (kg day^{-1})	0.051	CRPA, 2006[a]; CRPA, 2004[b]
Milk fat content (%)	3.59-3.71	ISTAT, several years [a], [b], [d], [e]; ISTAT, 2007[b]
Hours of work per day	0	CRPA, 2006
Portion of cows giving birth	0.90-0.97	AIA, 2005
Milk production (kg head^{-1} day^{-1})	11.5-17.2	CRPA, 2006[a]; ISTAT, 2007[b]; OSSLATTE/ISMEA, 2003; ISTAT, several years [a], [b], [c] [d], [e], [f];OSSLATTE, 2001
Digestibility of feed (%)	65	CRPA, 2006[a]; CRPA, 2005
Methane conversion rate (%)	6	CRPA, 2006
MJ/kg methane	55.65	IPCC, 2000

In a national publication, an analysis of the different milk production statistics has been described (Cóndor *et al*., 2005). Milk used for dairy production and milk used for calf feeding contribute to total milk production. This value has been reconstructed with national and ISTAT publications, as well as personal communication with ISTAT (ISTAT, 2007[e]). For calculating milk production (kg head^{-1} d^{-1}), total production has been divided by the number of animals and by 365 days, as suggested by the IPCC (2000). Therefore, lactating and non-lactating periods are included in the estimation of the CH_4 dairy cattle EF (CRPA, 2006[a]). In Table 6.3, the time series of the dairy cattle population, fat content in milk, portion of cows giving birth and milk production are presented.

In Table 6.6, the time series of the dairy cattle emission factors (EF) is presented. In 2005, the CH_4 dairy cattle EF was 112.9 kg CH_4 head^{-1} year^{-1} with an average milk production of 6,282 kg head^{-1} year^{-1} (17.2 kg head^{-1} day^{-1}). This value is close to the default EF of 109 kg CH_4 head^{-1} year^{-1} with a milk production of 6,000 kg head^{-1} year^{-1} reported by the IPCC (2006).

Non-dairy cattle

For non-dairy cattle, CH_4 emissions from enteric fermentation are estimated with Tier 2 approach (IPCC, 2000). The estimation of the EF uses country-specific data, disaggregated livestock categories (see Table 6.4), and is 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 from IPCC (2000). In table 6.5, parameters used for the estimation of non-dairy cattle EF are shown. Since 2006 submission, average weights have been updated with information form the Inter-regional project on nitrogen balance project (CRPA, 2006[a]; Regione Emilia Romagna, 2004).

In the 2007 submission, emissions and parameters have been reported, as requested; it is important to remark that some animal categories are aggregated, such as the non-dairy and swine category. For example, the non-dairy cattle category is composed of the different sub-categories shown in Table 6.4. In this particular case, the gross energy intake, methane conversion factor and emission factors for non-dairy cattle, are calculated as a weighted average.

Year	Dairy cattle (head)	Fat content in milk (%)	Portion of cows giving birth	Milk production yield (kg $head^{-1}$ d^{-1})
1990	2,641,755	3.59	0.97	11.5
1991	2,339,520	3.59	0.97	13.0
1992	2,146,398	3.59	0.96	13.9
1993	2,118,981	3.63	0.96	13.8
1994	2,011,919	3.64	0.96	14.5
1995	2,079,783	3.64	0.95	14.8
1996	2,080,369	3.65	0.95	15.2
1997	2,078,388	3.66	0.95	15.5
1998	2,116,176	3.71	0.93	15.3
1999	2,125,571	3.69	0.92	15.3
2000	2,065,000	3.65	0.93	15.1
2001	2,154,000	3.65	0.91	14.4
2002	1,910,948	3.67	0.91	16.2
2003	1,913,424	3.67	0.91	16.2
2004	1,838,330	3.71	0.90	16.8
2005	1,842,004	3.71	0.91	17.2

Table 6.3 Parameters used for the estimation of the CH_4 emission factor for dairy cattle

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
2005	500,049	1,418,545	26,424	615,921	588,660	181,971	102,081	466,566	37,971	471,733	4,409,921

Table 6.4 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 CH_4 emissions, as they are milk fed. Therefore, the average weight for the category "others" of <1 year take into account fattening male cattle, fattening heifer and heifer for replacement.

Table 6.5 Main parameters used for non-dairy cattle CH_4 emission factor estimations

National characteristics of Italian breeding are reflected in EFs and are related to age classification of animals and dry matter intake. In table 6.6, implied emission factors (IEF) for non-dairy cattle are presented. In 2005, the non dairy-cattle EF was 46.4 kg CH_4 head^{-1} year^{-1} while IPCC default EF is 48 kg CH_4 head^{-1} year^{-1} (IPCC, 1997).

Buffalo

Data collected in the framework of the MeditAIRaneo project have allowed the implementation of the Tier2 approach (IPCC, 2000) for the buffalo category. Two different country specific CH_4 emission factors, for cow buffalo and other buffaloes have been developed. Detailed description of the methodology, parameters and assumptions are reported in Cóndor et al., 2006. In 2005, the cow buffalo CH_4 emission factor was 78.4 kg CH_4 head^{-1} year^{-1} and for other buffaloes was 56.0 kg CH_4 head^{-1} year^{-1}. The IEF reported in the CRF is an average EF for the buffalo livestock category (71.02 kg CH_4 head^{-1} year^{-1}). In the following boxes, parameters used for the Tier 2 approach are presented:

Parameters for the calculation of CH_4 cow buffalo emission factors from enteric fermentation

Parameters	Value	Reference
Average body weight (kg)	630	Infascelli, 2003; Consorzio per la tutela del formaggio mozzarella di bufala campana, 2002
Coefficient NEm, cattle/buffalo (lactating)	0.335	IPCC, 2000
Pasture (%)	2.90	ISTAT, 2003; Zicarelli, 2001; expert judgement
Weight gain (kg day^{-1})	0.27	Estimations
Milk fat content (%)	7.7-8.1	ISTAT, several years [a], [b], [d], [e]; ISTAT, 2007[b]
Hours of work per day	0	Our estimation
Proportion of calving cows	0.84-0.89	Barile, 2005; De Rosa and Trabalzi, 2004
Milk production (kg $head^{-1}$ day^{-1})	1.9-4.4	ISTAT, 2007[b]; OSSLATTE/ISMEA, 2003; ;OSSLATTE, 2001; ISTAT, several years [a], [b], [c] [d], [e], [f]
Digestibility of feed (%)	65	Infascelli, 2003; Masucci et al., 1997, 1999;
Methane conversion rate (%)	6	CRPA, 2006
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 CH_4 emission factor was 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 was 21.16 kg CH_4 $head^{-1}$ $year^{-1}$.

Rabbits

Methane emissions from rabbits have been estimated using a country-specific EF 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 CH_4 conversion rate (CRPA, 2004[c]).

Other livestock categories

A tier 1 approach, with IPCC default emission factors, has been used to estimate CH_4 emissions from swine, sheep, goats, horses, mules and asses (IPCC, 1997). In Table 6.6, emission factors from 1990 to 2005 for all livestock categories (dairy cattle, non-dairy cattle, buffalo, swine, sheep, goats, horses, mules and asses, and rabbit) are presented. In Table 6.7, time series from livestock number are shown.

	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	68.3	8	5	18	10	1.5	1.5	0.08
2005	112.9	46.4	71.0	8	5	18	10	1.5	1.5	0.08

Table 6.6 Average CH_4 emission factors for enteric fermentation (kg CH_4 head^{-1} year^{-1})

Year	Buffalo	Sheep	Goat	Horses	Mules and asses	Sow	Other swine	Rabbit	Poultry
1990	94,500	8,739,253	1,258,962	287,847	83,853	650,919	7,755,602	14,893,771	173,341,562
1991	83,300	8,397,070	1,260,980	314,125	66,255	711,500	7,837,300	15,877,391	173,060,622
1992	103,200	8,460,557	1,355,485	315,848	56,946	691,400	7,553,000	16,398,563	172,683,589
1993	100,900	8,669,560	1,408,767	323,305	49,383	702,900	7,645,200	16,530,691	173,261,404
1994	108,300	9,964,108	1,658,051	323,986	43,063	677,100	7,346,300	16,905,054	178,659,192
1995	148,404	10,667,971	1,372,937	314,778	37,844	689,846	7,370,830	17,110,587	184,202,416
1996	171,558	10,943,457	1,419,225	312,080	34,120	726,155	7,444,937	17,433,566	183,044,930
1997	161,491	10,893,711	1,351,003	313,000	30,000	693,366	7,599,426	17,609,737	186,815,499
1998	186,276	10,894,264	1,331,077	290,000	33,500	707,644	7,614,981	17,705,163	198,799,819
1999	200,481	11,016,784	1,397,329	288,000	33,000	691,590	7,722,893	18,020,802	196,573,062
2000	192,000	11,089,000	1,375,000	280,000	33,000	708,000	7,599,000	17,873,993	176,722,211
2001	192,000	8,311,000	1,025,000	285,000	33,000	717,000	7,734,000	18,343,782	209,187,654
2002	185,438	8,138,309	987,844	277,819	28,913	751,159	8,415,099	18,505,272	205,524,395
2003	222,268	7,950,981	960,994	282,936	28,507	736,637	8,420,087	18,226,335	196,511,409
2004	210,195	8,106,043	977,984	277,767	28,932	724,891	8,247,181	21,199,217	191,315,963
2005	205,093	7,954,167	1,045,898	278,471	30,254	721,843	8,479,430	21,199,217	188,595,022

Table 6.7 Time series of number of animals from 1990 till 2005

6.2.3. Uncertainty and time-series consistency

Uncertainty related to CH_4 emissions from enteric fermentation were 28% for annual emissions, resulting from the combination of 20% of uncertainty for both activity data and emission factors.
In 2005, livestock CH_4 emissions from enteric fermentation have been 10.9% (516.77 Gg) lower than in 1990 (579.89 Gg), while from 1990 to 2005 cattle livestock has decreased by 19.4% (from 7,752,152 to 6,251,925 heads). Dairy cattle and non-dairy cattle have decreased by 30.3% (from 2,641,755 to 1,842,004) and 13.7% (from 5,110,397 to 4,409,921), respectively. The decrease in cattle number is driving down CH_4 emissions, particularly as emissions per head from cattle are 10 times greater than emissions per head of sheep or goat. In 2005, cattle contribute with 79.8% to total CH_4 emissions from enteric fermentation, sheep with 12.3% and the rest of livestock categories with 7.8%. In Table 6.8, emission trends from the enteric fermentation category are shown. Emissions from swine, as reported in the CRF are represented by other swine and sow category (13.80 Gg).

6.2.4. Source-specific QA/QC and verification

Since 2006 submission, specific activities from the MeditAIRanean project have been mainly focused on the assessment of critical points of the enteric fermentation category (CRPA, 2006[a]; Valli et al., 2004). In table 6.9, a list of parameters from the QA/QC plan is reported.

6.2.5. Source-specific recalculations

Milk production from the buffalo category has been updated from 2000 till 2004, no major changes have been appreciated in the cow buffalo emission factor. In Table 6.10, new and old dairy cattle emission factors, from 2006 and 2007 submissions, are shown.

6.2.6. Source-specific planned improvements

In the framework of collaboration between APAT and ISTAT (Agriculture unit) we expect to update activity data.

Year	Dairy cattle	Non-dairy cattle	Buffalo	Sheep	Goats	Horse	Mules and asses	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	13.18	66.49	5.13	5.13	0.33	1.08	11.60	1.42	**555.54**
2002	208.45	213.92	12.31	65.11	4.94	5.00	0.29	1.13	12.62	1.44	**525.21**
2003	208.65	214.13	14.71	63.61	4.80	5.09	0.29	1.10	12.63	1.42	**526.44**
2004	204.92	206.57	14.36	64.85	4.89	5.00	0.29	1.09	12.37	1.65	**515.98**
2005	207.95	204.62	14.57	63.63	5.23	5.01	0.30	1.08	12.72	1.65	**516.77**

Table 6.8 Trend in CH_4 emissions from enteric fermentation (Gg)

Sub category	Parameter	Year of submission 2007	2008	Activities
Dairy cattle	Fat content	√		Update of the parameter (ISTAT, 2007[b])
Dairy cattle	Portion cow giving birth	√		Update of the parameter obtained from AIA (2005)
Dairy cattle	Milk production	√		Update of the parameter (ISTAT, 2007[b])

Table 6.9 Improvements for the enteric fermentation category according to the QA/QC plan

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
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	
EF 2007 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	112.9

Table 6.10 Dairy cattle CH_4 emission factors for the enteric fermentation category (kg head $^{-1}$year^{-1})

6.3. Manure management (4B)

6.3.1 Source category description

Methane and nitrous oxide emissions from manure management are key sources. Nitrous oxide emissions are key source at level for Tier 1 and Tier 2, and trend assessment (Tier 2), while CH_4 emissions are key sources at level for Tier 1 and Tier 2, and Tier 2 trend assessment.
In 2005, CH_4 emissions from manure management were 150.0 Gg, which represents 20.3% of CH_4 emissions for the agriculture sector (20.1% in 1990) and 7.9% for national CH_4 emissions (8.3% in 1990). CH_4 emissions from swine were 69.24 Gg and cattle 59.19 Gg; these sub-categories represented 46.2% and 39.5%, respectively; from total CH_4 manure management emissions.
In 2005, N_2O emissions from manure management were 11.90 Gg, which represents 17.0% of total N_2O emissions for the agriculture sector (16.8% in 1990) and 9.1% for national N_2O emissions (10.3 % in 1990). In 2005, N_2O emissions from this source mainly consist of the solid storage source (10.51 Gg), which accounts for 88.4% of the N_2O manure management source.
For this sector, parameters related to the estimation of CH_4 and N_2O emissions have been updated since the 2006 submission. Parameters such as the average weight, production of slurry and solid manure and the nitrogen excretion rates have been updated thanks to the Inter-regional project on nitrogen balance and other national research studies.

6.3.2. Methodological issues

A IPCC Tier 2 approach has been used for estimating CH_4 emission factors for manure management from cattle, buffalo and swine. For estimating slurry and solid manure EFs and the specific conversion factor, a detailed methodology (*Method 1*), for cattle and buffalo category have been applied at a regional basis. Then, a simplified methodology, for estimating emission factors time series, has been applied (*Method 2*). Livestock population activity data has been collected from ISTAT (time series: see Table 6.3; 6.4; 6.7).

Methane emissions (cattle and buffalo)

Method 1: Regional basis

Methane emissions estimations for manure management are drawn up on a regional basis and depend on specific manure management practices and environmental conditions (Safley et al., 1992; Steed and Hashimoto, 1995; Husted, 1994). In particular, the following factors are used: average regional monthly temperatures (UCEA, 2007), amount of slurry and solid manure produced per livestock category (CRPA, 2006[a]; Regione Emilia Romagna, 2004) and management techniques for the application of slurry and solid manure for agricultural purposes in Italy (CRPA, 1993).
For cattle and buffalo, the estimation of the EF begins with the calculation of the *methane emission rate* (g CH_4 m^{-3} day^{-1}), which is obtained from an equation presented for slurry (Husted, 1994) and solid manure (Husted, 1993). Then the *methane emission rate* is transformed to g m^{-3} $month^{-1}$. The equations used are presented below and have been reported by CRPA (CRPA, 2006[a]; 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 with 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]). On the other hand, the production of solid manure and slurry have been estimated assuming a distribution of housing systems in Italy which will be updated with information coming from the "farm structure survey" 2005,. Emission factors for slurry and solid manure (g CH_4 $head^{-1}$ $month^{-1}$) are calculated for each month, and are obtained with the *methane emission rates* (Eq. 6.1 and 6.2), and the volume of slurry and solid manure produced. The annual EF for each livestock category is the sum of slurry and solid manure EFs (kg CH_4 $head^{-1}$ $year^{-1}$). Then, to correlate CH_4 emission production and volatile solid production a *specific conversion factor* has been estimated. Later, this factor is used for the simplified methodology (*Method 2*). The *specific conversion factor* values for slurry and solid manure are 15.32 g CH_4/kg VS and 4.80 g CH_4/kg VS, respectively.

Method 2: National basis

A simplified methodology (*Method 2*) for estimating methane EFs from manure management has been used for the whole time series. Slurry and solid manure EF (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. Furthermore, the production of volatile solids (kg $head^{-1}day^{-1}$) has been estimated with the slurry and solid manure production, and the factors proposed by Husted: 47g VS/kg (slurry) and 142 g VS/kg, (solid manure). The daily VS excreted, estimated for slurry and solid manure, are summed and used for estimating the methane producing potential (Bo). In Table 6.11, EF estimations are presented.

$$EF \text{ slurry} = 15.32\ gCH_4/Kg\ VS \bullet VS \text{ production slurry } (kg\ VS\ head^{-1}\ day\text{-}^{1}) \bullet 365 \text{ days} \qquad \textit{Eq. 6.3}$$

$$EF \text{ manure} = 4.8\ gCH_4/Kg\ VS \bullet VS \text{ production slurry } (kg\ VS\ head^{-1}\ day\text{-}^{1}) \bullet 365 \text{ days} \qquad \textit{Eq. 6.4}$$

Livestock category	**Slurry (kg CH_4 $head^{-1}$ yr^{-1})**	**Solid manure (kg CH_4 $head^{-1}$ yr^{-1})**	**CH_4 manure management EF (kg CH_4 $head^{-1}$ yr^{-1})**
Calf (*vitelli*)	6.22	0.00	6.22
Cattle (*bovini*)	5.10	3.51	8.61
Female cattle (*bovine*)	2.83	4.12	6.95
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*)	4.93	10.32	15.25
Other buffaloes (*bufalini*)	3.12	3.17	6.30

Table 6.11 Methane manure management emission factors for cattle and buffalo in 2005 (kg CH_4 $head^{-1}$ yr^{-1})

Since 2006 submission, the average production of slurry and solid manure per livestock category per day (m^3 $head^{-1}$ day^{-1}), has been updated, with results from the Inter-regional project on nitrogen balance project (Regione Emilia Romagna, 2004). Currently, a time series of slurry and solid manure production has been obtained, on the basis of the type and distribution of housing systems for the different animal categories, and average weight of animals. In Table 6.12 the average manure management EFs are shown.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	kg CH_4 $head^{-1}$ yr^{-1}															
Calf	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	6.22
Cattle	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	8.61
Female cattle	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	6.95
Other dairy cattle	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	10.66
Dairy cattle	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	15.04
Cow buffalo	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	15.25
Other buffaloes	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	6.30

Table 6.12 Methane manure management emission factors for cattle and buffalo (kg CH_4 $head^{-1}$ yr^{-1})

For the manure management category, in the 2006 submission, reduction of CH_4 emissions because of biogas production has been introduced. Activity data is collected every year from the National Electric Network - TERNA[10] (2006). Reductions of CH_4 emissions have been assumed for cattle and swine livestock categories, and distributed according to the contribution of emissions from each category. This reduction is evident in the IEF reported in the CRF. In 2005, IEFs, for dairy cattle and non-dairy cattle were 14.36 kg CH_4 $head^{-1}$ $year^{-1}$ and 7.43 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 (IPCC, 1997). The IEF for non-dairy cattle and buffalo represent a weighted average. The non-dairy cattle IEF includes: calf, cattle, female cattle and other dairy cattle, instead the buffalo category includes: cow buffalo and other buffaloes sub-categories. As reported in the following box, we are comparing estimated EF and IEF, differences, as mentioned before, are related to the amount of CH_4 reductions from biogas recovery.

Livestock category	EF (kg CH_4 $head^{-1}$ yr^{-1})	IEF(*) (kg CH_4 $head^{-1}$ yr^{-1})
Dairy cattle	15.04	14.36
Non-dairy cattle	7.78	7.43
Buffalo	12.29	12.29

(*) IEF as reported in the CRF

For reporting purposes, the estimation of the methane producing potential (Bo), has been estimated with Equation 4.17 from IPCC (2000). The average methane conversion factors (MCF), for each manure management system classified by climate, are estimated with animal population data coming from the Agriculture Census from 1990 and 2000 and the farm and structure survey 2005 (ISTAT, 2007[f]). Average MCFs have not been used for estimating manure management EF, but they have been useful to verify the EF accuracy. In the following box, estimated country-specific VS and Bo parameters, and IPCC default values from cattle and swine livestock categories are presented. Differences are mainly attributed to country-specific characteristics.

[10] TERNA, Rete Elettrica Nazionale

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	0.14	0.24
Non-dairy cattle	2.85	2.68	0.13	0.17
Buffalo	5.31	2.68	0.13	0.10
Swine	0.35	0.50	0.42	0.45

Methane emissions (swine)

For the estimation of CH_4 emissions from swine, a country-specific *methane emission rate* has been experimentally determined at the Research Centre on Animal Production (CRPA, 1996). The estimation of the EF 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 the livestock population, average weight for fattening swine and sows, and *methane emission rate*. Methane emission rates, which are 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 6.13, characteristics of swine breeding and EF are shown.
Since 2006 submission, parameters such as the average weight of sows, production of slurry (t year^{-1} per t live weight) and volatile solid content in the slurry (g SV/kg slurry w.b.) have been updated. The slurry production has been estimated considering the different swine categories, which are classified by weight and housing characteristics. Volatile solids content has been determined experimentally from 598 measurements done by CRPA (2006[a]).

In 2005, the EF from sow was 22.30 kg CH_4 head^{-1}year^{-1} and 8.35 kg CH_4 head^{-1} year^{-1} for the other swine category (average EF swine of 7.89 kg CH_4 head^{-1}year^{-1}). Instead, the IEF as reported in the CRF is 7.52 kg CH_4 head^{-1} year^{-1}. Also for the swine category, is evident the difference between the EF and the IEF, the reason is due to the reduction in CH_4 because of biogas recovery, as described for the cattle category.
For reporting purposes, the VS daily excretion and Bo have been estimated as a procedure to verify EF accuracy. The VS daily excretion 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 (2000).

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	**84**	**568,440**	**13,768**	**8.35**
20-50 kg	35	65,044	13,768	3.48
50-80 kg	65	94,900	13,768	6.46
80-110 kg	95	137,750	13,768	9.44
110 kg and more	135	265,950	13,768	13.41
Boar	200	4,796	13,768	19.86
Sow	**172**	**141,400**	**15,783**	**22.30**
Piglets	10	17,171	15,783	1.14
Sow	172.1	124,229	15,783	19.60
			TOTAL	**7.89**

Table 6.13 Methane manure management parameters and emission factors for swine in 2005

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. Other two specific characteristics which have to be considered are the feeding situation, 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 (Mordenti et al., 1997). These peculiarities of Italian swine production influence the methane EF for manure management as well as nitrogen excretion factors used for the estimating of N_2O emissions.

Year	Dairy cattle	Non-dairy cattle	Buffalo	Sow	Other swine	Rabbit	Hen	Broiler	Other poultry
				kg CH_4 head^{-1} year^{-1}					
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	8.27	0.080	0.082	0.079	0.079
2005	15.0	7.8	12.3	22.30	8.35	0.080	0.082	0.079	0.079

Table 6.14 Average methane EF for manure management (kg CH_4 head^{-1} year^{-1})

Other livestock categories

Methane emission factors used for calculating the other livestock categories for the manure management are those proposed by IPCC. Since the yearly average temperature in Italy is 13 °C, EFs are characteristic of the "cold" climatic region (IPCC, 1997). In Table 6.14, the average methane EF for cattle, buffalo, swine, rabbit and poultry categories are shown. For sheep, goat, horses and mule and asses, the following EF 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.

Nitrous oxide emissions

Nitrous oxide emissions have been estimated with equation 4.18 from IPCC, as suggested by the IPCC (2000). Different parameters have been used for estimations, such as the number of livestock species, country-specific nitrogen excretion rates per livestock category, the fraction of total annual excretion per livestock category related to a manure management system, and EFs 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 distribution in Italy. For these management systems, we have used the following EFs: 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). The chicken-dung drying process system has been considered since 1995 since it has been significantly widespread in poultry breeding (CRPA, 1997[b]; CRPA, 2000).

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 6.15). Since 2006 submission, different parameters have been updated such as the nitrogen excretion rates (CRPA, 2006[a]; GU, 2006; Xiccato et al., 2005), slurry and solid manure production and the average weight (CRPA, 2006[a]; GU, 2006; Regione Emilia Romagna, 2004). In table 6.15, nitrogen excretion rates used for the estimation of N_2O are shown. The nitrogen excretion rate for swine as reported in CRF (11.65 kg head^{-1} yr^{-1}**)** is estimated as a weighted average, which considers sow and other swine.

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	48.5	1.2	49.8
Dairy cattle	603	110.2	5.8	116.0
Buffalo	525	92.2	2.8	94.9
Other swine	84	12.8	0.0	12.8
Sow	172	28.3	0.0	28.3
Sheep	47	1.6	14.6	16.2
Goat	47	1.6	14.6	16.2
Horses	500	20.0	30.0	50.0
Mules and asses	300	20.0	30.0	50.0
Poultry	1.8	0.54	0.0	0.54
Rabbit	1.6	1.0	0.0	1.0

Table 6.15 Average weight and nitrogen excretion rates in 2005

As mentioned before, since 2006 submission, country-specific annual nitrogen excretion rates have been incorporated with information form the Inter-regional nitrogen balance project. The nitrogen balance project involved Emilia Romagna, Lombardia, Piemonte and Veneto regions, where animal breeding is concentrated. The nitrogen balance methodology was followed, as suggested by IPCC, and as a result, estimations of nitrogen excretion rates[11] and net nitrogen arriving to the field[12] were obtained. The project took into account 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. Final annual nitrogen excretion rates used for the UNFCCC and CLRTAP national inventories have been reported by CRPA (2006[a]). In Table 6.16, nitrogen excretion rate trends from livestock categories are shown. For non-dairy cattle, buffalo, other swine, and sow values change because they are weighted average of different sub-categories.

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

Year	Dairy cattle	Non-dairy cattle	Buffalo	Other swine	Sow	Horses	Mules and asses	Goat	Sheep	Hen	Broilers	Other poultry	Rabbit	Fur animals
							kg head^{-1} yr^{-1}							
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	12.7	28.2	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1
2005	116.0	49.8	94.9	12.8	28.3	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1

Table 6.16 Nitrogen excretion rates for all livestock categories (kg head^{-1} yr^{-1})

Also, since 2006 submission, new average weight data has been updated and used for CLRTAP and UNFCCC national inventories. For a verification purpose of the national average weight of the different livestock categories, a time series reported by ISTAT in the yearbooks (animal weight before slaughter) has been collected CRPA (2006[a]). For the specific case of sheep and goat, a detailed analysis was done with information coming the National Association for Sheep Farming [13] (ASSONAPA, 2006). To estimate the average weight for sheep and goat, breed distribution in Italy and consistency for each breed have been considered (CRPA, 2006[a]; PROINCARNE, 2005). Slurry and solid manure production parameters has been updated also since 2006 submission. These parameters include estimations which consider characteristics from Italian breeding, for slurry and solid manure effluents, housing systems and the distribution for the different animal categories (CRPA, 2006[a]; Bonazzi et al., 2005; APAT, 2004[a]; APAT, 2004[b]).

6.3.3. Uncertainty and time-series consistency

Uncertainty of CH_4 and N_2O 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 2005, livestock CH_4 emissions from manure management were 9.0% (150.0 Gg CH_4) lower than in 1990 (164.86 Gg CH_4). From 1990 till 2005, dairy and non-dairy cattle livestock population have decreased by 30.3% and 13.7%, respectively; whereas swine has increased by 9.4%. Consequently, manure management emissions are mainly been driven down due to the reduction in number of cattle. We have to consider that cattle CH_4 emissions contribute with 39.5% (in 1990 with 47.3%) to total manure management emissions and swine with 46.2% (in 1990 with 41.4%). In Table 6.17, CH_4 emission trends from manure management are presented.

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

Year	Dairy cattle	Non-dairy cattle	Buffalo	Sheep	Goat	Horse	Other equines	Poultry	Swine	Rabbit	TOTAL
						Gg					
1990	39.74	38.18	1.15	1.90	0.18	0.43	0.07	13.82	68.19	1.19	**164.86**
1991	35.12	42.40	0.99	1.83	0.18	0.46	0.06	13.80	68.70	1.27	**164.82**
1992	32.26	41.15	1.24	1.84	0.20	0.47	0.05	13.77	66.38	1.31	**158.67**
1993	31.86	40.36	1.20	1.89	0.20	0.48	0.04	13.82	67.16	1.32	**158.32**
1994	29.93	39.40	1.29	2.17	0.24	0.48	0.04	14.24	64.20	1.35	**153.34**
1995	30.85	40.01	1.77	2.32	0.20	0.47	0.03	14.67	64.79	1.36	**156.48**
1996	30.88	39.14	2.04	2.38	0.21	0.46	0.03	14.57	65.80	1.39	**156.90**
1997	30.89	38.76	1.92	2.37	0.20	0.46	0.03	14.87	65.36	1.40	**156.26**
1998	31.52	38.00	2.25	2.37	0.19	0.43	0.03	15.85	65.90	1.41	**157.94**
1999	31.62	38.47	2.43	2.40	0.20	0.43	0.03	15.67	66.80	1.44	**159.48**
2000	30.80	37.92	2.25	2.41	0.20	0.41	0.03	14.09	66.56	1.42	**156.10**
2001	31.92	36.86	2.28	1.81	0.15	0.42	0.03	16.68	67.24	1.46	**158.85**
2002	28.17	34.54	2.61	1.77	0.14	0.41	0.02	16.39	69.85	1.48	**155.39**
2003	28.11	34.47	2.89	1.73	0.14	0.42	0.02	15.68	69.93	1.45	**154.84**
2004	26.73	33.38	2.70	1.76	0.14	0.41	0.02	15.27	68.14	1.69	**150.26**
2005	26.44	32.74	2.52	1.73	0.15	0.41	0.03	15.05	69.24	1.69	**150.00**

Table 6.17 Trend in CH_4 emissions from manure management (Gg)

In 2005, N_2O emissions from manure management were 5.9% (11.90 Gg N_2O) lower than in 1990 (12.65 Gg N_2O); the major contribution is given by the solid storage system with 88.4% (in 1990 with 95.1%). In Table 6.18, N_2O emissions for the different manure management systems are presented.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
									Gg							
Liquid system	0.62	0.62	0.59	0.59	0.57	0.57	0.56	0.56	0.56	0.56	0.54	0.54	0.52	0.52	0.51	0.51
Solid storage	12.03	12.01	11.50	11.39	11.37	11.54	11.61	11.63	11.72	11.80	11.36	11.79	11.04	10.90	10.64	10.51
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	0.87
TOTAL	**12.65**	**12.63**	**12.09**	**11.98**	**11.93**	**12.20**	**12.34**	**12.44**	**12.70**	**12.89**	**12.46**	**13.11**	**12.41**	**12.31**	**12.03**	**11.90**

Table 6.18 Trend in N_2O emissions due to manure management, (Gg)

6.3.4. Source-specific QA/QC and verification

In Table 6.19, past and future improvements in agreement with the QA/QC plan are presented.

Category/sub category	Parameter	Year of submission			Activities
		2006	2007	2008	
Livestock categories	Type of housing			√	A query on the type of housing of different livestock categories has been introduced in the Farm and structure survey 2005. Results are expected to be incorporated in submission 2008.
Livestock categories	Storage facilities			√	We expect to get more detailed data from the Farm and Structure Survey 2007, where a query related to storage facilities for slurry and solid manure have been incorporated.
Livestock categories	Type of housing			√	We expect to verify information obtain from the APAT/MINAMIENTE convention related to ammonia reduction (CRPA, 2006[b]).

Livestock categories	Biogas	√	√	In submission 2006, we have applied a reduction because of the recovery of biogas. Animal categories, which are involved, are swine and cattle. Update of biogas data coming from TERNA will be done every year.
Livestock categories	Cattle	√		In submission 2006, we have changed the distribution of solid and liquid manure according to the weight of animals, like this, GHG methodologies are consistent with the ammonia national inventory.

Table 6.19 Improvements for manure management category according to the QA/QC plan

6.3.5. Source-specific recalculations

In Table 6.20, we provide information on parameters used in 2005 and 2007. Since 2006 submission, country-specific parameters have been collected and updated from the Inter-regional nitrogen balance project. These parameters have been used for preparing UNFCCC/CLRTAP national emission inventories. Activity data for the rabbit category (number of animals) has been updated. We have applied a reduction of CH_4 because of biogas production for cattle and swine categories, as described in section 6.3.2.

6.3.6. Source-specific planned improvements

A national publication describes how future agricultural surveys will contribute to improving the national agriculture emission inventory (Cóndor et al., 2005). We expect results from the "farm and structure survey"[14] 2005 related to the type of housing. Moreover, information on the type of housing for swine and poultry are expected from the convention APAT/ Ministry for the Environment, Land and Sea. A new query on liquid and manure storage systems has been incorporated in the FSS 2007. As soon as data from the "farm and structure survey" 2005 and 2007 are available, we will update information on housing and storage systems. We are planning to prepare a specific survey together with ISTAT and CRPA for land spreading practices.

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

Livestock category			Average weight (kg) Submission 2005	Average weight (kg) Submission 2007	N exretion (kgN head^{-1} yr^{-1}) Submission 2005	N exretion (kgN head^{-1} yr^{-1}) Submission 2007
DAIRY CATTLE (*vacche da latte*)			650	603	94.9	116
NON- DAIRY CATTLE						
Less than 1 year (*)			190	Variable (218-228)	23.1	25.2 (**)
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
BUFFALO		Cow buffalo (*bufale*)	650	630	94.9	116
		Other buffaloes (*altri bufalini*)	300	313	35.2	52.2
OTHER SWINE	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)	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

Table 6.20. Parameters used in 2005 and 2007 submissions for the different livestock categories

(*) 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*); (**) values are variable for the time series.

6.4. Rice cultivation (4C)

6.4.1. Source category description

For the rice cultivation category, only CH_4 emissions are estimated, other GHGs do not occur; N_2O from fertilisation during cultivation has been estimated and reported in "Agricultural soils" under direct soil emissions - synthetic fertilizers. In 2005, CH_4 emissions from rice cultivation were 69.74 Gg, which represents 9.5% of CH_4 emissions for the agriculture sector (9.1% in 1990) and 3.69% for national CH_4 emissions (3.76% in 1990).
In Italy, CH_4 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 categories, the single aeration and multiple aeration, with CH_4 emissions of 9.36 Gg and 60.38 Gg, respectively.
In response to UNFCCC review processes from 2004 and 2005 (UNFCCC, 2005; 2004) and in consultation with an expert in CH_4 emissions and rice cultivation (Wassmann, 2005), since 2006 submission, a detailed methodology has been implemented. Therefore, new activity data and parameters have been used for the estimation of CH_4 emissions (Cóndor et al., 2007). We have established an expert group on rice cultivation together with the C.R.A. – Experimental Institute of Cereal Research – Rice Research Section of Vercelli. Different national experts from the rice cultivation sector have been also contacted [15]. Moreover, the quality of the Italian rice emission inventory has been verified by simulating with the DNDC[16] model. Initial results from Leip and Bocchi (2007) have found a high correspondence between the emission factors used for the Italian inventory and those simulated with DNDC model.

6.4.2. Methodological issues

For the estimation of CH_4 emissions from rice cultivation a detailed methodology has been implemented following IPCC guidelines (IPCC, 2006). We have considered country-specific circumstances and used 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 CH_4 emissions from rice cultivation

Parameters	Reference
Cultivated surface with "dry-seeded" technique (%)	Centro Ricerche sul Riso, 2006
Cultivated surface – national (ha)	ISTAT, 2007[d]; ISTAT, several years [a],[b]
Cultivated surface by rice varieties (ha)	ENR, 2007
Cultivation period of rice varieties (days)	ENR, 2007
Methane emission factor (kg CH_4 m^{-2} d^{-1})	Leip et al., 2002; Schutz et al., 1989[a], [b]
Crop production (t yr^{-1})	ISTAT, several years [a],[b]; ISTAT, 2007[d]
Yield (t ha^{-1})	Estimations based on cultivated surface and crop production data
Straw incorporation (%)	Expert judgement (Tinarelli, 2005; Lupotto et al., 2005)
Agronomic practices (%)	ISTAT, 2006[b]; Tinarelli, 2005; Lupotto et al., 2005; Zavattaro et. al, 2004; Baldoni & Giardini, 1989; Tinarelli, 1973; 1986
Scaling factors (SFw, SFp, SFo)	IPCC, 2006; Yan et. al, 2005

[15] 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).
[16] DNDC, Denitrification Decomposition model

Rice cultivation practise

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 (Regione Emilia Romagna, 2005; Mannini, 2004; Tossato & Regis, 2002). In Table 6.21, water regimes descriptions 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 & Giardini, 1989). 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 & Pruneddu, 1996).

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

Table 6.21 Water regimes in Italy and classification according to IPCC guidelines
(*) 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*).

In general, rice seeds are mechanically broadcasted in flooded fields. However, in Italy for the last 15 years, seeds are also drilled to dry soil in rows. The rice which has been 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 & 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 & Nguyen, 2004; Baldoni & Giardini, 1989; Tinarelli, 1973; 1986).

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 & Giardini, 1989).

In Italy, another type of fertilization practise is the incorporation of straw. The incorporation period can vary according to weather conditions, but probably mainly incorporated approximately one month before flooding (Russo, 1988; Russo 1976). Rice straw are 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).

Methane emission factor

An analysis on recent and past literature, for the CH_4 daily emission factor (kg CH_4 m^{-2} d^{-1}), has been done. Different scientific publications related to the CH_4 daily emission factor measurements 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, 1989[a],[b]; Holzapfel-Pschorn & Seiler, 1986), other publications are indirectly related with CH_4 production (Kruger et al., 2005; Weber et al., 2001; Dannenberg & Conrad, 1999; Roy et al., 1997). Butterbach-Bahl et al. have presented interesting results associated to the difference in EF of two cultivation periods (1990 and 1991). In these consecutive years, fields planted with rice cultivar Lido showed CH_4 emissions 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 CH_4 emission factor for years 1998 and 1999; values are similar to those presented in previous publications (Schutz, 1989[a], [b]; Holzapfel-Pschorn & Seiler, 1986). Leip et al., have also published specific CH_4 emission factors for a particular agronomic practice, which has been presented in Table 6.21, 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.

The estimation of CH_4 emissions for the rice cultivation category considers an irrigated regime, which includes intermittently flooded with single aeration and multiple aeration regimes. The CH_4 emission factor has been adjusted with the following parameters: daily integrated emission factor for continuously flooded fields without organic fertilizers, 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*). Scaling factor parameters have been updated according to a recent publication (Yan et al., 2005) and new IPCC 2006 Guidelines (IPCC, 2006). Assumptions of agronomic practices are described in Table 6.21; instead, parameters used for CH_4 emission estimations are shown in Table 6.22.

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)	38,775	92,630	92,630
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	2.1	2.1	2.1
Adjusted daily EF (g CH_4 m^{-2} d^{-1})	0.18	0.21	0.21
Days of cultivation (days)	137	155	155
Seasonal EF (g CH_4 m^{-2} yr^{-1})	24.15	32.59	32.59
Methane emissions (Gg)	9.36	30.19	30.19

Table 6.22. Parameters used for estimating CH_4 emissions from rice cultivation in 2005

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 2005, CH_4 emissions from rice cultivation were 6.3% (69.74 Gg CH_4) lower than in 1990 (74.39 Gg CH_4). In Italy, the driving force of CH_4 emissions from rice cultivation is the harvest area and the percentage of single aerated surface. Methane emissions have decreased by 6.3% and the harvest area has increased by 4.0%, from 215,442 ha $year^{-1}$ in 1990 to 224,015 ha $year^{-1}$ in 2005. The percentage of single aerated surfaces have increased from 1% (1990) to 17.3% (2005); 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 national available statistics (Centro Ricerche sul Riso, 2006). In Table 6.24, CH_4 emissions from rice cultivation and harvested area are presented.

6.4.4. Source-specific QA/QC and verification

In Table 6.23, improvements according to the QA/QC plan are shown.

Category/sub category	**Parameter**	**Year of submission**		**Activities**
		2006	**2007**	
Activity data	Days of cultivation from cultivars		√	Update of days of cultivation according to information available from ENR (2007)
Activity data	Cultivated surface		√	Update of days of cultivated surface according to information available from ENR (2007)

Table 6.23 Improvements for the rice cultivation category according to the QA/QC plan

6.4.5. Source-specific recalculations

In Table 6.24, CH_4 emission from 2005 and 2006 submissions are presented. Period of cultivation of varieties and cultivated surfaces have been updated for the rice cultivation sector.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
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	2.24
Emissions 2006 submission (Gg)	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	
Emissions 2007 submission (Gg)	74.4	71.1	73.9	77.5	79.2	78.9	77.3	76.9	73.0	71.3	65.8	65.8	67.6	69.6	71.9	69.7

Table 6.24 Harvest area and CH_4 emissions from the rice cultivation sector

6.4.6. Source-specific planned improvements

Lack of experimental data and knowledgement 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 the different number of aerations is practiced, which depends on the degree and the type of infestation, and the positive or negative results of the herbicide treatment application (Spanu, 2006). In Table 6.21, a general classification has been done for the most common agronomic practices in Italy. Since 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 Lombardia regions, represented 94.8% of the national surface area of rice cultivation, while in 2005 it represented 94.3% (ENR, 2007; Confalonieri and Bocchi, 2005).

6.5. Agriculture soils (4D)

6.5.1. Source category description

Direct and indirect N_2O emissions from agricultural soils are key sources at level and trend assessment, both with 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 2005, N_2O emissions from agricultural soils were 58.20 Gg, representing 83.0% of emissions for the agriculture sector (83.2% in 1990) and 44.7% for national N_2O emissions (55.1 % in 1990). Nitrous oxide emissions from this source mainly consist of direct soil emissions with 29.02 Gg and indirect soil emissions with 24.24 Gg.

In Italy, agricultural soil emissions are estimated for direct and indirect soils and animal production. For direct soil emissions the following 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”.

APAT is in charge of collecting, elaborating and reporting national emission inventories for UNFCCC and CLRTAP (APAT, 2005), using consistent methodologies and parameters. Since 2006 submission, UNFCCC/CLRTAP national inventories have been updated with country specific nitrogen excretion rates and emission factors. The nitrogen balance coming from the CLRTAP emission inventory feeds the UNFCCC inventory, specifically for the estimation of $FRAC_{GASM}$ and $FRAC_{GASF}$ parameters, which are used for calculating F_{AM} and F_{SN}. As requested in the review process (UNFCCC, 2005), a review of the $FRAC_{LEACH}$ parameter has been done. Italy has verified that the IPCC default value is similar to the country specific reference value reported for the main regional basin authority - Po Valley (ADBPO, 1994; ADBPO, 2001).

6.5.2. Methodological issues

Methodologies used for estimating N_2O emissions from "Agricultural soils" follow the IPCC approach. Emission factors suggested by IPCC (1997) and by the Research Centre on Animal Production (CRPA, 2000; CRPA, 1997[b]) have been used. Activity data have been collected from different sources, as described in the following box. In Table 6.33, time series of cultivated surface and crop production used for the preparation of the emission inventory are presented, instead in Table 6.31, the time series of the N content from fertilizers are shown.

Data used for estimating agricultural soil emissions

Data	Reference
Fertilizer distributed (t/yr)	ISTAT, 2007[c]; ISTAT, several years [a],[b]
Nitrogen content (%)	ISTAT, 2007[c]; ISTAT, several years [a],[b]
N excretion rates (kg $head^{-1}$ yr^{-1})	CRPA, 2006[a]; GU, 2006; Xiccato et al., 2005
Cultivated surface (ha yr^{-1})	ISTAT, 2007[d]; ISTAT, several years [a],[b]
Annual crop production (t yr^{-1})	ISTAT, 2007[d]; ISTAT, several years [a],[b]
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, 2007[a]; ISTAT, several years [a],[b]

For estimating N_2O 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 synthetic fertilizers (F_{SN}), animal waste applied to soil (F_{AM}), crop residues (F_{CR}), N-fixing crops (F_{BN}) and cultivation of histosols (F_{OS}) with the application of 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 as suggested by IPCC (1997).

Direct emissions

Synthetic fertilizers (F_{SN})

The total use of synthetic fertilizer (expressed in t N $year^{-1}$) has been estimated for each type of fertilizer from 1990 till 2005. The calculation of synthetic fertilizer use (F_{SN}**)** has been obtained by 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. N_2O emissions for synthetic fertilizers have been obtained multiplying F_{SN} by the emission factor 0.0125 kg N-N_2O/kg N (IPCC, 1997). In Table 6.25, fertilizer's distribution, nitrogen content, and total use of fertilizer are presented. In 2005, the total use of synthetic fertilizers was 779,846 t N, while F_{SN} parameter was 710,888 t N (time series Table 6.28). In the current submission, a specification for "Other nitrogenous fertilizers" has been introduced, as found from a national research study (ENEA, 2006). This improvement has been introduced since 1998, because of activity data availability. In Table 6.31, we present the time series of N content from fertilizers.

Type of fertilizers	Fertilizers distributed (t/yr)	Nitrogen content (%)	Total use of synthetic fertilizers (t N yr^{-1})
Ammonium sulphate	134,295	20.7%	27,855
Calcium cianamide	11,912	19.8%	2,357
Ammonium nitrate < 27%	406,372	22.3%	90,493
Ammonium nitrate > 27%	139,921	47.4%	66,313
Calcium nitrate	70,909	15.6%	11,066
Urea	691,255	46.0%	317,814
Other nitric nitrogen (*Altri azotati nitrico*)	151,816	26.8%	5,219
Other ammoniacal nitrogen (*Altri azotati ammoniacale*)	-	-	18,069
Other amidic nitrogenous (*Altri azotati ammidico*)	-	-	17,420
Phosphate nitrogen	393,804	17.7%	69,758
Potassium nitrogen	77,243	15.9%	12,289
NPK nitrogen	863,545	12.3%	106,384
Organic mineral	353,366	9.9%	34,809
TOTAL	**3,294,437**		**779,846**

Table 6.25 Total use of synthetic fertilizer in 2005 (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 country-specific nitrogen excretion rates (CRPA, 2006[a]; GU, 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 6.26). The estimation has followed the IPCC definition; therefore, the NH_3 and NO_x emissions from animal manure have been divided by the total nitrogen excreted. The F_{AM} (t yr^{-1}) value has been estimated by summing the F_{AM} for each livestock category; then emissions have been calculated with emission factor 0.0125 kg N-N_2O/kgN (IPCC, 1997). In 2005, F_{AM} parameter was 438,969 t N. The time series of $FRAC_{GASM}$ parameter used for the inventory is reported in Table 6.26.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
$FRAC_{GASF}$	0.087	0.087	0.086	0.090	0.091	0.089	0.085	0.086	0.089	0.091	0.089	0.089	0.090	0.090	0.091	0.088
$FRAC_{GASM}$	0.318	0.318	0.314	0.310	0.300	0.297	0.294	0.293	0.292	0.289	0.286	0.299	0.296	0.295	0.294	0.294

Table 6.26. $FRAC_{GASF}$ 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. Peculiarities that are present in Italy have been considered: N-fixing crops and legumes forage. F_{BN} has been calculated with two parameters: cultivated surface and nitrogen fixed per hectare (Erdamn 1959 in Giardini, 1983). Emissions have been calculated using the emission factor 0.0125 kg N_N2O/kgN (IPCC, 1997). In Table 6.27, cultivated surface from N-fixing species (ha yr^{-1}) and nitrogen fixed by each species (kg N ha^{-1} yr^{-1}) are presented. In 2005, F_{BN} parameter was 176,624 t N (time series Table 6.28).

Crop residues (F_{CR})

For the estimation of nitrogen input from crop residues (F_{CR}), a country-specific methodology has been used. For all crops, the total amount of crop residues has been estimated (t dry matter yr^{-1}), 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. The F_{CR} parameter has been obtained by adding the nitrogen content of cultivars crop residues. In 2005, F_{CR} parameter was 145,247 t N (time series Table 6.28). Emissions are calculated with emission factor 0.0125 kg N-N_2O/kg N (IPCC, 1997). The time series of crop residues production is shown in Table 6.33.

	Nitrogen fixed	**1990**	**1995**	**2000**	**2005**
	(kg N $ha^{-1}yr^{-1}$)		**(ha)**		
Bean, fresh seed (*fagiolo*)	40	29,096	23,943	23,448	23,146
Bean, dry seed (*fagiolo*)	40	23,002	14,462	11,046	8,755
Broad bean, fresh seed (*fava*)	40	16,564	14,180	11,998	9,484
Broad bean, dry seed (*fava*)	40	104,045	63,257	47,841	48,507
Pea, fresh seed (*pisello*)	50	28,192	21,582	11,403	11,636
Pea, dry seed (*pisello*)	72	10,127	6,625	4,498	11,134
Chickpea (*cece*)	40	4,624	3,023	3,996	5,256
Lentil (*lenticchia*)	40	1,048	1,038	1,016	1,786
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	152,331
Alfalfa (*erba medica)*	194	987,000	823,834	810,866	779,430
Clover grass (*trifoglio)*	103	224,087	125,009	114,844	103,677
TOTAL		**1,958,025**	**1,301,746**	**1,307,102**	**1,164,642**

Table 6.27. Cultivated surface and nitrogen fixed by each variety

Year	F_{SN} (t N)	F_{AM} (t N)	F_{BN} (t N)	F_{CR} (t N)	F_{os} (ha)
1990	691,723	475,266	254,654	147,541	9,000
1991	764,911	474,696	240,032	149,041	9,000
1992	808,237	455,743	228,560	152,456	9,000
1993	860,390	452,499	211,235	141,823	9,000
1994	795,479	446,134	201,884	141,799	9,000
1995	726,343	454,235	191,018	142,216	9,000
1996	691,890	455,113	190,601	145,826	9,000
1997	782,973	457,531	194,257	147,351	9,000
1998	703,640	464,430	202,718	150,090	9,000
1999	716,405	470,172	191,722	150,228	9,000
2000	715,366	457,993	189,545	144,372	9,000
2001	737,063	473,434	182,928	137,779	9,000
2002	745,286	453,207	177,529	142,457	9,000
2003	750,296	452,663	175,154	119,184	9,000
2004	765,064	441,006	172,532	143,168	9,000
2005	710,888	438,969	176,624	145,247	9,000

Table 6.28 Parameters used for the estimation of direct and indirect N_2O emissions

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 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 most prevalent.

Animal production

As mentioned in section 6.3.2, when estimating N_2O emissions from manure management, the amount related to manure excreted while grazing is subtracted and reported in “Agricultural soils” under animal production**.** In Table 6.15, nitrogen excretion rates - housing and grazing (kg $head^{-1}yr^{-1}$) used for estimations are presented. Nitrous oxide emissions are estimated with the 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).

Indirect emissions

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

- Atmospheric deposition
- Nitrogen leaching and run-off

The estimation of N_2O emissions due to atmospheric deposition of NH_3 and NO_x has followed the IPCC approach (IPCC, 1997). Parameters which have been used are: total use of synthetic fertilizer, t N yr^{-1}, $FRAC_{GASF}$ 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, 2000;

IPCC, 1997). The estimation of N_2O emissions due to nitrogen leaching and run-off has followed the IPCC approach (IPCC, 1997). Parameters which have been used are: total use of synthetic fertilizer, t N yr^{-1} (see Table 6.25), total N excreted by livestock (kg $head^{-1}$ yr^{-1}), $FRAC_{LEACH}$ emission factor 0.3 N/kg nitrogen of fertilizer or manure and the emission factor 0.025 Kg N_2O-N per kg nitrogen leaching/run-off (IPCC, 2000; IPCC, 1997). As mentioned above, the $FRAC_{LEACH}$ IPCC default value has been compared with the country specific $FRAC_{LEACH.}$ The last value is reported for the main basin in Italy where agriculture activities are concentrated (ADBPO, 2001; ADBPO, 1994).

6.5.3. Uncertainty and time-series consistency

Uncertainty for N_2O emissions from agricultural soils (direct soil emissions, indirect soil emissions and animal production) have been estimated to be 102%, as combination of 20% and 100% for activity data and emission factor, respectively. In the Table 6.29, time series of N_2O emission are reported.

Year	Direct Soil Emissions	Animal Production	Indirect Soil emissions	TOTAL
		Gg		
1990	30.94	5.60	26.16	62.70
1991	32.11	5.45	27.08	64.64
1992	32.43	5.47	27.08	64.98
1993	32.84	5.59	27.83	66.25
1994	31.25	6.27	26.96	64.48
1995	29.85	6.44	26.11	62.39
1996	29.25	6.58	25.51	61.34
1997	31.19	6.52	26.82	64.53
1998	29.99	6.50	25.84	62.33
1999	30.14	6.59	26.20	62.93
2000	29.72	6.60	25.73	62.06
2001	30.19	5.19	25.81	61.18
2002	29.94	5.03	25.27	60.24
2003	29.52	4.93	25.22	59.68
2004	30.01	4.98	25.15	60.14
2005	29.02	4.94	24.24	58.20

Table 6.29 Nitrous oxide emission trends from Agricultural soils (Gg)

In 2005, N_2O emissions from agricultural soils were 7.2% (58.20 Gg N_2O) lower than in 1990 (62.70 Gg N_2O). In 2005, major contributions come from direct soil emissions (29.02 Gg) and indirect soil emissions (24.24 Gg), which represent 49.9% and 41.6% of N_2O emissions, respectively. Indirect N_2O emissions from nitrogen leaching and run-off sub-category has the highest contribution with respect to total agricultural soil N_2O emissions, with 19.14 Gg N_2O, representing 32.9% Nitrous oxide emissions from leaching and run-off are related to the nitrogen content in fertilizers and animal wastes; therefore, emissions are mainly linked to the use of fertilizers in the country and the variation in livestock number. In 2005, the second main source respect to total N_2O emissions were direct emissions of synthetic fertilizers with 13.96 Gg (24.0%), followed by animal wastes applied to soils, with 8.62 Gg (14.8%). In Table 6.30, a time series of N_2O emissions is presented. We should highlight that between 1996 and 1997 there has been a high increase in nitrogen fertilizers in Italy, therefore, emissions from N_2O could be identified as outlier (see Table 6.31).

Year	Direct N_2O emissions					Animal Production	Indirect N_2O emissions	
	Synthetic fertilizer	Animal Wastes Applied to Soils	N-fixing Crops	Crop Residue	Cultivation of Histosols		Atmospheric Deposition	Nitrogen Leaching and Run-off
			Gg			Gg	Gg	
1990	13.59	9.34	5.00	2.90	0.11	5.60	5.95	20.22
1991	15.03	9.32	4.71	2.93	0.11	5.45	6.01	21.07
1992	15.88	8.95	4.49	2.99	0.11	5.47	5.84	21.23
1993	16.90	8.89	4.15	2.79	0.11	5.59	5.92	21.91
1994	15.63	8.76	3.97	2.79	0.11	6.27	5.76	21.20
1995	14.27	8.92	3.75	2.79	0.11	6.44	5.65	20.45
1996	13.59	8.94	3.74	2.86	0.11	6.58	5.51	20.00
1997	15.38	8.99	3.82	2.89	0.11	6.52	5.64	21.18
1998	13.82	9.12	3.98	2.95	0.11	6.50	5.57	20.27
1999	14.07	9.24	3.77	2.95	0.11	6.59	5.63	20.57
2000	14.05	9.00	3.72	2.84	0.11	6.60	5.45	20.28
2001	14.48	9.30	3.59	2.71	0.11	5.19	5.53	20.27
2002	14.64	8.90	3.49	2.80	0.11	5.03	5.34	19.93
2003	14.74	8.89	3.44	2.34	0.11	4.93	5.30	19.92
2004	15.03	8.66	3.39	2.81	0.11	4.98	5.23	19.92
2005	13.96	8.62	3.47	2.85	0.11	4.94	5.10	19.14

Table 6.30 Nitrous oxide emission trends from Agricultural soils (Gg)

6.5.4. Source-specific QA/QC and verification

Synthetic fertilizers and nitrogen content have been compared with the international FAO agriculture database statistics (FAO, 2007). In Table 6.31, 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) and 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. In Table 6.32, the QA/QC plan for this category is presented. In order to improve transparency, in Table 6.33, time series of activity data used for N_2O estimations have been provided.

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	772,227	845,000
1999	788,243	868,000
2000	785,593	828,000
2001	808,964	773,161
2002	819,352	785,314
2003	824,649	Not available
2004	841,363	Not available
2005	779,846	Not available

Table 6.31 Total annual N content in fertilizer applied from 1990 to 2005

Category/sub category	Parameter	Year of submission			Activities
		2006	2007	2008	
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).
Activity data	Fertilizer		√		From 1998-2005 we have divided urea and other nitrogen fertilizers, as suggested by a research study (ENEA, 2006).
Activity data	Fertilizer			√	Verify outcomes from APAT/MINAMBIENTE project for the use of slow release fertilizers.
Emission factor	Fertilizer	√			In submission 2006, we have updated the emission factor used for N-NOx estimations 0.3% to 0.7%.

Table 6.32 Improvements for the agricultural soils category in the QA/QC plan

Year	Cultivated surface (ha)	Crop production (t)	Total residue production (dry matter)
1990	2,128,674	82,247,958	20,719,032
1991	1,945,347	83,683,020	21,282,647
1992	1,831,020	86,462,112	21,505,656
1993	1,623,307	80,844,539	20,516,890
1994	1,568,346	81,267,156	20,465,054
1995	1,484,453	81,343,949	20,466,710
1996	1,484,242	83,163,618	21,302,559
1997	1,548,889	83,792,787	20,778,350
1998	1,622,647	84,466,234	21,453,885
1999	1,494,345	87,413,587	21,412,200
2000	1,491,315	82,090,948	20,685,353
2001	1,438,578	77,979,120	19,813,878
2002	1,350,329	82,289,945	20,647,499
2003	1,338,109	66,503,842	17,301,569
2004	1,314,187	81,401,102	21,350,712
2005	1,338,663	84,706,367	20,800,557

Table 6.33 Cultivated surface, crop production and total residue production time series

6.5.5. Source-specific recalculations

Activity data for cultivated surface and crop production have been updated from 2000 till 2004. We have also introduced a new classification of fertilizer, which are “Other nitrogenous fertilizers” since 1998 till 2005, because of data availability.

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 identified as key source. In 2005, CH_4 emissions from this source were 0.62 Gg, which represents only 0.084% of emissions for the agriculture sector (0.076% in 1990). Nitrous oxide emissions were 0.013 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. Different 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. Activity data time series, which is used for the estimation of GHGs are shown in Table 6.34.

Data used for estimating field burning of agriculture residues emission

Data	Reference
Annual crop production	ISTAT, 2007[d]; ISTAT, several years [a],[b]
Removable residues/product ratio	CESTAAT, 1988
Fixed residues/removable residues ratio	ENEA, 1994
Fraction of dry matter in residues	IPCC, 1997; CRPA/CNR, 1992; CESTAAT, 1988; Borgioli, 1981
Fraction of the field where "fixed" residues are burned	ANPA-ONR, 2001; CESTAAT, 1988; IPCC,1997
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

Year	Wheat	Barley	Maize	Oats	Rye	Rice	Sorghum
1990	8,108,500	1,702,500	5,863,900	298,400	20,800	1,290,700	114,200
1991	9,415,700	1,792,900	6,237,700	359,400	18,800	1,235,600	149,500
1992	8,938,400	1,742,087	7,394,100	333,100	22,586	1,271,600	178,700
1993	8,169,800	1,634,200	8,028,900	372,200	22,800	1,305,100	226,800
1994	8,251,401	1,467,378	7,483,438	354,660	20,295	1,360,519	236,060
1995	7,946,081	1,387,069	8,454,164	301,322	19,780	1,320,851	214,802
1996	8,424,492	1,350,494	9,547,541	351,622	20,400	1,359,697	209,191
1997	6,758,351	1,179,575	10,004,700	310,706	19,000	1,442,400	173,570
1998	8,338,301	1,359,076	9,054,600	362,627	20,100	1,407,100	159,872
1999	7,742,782	1,313,323	10,017,178	331,150	12,363	1,427,130	202,370
2000	7,427,660	1,261,560	10,139,639	317,926	10,292	1,245,555	215,200
2001	6,413,329	1,125,720	10,556,185	310,087	8,588	1,272,952	213,992
2002	7,547,763	1,190,326	10,554,423	328,759	9,631	1,378,796	215,072
2003	6,229,454	1,020,838	8,702,289	306,425	6,941	1,448,212	158,217
2004	8,638,721	1,156,620	11,368,007	337,694	7,851	1,523,436	215,394
2005	7,717,129	1,214,054	10,427,930	429,153	7,876	1,444,946	184,915

Table 6.34 Time series of activity data used for field burning of agricultural residues

The same methodology has been used to estimate emissions from burning of agriculture residues, 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 refer 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[17] (t), estimated with annual crop production, removable residues/product ratio, and “fixed” residue/removable residues ratio.
b) Amount of dry residues in “fixed” residue[18] (t dry matter), calculated with amount of burnable residues and fraction of dry matter.
c) Amount of “fixed” dry residues oxidized[19] (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[20] (t C), calculated with the amount of “fixed” dry residue oxidized and the fraction of carbon from the dry matter of residues.
e) $C\text{-}CH_4$ from stubble burning[21] (t $C\text{-}CH_4$), calculated with the amount of carbon from stubble burning release in air and default emissions rate for $C\text{-}CH_4$, equal to 0.005 (IPCC, 1997).

In 2005 final CH_4 emissions from on field burning of agriculture residues (0.62 Gg CH_4) have been estimated multiplying the $C\text{-}CH_4$ value (0.466 Gg $C\text{-}CH_4$) by the coefficient 16/12. In Table 6.35,

[17] Quantità di residuo "fisso" bruciabile (produzione totale) (ton)
[18] Quantità di residuo secco nel residuo "fisso" (tonnellate di sostanza secca)
[19] Quantità residuo secco "fisso" ossidato (ton di sost. secca)
[20] Quantità di carbonio rilasciato in aria dalla combustione delle stoppie (tonnellate di carbonio)
[21] Emissione di C-CH4 dalla combustione delle stoppie (tonnellate di C-CH4)

parameters used for the estimation of CH_4 emissions from on field burning of agriculture residues are shown.

Crop	Annual crop 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)	$C\text{-}CH_4$ from stubble burning (t $C\text{-}CH_4$)
Wheat (*frumento*)	7,717	1,331	1,136	99	48	241
Rye (*segale*)	8	1	1	0.11	0.04	0.19
Barley (*orzo*)	1,214	243	208	19	7	35
Oats (*avena*)	429	75	65	6	2	12
Rice (*riso*)	1,445	242	182	82	34	169
Maize (*granoturco)*	10,428	1,043	434	0	0	0
Sorghum (*sorgo da granella*)	185	65	54	5	2	9
TOTAL	21,426	3,000	2,079	211	93	466

Table 6.35 Parameters used for the estimation of CH_4 emissions from agriculture residues in 2005

For estimating N_2O 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[22] (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) $N\text{-}N_2O$ from stubble burning[23] (t $N\text{-}N_2O$), 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 2005, final N_2O emissions from on field burning of agriculture residues (0.013 Gg N_2O) are estimated by multiplying the $N\text{-}N_2O$ value (0.008 Gg N) with the coefficient 44/28. In Table 6.36, parameters used for the estimation of CH_4 emissions from field burning of agriculture residues are presented.

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)	$N\text{-}N_2O$ from stubble burning (t $N\text{-}N_2O$)
Wheat (*frumento*)	99	0.030	0.005	0.477	3.3
Rye (*segale*)	0.11	0.036	0.006	0.001	0.0
Barley (*orzo*)	19	0.037	0.006	0.111	0.8
Oats (*avena*)	6	0.040	0.006	0.037	0.3
Rice (*riso*)	82	0.041	0.007	0.536	3.8
Maize (*granoturco)*	0		0.007	0.000	0.0
Sorghum (*sorgo da granella*)	5	0.037	0.006	0.029	0.2
TOTAL	211			1.190	8.3

Table 6.36 Parameters used for the estimation of nitrous oxide from agriculture residues in 2005

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

6.6.3. Uncertainty and time-series consistency

Uncertainty for CH_4 and N_2O emissions from field burning of agriculture residues are estimated to be 54% as a result of 50% and 20% for activity data and emission factor, respectively. In 2005, CH_4 emissions from field burning of agriculture residues were 0.31% (0.623 Gg CH_4) higher than in 1990 (0.621 Gg CH_4). In 2005, N_2O emissions were 0.013 Gg N_2O. Variation in emissions trend is related to cereal production. In Table 6.37, CH_4 and N_2O time series are shown.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
									Gg							
CH_4 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	0.67	0.62
N_2O emissions	0.013	0.014	0.014	0.013	0.013	0.013	0.013	0.012	0.013	0.013	0.012	0.011	0.013	0.012	0.014	0.013

Table 6.37 CH_4 and N_2O emission trends from field burning of agriculture residues (Gg)

6.6.4. Source-specific QA/QC and verification

In Table 6.38, the QA/QC plan for this sector is presented:

Category/sub category	Parameter	Year of submission 2007	2008	Activities
Activity data	Annual crop production	√		Update activity data from 2000- 2004 according to data from ISTAT
Activity data	% 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 6.38 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 from 2000 till 2004 to last update from ISTAT.

6.6.6. Source-specific planned improvements

In response to the Italian Individual Review, future improvements will consider the validation of the parameter used for 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” 2003.

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 110.2 Mt of CO_2 removals from the atmosphere in 2005.
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 calculated by a growth model, applied to national forestry inventory data, with country specific used emission factors.

In 2005, CO_2 emissions and removals from forest land remaining forest land, from land converted to forest land, cropland remaining cropland are ranked among the top-10 level 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 2005 are shown in Figure 7.1.
In Table 7.1 emissions and removals time series is reported.

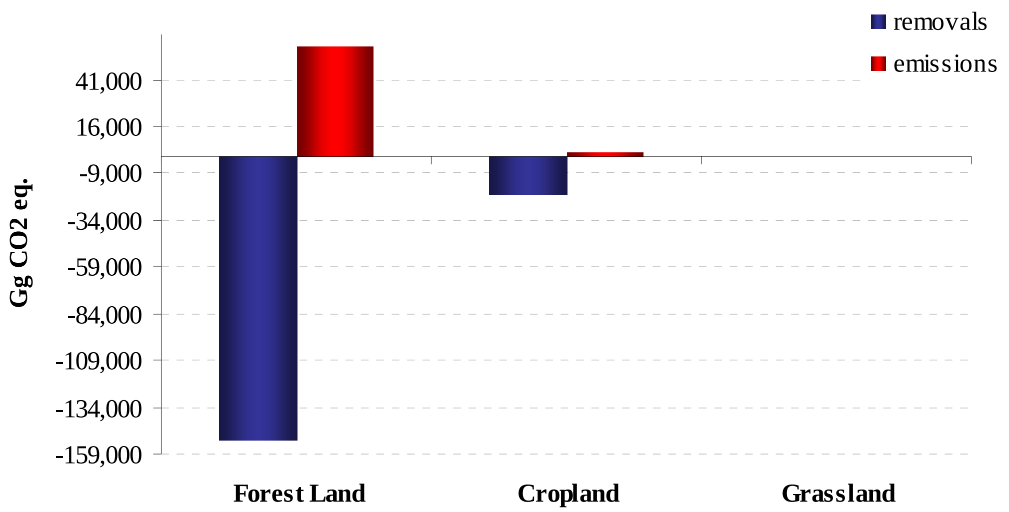

Figure 7.1 Greenhouse gas removals and emissions in LULUCF sector in 2005 (Gg CO_2 eq.)

GHG Gas Source and Sink Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
CO_2	**-79,992**	**-101,933**	**-98,070**	**-83,268**	**-98,853**	**-103,992**	**-106,858**	**-99,732**	**-96,581**	**-104,119**	**-98,097**	**-110,527**	**-114,671**	**-112,908**	**-105,504**	**-110,836**
A. Forest Land	-59,226	-80,871	-77,216	-62,782	-79,072	-84,419	-87,356	-79,988	-77,887	-85,586	-79,512	-88,094	-94,563	-84,672	-92,546	-92,330
B. Cropland	-22,047	-22,579	-22,337	-21,766	-21,061	-20,853	-20,481	-21,024	-19,974	-19,814	-19,866	-21,271	-21,129	-20,341	-14,238	-19,787
C. Grassland	0	-1,011	-1,048	0	0	0	-1,593	0	0	0	0	-3,721	-1,538	-10,454	0	0
D. Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Settlements	1,280	2,527	2,531	1,280	1,280	1,280	2,572	1,280	1,280	1,280	1,280	2,559	2,560	2,559	1,280	1,280
F. Other Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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**	**34.16**
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	34.16
B. Cropland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. Grassland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D. Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Settlements	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. Other Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N_2O	**30.92**	**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**	**870.26**	**132.27**
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	6.59
B. Cropland	16.42	0	0	39.65	100.23	80.40	0	20.24	160.25	227.42	221.00	0	0	0	866.75	125.68
C. Grassland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D. Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Settlements	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. Other Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LULUCF (*Gg CO2 equivalent*)	**-79,818**	**-101,233**	**-97,344**	**-82,402**	**-98,026**	**-103,222**	**-106,174**	**-98,970**	**-95,666**	**-103,185**	**-97,121**	**-109,806**	**-113,977**	**-112,177**	**-103,940**	**-110,010**

Table 7.1 Trend in greenhouse gas emissions from the LULUCF sector in the period 1990-2005 (Gg CO_2 eq.)

CO_2 emissions and removals in LULUCF sector, in the period 1990-2005 are shown in Figure 7.2.

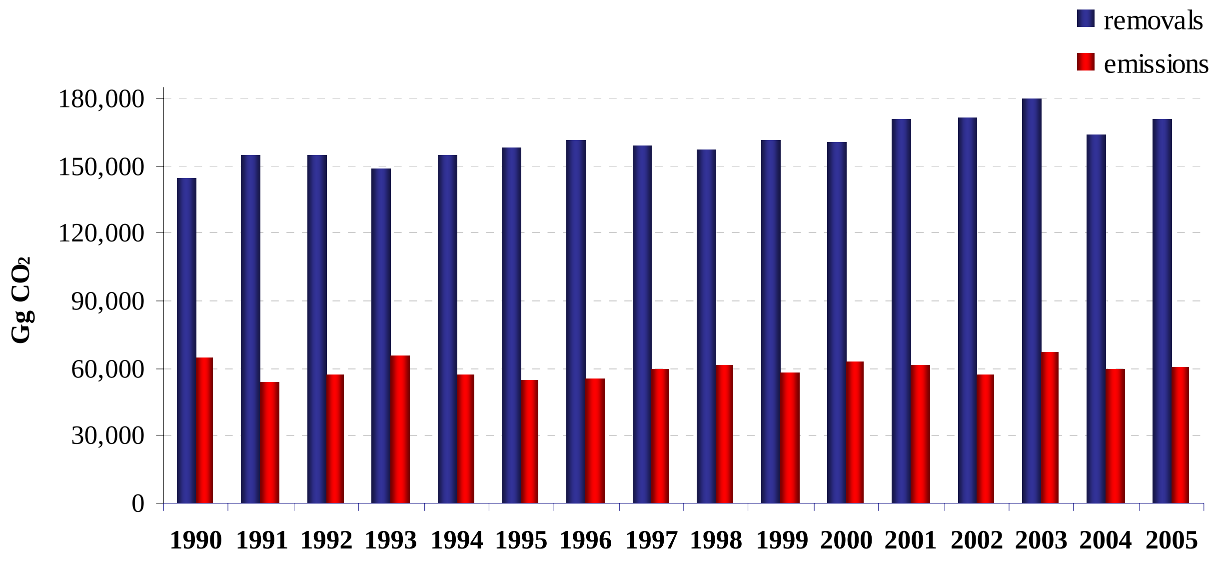

Figure 7.2 CO_2 removals and emissions in LULUCF sector in the period 1990-2005 (Gg CO_2)

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, conversion to cropland and land converted to settlements have been identified as key sources or sinks. Concerni 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	Land converted to forest land	key (L,T)
5.B.1	CO_2	Cropland remaining cropland	key (L, T)
5.B.2	CO_2	Land converted to cropland	key (T2)
5.C	CO_2	Grassland	Non-key
5.D	CO_2	Wetlands	Non-key
5.E	CO_2	Settlements remaining Settlements	Non-key
5.E	CO_2	Land converted to Settlements	key (L2, T2)
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	Land converted to cropland	Non-key

Table 7.2 Key categories identification in LULUCF sector

For the land use conversion, land use change (LUC) matrices have been used; the matrices have permit 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 1990–2005 have been assembled based on 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 (informed by expert judgement) of known patterns of land-use changes in Italy as well as the need for the total national area to remain 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 occurs. 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 reported as a whole in 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 and 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 most of the decomposition flux, commonly described by first-order decomposition kinetics (Olson, 1963). In a similar way, soils are expected to gain carbon in cropland converted to grassland (Guo & Giffort 2002, Post and Kwon 2000) at fast rates in the first stages of the conversion (Reeder 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.

Considering the spatial resolution of data used, 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, in spite of considering them over the time period (20 years as default) specified by IPCC LULUCF GPG (2003). From a technical point of view, we are confident to account, by this method, for the larger 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 1990–2005 are reported.

		1989						
		Forest	Grassland	Cropland	Wetland	Settlements	Other Land	*Initial sum*
	1990	9,145	7,683	11,021	57	1,340	887	*30,134*
1990	**Forest**	**9,145**						*9,145*
	Grassland	118	**7,683**	7		8		*7,683*
	Cropland		0	**11,021**		0		*11,021*
	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	9,380	7,474	10,979	57	1,356	887	*30,134*
1992	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	9,498	7,398	10,928	57	1,365	887	*30,134*
1993	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	9,616	7,256	10,945	57	1,373	887	*30,134*
1994	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	9,733	7,087	10,988	57	1,381	887	*30,134*
1995	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	9,851	6,927	11,022	57	1,389	887	*30,134*
1996	**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		422	**10,988**		8		*10,988*
	Wetland				**57**			*57*
	Settlements					**1,447**		*1,447*
	Other Land						**887**	*887*
	Final sum	*10,791*	*6,385*	*10,558*	*57*	*1,455*	*887*	30,134

		2003						
		Forest	**Grassland**	**Cropland**	**Wetland**	**Settlements**	**Other Land**	*Initial sum*
	2004	10,791	6,385	10,558	57	1,455	887	*30,134*
2004	**Forest**	**10,791**						*10,791*
	Grassland	118	**6,385**	369		8		*6,385*
	Cropland		0	**10,558**		0		*10,558*
	Wetland				**57**			*57*
	Settlements					**1,455**		*1,455*
	Other Land						**887**	*887*
	Final sum	*10,909*	*5,890*	*10,927*	*57*	*1,464*	*887*	30,134

		2004						
		Forest	**Grassland**	**Cropland**	**Wetland**	**Settlements**	**Other Land**	*Initial sum*
	2005	10,909	5,890	10,927	57	1,464	887	*30,134*
2005	**Forest**	**10,909**						*10,909*
	Grassland	118	**5,890**	54		8		*5,890*
	Cropland		0	**10,927**		0		*10,927*
	Wetland				**57**			*57*
	Settlements					**1,464**		*1,464*
	Other Land						**887**	*887*
	Final sum	*11,026*	*5,710*	*10,980*	*57*	*1,472*	*887*	30,134

Table 7.3 Land use change matrices for the years 1990-2005 (kha)

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 81% of total CO_2 2005 LULUCF emissions and removals, while the mean forest land removals for the years 1990-2005 is 78% 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 2005 forest land CO_2 removals, respectively.

Forest land	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
- living biomass	*36*	*44*	*43*	*39*	*44*	*45*	*46*	*44*	*44*	*45*	*44*	*46*	*47*	*45*	*47*	*47*
- dead organic matter	*9*	*8*	*9*	*9*	*9*	*8*	*8*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*
- soils	*55*	*48*	*49*	*52*	*48*	*47*	*46*	*47*	*47*	*46*	*47*	*45*	*44*	*46*	*45*	*45*

Table 7.4 Percentage contribution of carbon pools to forest land category, in 1990-2005 (%)

CO_2 removals from forest land remaining forest land have 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 identified as key category in level assessment (Tier 1);
Concerning the CH_4 and 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), estimating 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[24], 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 3×3 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 1×1 km, was 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. Assuming that the defined trend may well represent the near future, it was possible to extrapolate data for 2003-2005.
Additional source of information is the National Statistics Institute (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 2005, the following methodology was applied:

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[25], for each forest typology by the Italian yield tables collection.

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[24]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*

[25] 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.

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

where the general constrain for the parameters are the following:

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

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:

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

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 is 0.0116, concerning the evergreen forest, and 0.00117, for deciduous forest, according to the LULUCF GPG (IPCC, 2003).
The rate of draining and grazing, applied to protective forest, has been set as 3% following an 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]), even if data on biomass removed in commercial harvest published by ISTAT are probably underestimated, particularly concerning fuelwood consumption (Ciccarese et al., 1999). 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

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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 Jabssen and Heuberger (1995).

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.

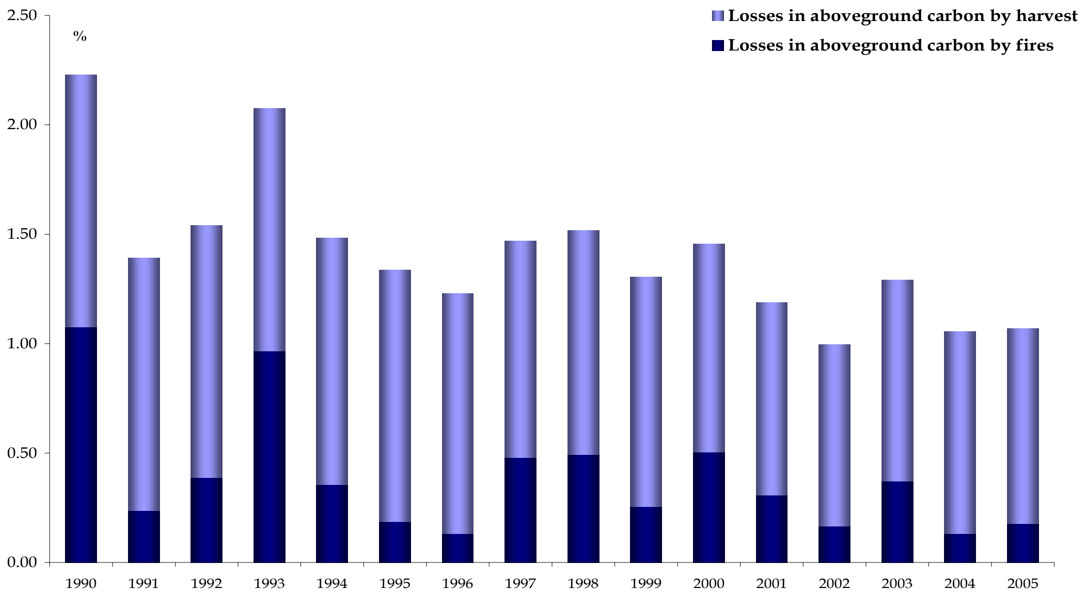

Figure 7.3 Losses by harvest and fires in relation to aboveground carbon (%)

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	3,596,645	5,003,270	562,517	1,312,728	10,475,160	4,476	7,257	591	1,985	14,091
1991	767,972	1,052,930	199,336	351,979	2,372,216	957	1,525	207	532	3,188
1992	1,189,490	1,877,685	265,576	604,804	3,937,556	1,485	2,714	273	913	5,285
1993	3,275,096	3,652,446	1,373,673	1,540,808	9,842,023	4,091	5,271	1,398	2,325	13,192
1994	1,255,037	912,150	891,531	723,258	3,781,975	1,570	1,314	900	1,091	5,065
1995	590,122	1,124,517	64,556	229,956	2,009,152	740	1,618	65	347	2,689
1996	607,367	574,242	86,291	196,597	1,464,497	762	825	86	296	1,960
1997	1,838,317	2,703,653	242,180	641,728	5,425,879	2,311	3,882	242	967	7,258
1998	2,263,406	1,820,796	657,517	945,449	5,687,168	2,848	2,611	655	1,424	7,605
1999	905,249	1,279,509	410,708	414,620	3,010,086	1,141	1,833	408	624	4,025
2000	2,296,806	2,204,157	618,686	910,445	6,030,094	2,897	3,155	614	1,370	8,061
2001	1,330,418	1,498,268	376,083	566,232	3,771,002	1,680	2,142	373	852	5,040
2002	614,215	1,041,473	69,448	351,051	2,076,187	777	1,488	69	528	2,775
2003	1,495,228	2,023,141	523,990	699,212	4,741,571	1,893	2,888	519	1,051	6,337
2004	532,272	770,050	62,397	331,883	1,696,602	675	1,098	62	499	2,267
2005	558,995	1,399,891	46,563	350,135	2,355,583	710	1,995	46	526	3,148

Table 7.5 Burned growing stocks (m^3) and CO_2 released (Gg) for the years 1990-2005

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 2005, 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 the 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 the 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 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

Belowground biomass was estimated applying a Root/Shoot ratio to the aboveground biomass. 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 LULUCF GPG (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[26]) of 20%, as the only available national information refers to dead standing trees in high forest stands.

[26] In accordance with the FAO –GFRA Update 2005 Specification of National Reporting Tables for FRA 2005 (FAO, 2004 [a])

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[27] (*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}] are reported.

	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

[27] CANIF project: http://www.bgc-jena.mpg.de/bgc-processes/research/Schulze_Euro_CANIF.html

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}] are 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	$y = 0.9843 \cdot x + 5.0746$
coppices	european beech	$y = 0.3922 \cdot x + 65.356$
	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, as requested by "*Report of the individual review of the greenhouse gas*

inventory of Italy submitted in 2005[28]" 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, are reported.

	Carbon stock change in living biomass			**Net C stock change in dead organic matter**	**Net C stock change in mineral soils**
	Increase	***Decrease***	***Net change***		
year			*Gg C*		
1990	293.56	-802.31	-508.75	17.97	3573.65
1991	294.45	-634.01	-339.56	23.22	3598.21
1992	295.11	-671.52	-376.41	22.21	3618.62
1993	295.61	-786.38	-490.77	19.68	3622.08
1994	295.86	-666.37	-370.51	22.56	3642.07
1995	296.04	-634.18	-338.13	22.93	3668.02
1996	296.31	-616.46	-320.14	23.73	3695.18
1997	296.35	-676.24	-379.89	21.84	3714.67
1998	296.20	-692.07	-395.87	21.26	3730.62
1999	296.32	-645.12	-348.80	23.02	3753.97
2000	296.49	-690.81	-394.32	21.73	3770.10
2001	296.47	-636.10	-339.63	23.11	3794.21
2002	296.41	-596.02	-299.62	24.15	3823.70
2003	296.42	-670.55	-374.12	21.96	3843.94
2004	296.41	-622.40	-325.99	23.35	3870.92
2005	296.39	-629.17	-332.78	22.90	3897.41

Table 7.10 Carbon stock changes in land converting to forest land (Gg C)

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 1990–2005, 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:

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

[28]UNFCCC 2006, Inventory Review Reports 2006: http://unfccc.int/resource/docs/2005/arr/ita.pdf

where the terms $V_{AG_{1985}}$, $V_{BG_{1985}}$, $V_{D_{1985}}$, $V_{L_{1985}}$ and $V_{S_{1985}}$ 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 are 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[29] 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 assess the litter and soil carbon stocks. In Table 7.12, the values of carbon stocks in the five pools for 1985 and the abovementioned uncertainties are reported:

[29] 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 (t CO_2 eq. ha^{-1}) 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 untill 2005, following the Tier 1 approach. The equation for the estimates of the 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 paragraph 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)[30]	E_{NFI}	51.6%
Harvest[31]	E_{H}	30%
Fire[32]	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 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 1990-2005 period are reported:

[30] 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
[31] Good Practice Guidance default value (IPCC, 2003)
[32] Good Practice Guidance default value (IPCC, 2003)

1985	84.91%
1986	84.81%
1987	88.09%
1988	88.32%
1989	88.26%
1990	88.25%
1991	88.15%
1992	87.97%
1993	87.93%
1994	87.84%
1995	87.65%
1996	87.46%
1997	87.32%
1998	87.22%
1999	87.07%
2000	86.93%
2001	86.77%
2002	86.57%
2003	86.41%
2004	86.27%
2005	86.09%

Table 7.16 Overall uncertainties 1985 – 2005 (%)

The overall uncertainty in the model between 1990 and 2005 has been assessed with the following relation:

$$E_{1990-2005} = \frac{\sqrt{(E_{1990} \cdot V_{1990})^2 + (E_{2005} \cdot V_{2005})^2}}{\left|V_{1990} + V_{2005}\right|}$$

where the terms 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 year 1990–2005 is equal to 61.75%.

The tables reporting the uncertainties referring to all the categories (Forest Land, Cropland, Grassland, Wetlands, Settlements, Other Land) are 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[33], ISTAT data[34]) has been done. Data entries have been checked several times during the compilation of the inventory; particular attention has been focussed on the categories showing significant changes between two years in succession. 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

[33] FAO, 2005. FAOSTAT, http://faostat.fao.org

[34] ISTAT, several years [a], [b], [c]

project to harmonise the estimation and reporting of EU member states, in 2003, led to a 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 IPCC LULUCF GPG (IPCC, 2003). Modest deviations from the precedent sectoral estimates occurred, essentially because of changes in the new data concerning harvested and burned areas, resulting in a mean increase of 0.3% in living biomass, 0.2% in dead organic matter and 0.1% in soils carbon pools estimates; the mean increase, in total forest land category, is equal to 0.2%, as shown in the figure 7.4.

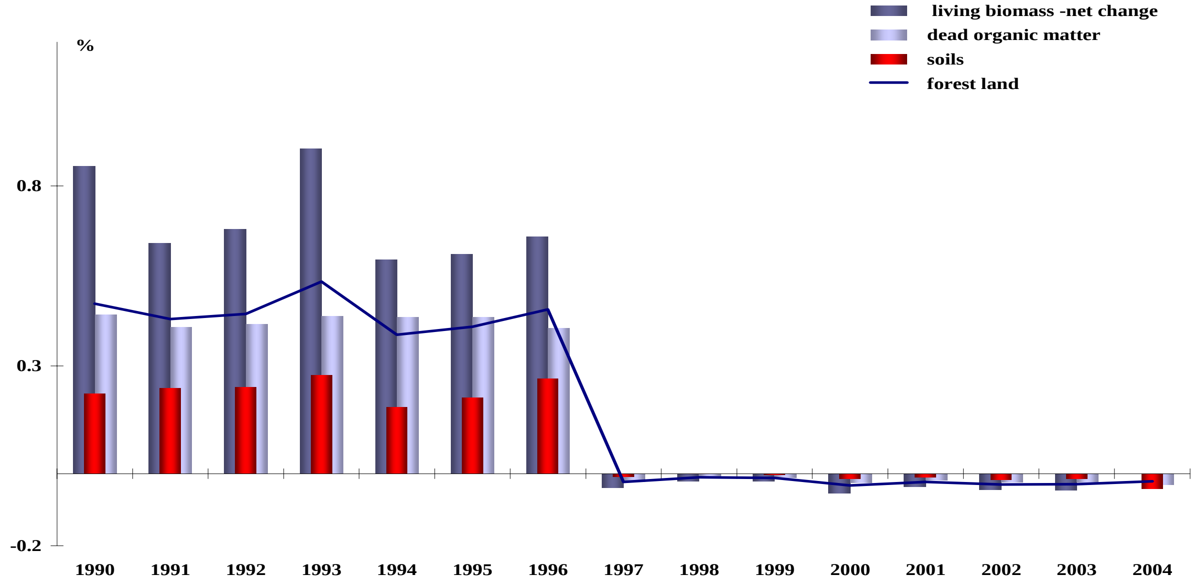

Figure 7.4 Difference between current and 2006 submission carbon pools estimates (%)

7.2.6 Source-specific planned improvements

The final result of the new forest inventory, available in 2007, will allow a more precise evaluation of the estimated time series, in order to reduce the related uncertainty. An expert panel on forest fires has been set up, in order to obtain geographically reference data on burned area; the overlapping of land use map and georeferenced data should assure the estimates of burned areas in the different land uses. 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 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 17.8% of total CO_2 LULUCF emissions and removals, in particular the living biomass removals represent 93%, while the emissions from soils stand for 7% 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 the 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 have been subdivided into annual and perennial woody crops.
The estimates of carbon stocks changes are applied to aboveground biomass only, according to the LULUCF 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 a period equal to a nominal harvest/maturity cycle (30 years for temperate climate region), as implied by the basic assumption of Tier 1, since the 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 5.546 Tg C for 2005, as well as 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 has been not 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 1990-2005 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 or dolomite to agricultural soils have occurred.

Land converted to Cropland

In accordance with the GPG methodology, estimates of carbon stock change in living biomass has 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 reported as a whole in 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). Considering the spatial resolution of data 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, in spite of considering them over the time period (20 years as default) specified by IPCC LULUCF GPG (2003).
CO_2 emissions from cultivated organic soils (CRPA, 1997) in cropland remaining cropland have been estimated, using default emission factor for warm temperate area, reported in Table 3.3.5 of LULUCF GPG (IPCC, 2003).
N_2O emissions arising from the conversion of land to cropland have been also estimated, and reported in the CRF 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 Italy) to cropland, during each year, from 1990 to 2005, 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 LULUCF GPG equation 3.3.8 (IPCC, 2003) has been used to estimate the change in carbon stocks resulting from the land use change.
Following the Tier1, the carbon stocks change per area for land converted to cropland is assumed 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 estimate for standing biomass grassland, as dry matter, reported in Table 3.4.2 of LULUCF GPG (IPCC, 2003) for warm temperate-dry has 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 to 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- 2005. C emissions [Gg C] due to change in carbon stocks in living biomass in land converted to cropland, are reported in Table 7.17.

	Conversion Area	$\Delta C_{\text{converted land}}$
year	*kha*	*Gg C*
1990	7	9.09
1991	0	0
1992	0	0
1993	17	21.95
1994	43	55.49
1995	34	44.51
1996	0	0.00
1997	9	11.2047
1998	68	88.71
1999	97	125.89
2000	94	122.34
2001	0	0
2002	0	0
2003	0	0
2004	369	479.80
2005	54	69.57

Table 7.17 Change in carbon stock in living biomass in land converted to cropland (Gg C)

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 30 cm has been estimated equal to 44,5 ± 10 t (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 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 (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
1990	7	-40.5
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	369	-2,135.1
2005	54	-309.6

Table 7.18 Change in carbon stock in soil in land converted to cropland (Gg C)

No CO_2 emissions from organic soils or from application of carbonate containing lime or dolomite to agricultural soils have occurred.

7.3.3 Source-specific recalculations

In response to the 2005 submission review process and in agreement with the LULUCF GPG, starting from 2006 inventory submission, soil emissions from cropland remaining cropland previously calculated on the only basis of changes in area surfaces and not to changes in management practices, have been deleted because not related to a real change in carbon content in soils. In the current submission, emissions from organic soils have been estimated: if carbon stock change from organic soils is not considered, no substantial differences are perceptible in the comparison between 2006 and 2007 submission. An exception has to be made for the 1990, where the variation is caused by a reporting mistake of 1990 activity data (in 2006 submission), and for 2004 where the increase of 5% is due to the updating of activity data by the National Institute of Statistics (ISTAT).

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 2005, because of the choice of the inventory time and the method applied (Tier 1) for the estimates of living biomass emissions. In the period 1990-2005 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 to the GPG no data regarding the dead organic matter pool have been provided, since not enough information is available.
According to the LULUCF GPG (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 has been not 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 1990-2005 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, estimates 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 the 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, estimate of carbon stock change in living biomass has 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 reported as a whole in 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, in spite of considering them over the time period (20 years as default) specified by IPCC LULUCF GPG (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 Italy) to grassland during each year, from 1990 to 2005, 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 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 the 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 1990-2005. C emissions [Gg C] due to change in carbon stocks in living biomass in land converted to grassland, are reported in Table 7.19.

year	Conversion Area *k ha*	C_{before} *t C ha^{-1}*	ΔC_{growth} *t C ha^{-1}*	ΔC *Gg C*
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	422	5	3.05	-823.1
2004	0	6	3.05	0
2005	0	6	3.05	0

Table 7.19 Change in carbon stock in living biomass in land converted to grassland (Gg C)

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 30 cm, has been estimated equal to 44,5 $\pm$ 10 t (Ciccarese *et al.*, 2000).
As mentioned above, 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 different 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. Finally, the annual change in carbon stocks in mineral soils has been 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.

	Conversion Area	Carbon stock
year	*k ha*	*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	422	3,674.1
2004	0	0
2005	0	0

Table 7.20 Change in carbon stock in soil (Gg C)

7.4.3 Source-specific recalculations

In response to the 2005 submission review process, as already reported in 2006 submission and in agreement with the LULUCF GPG (IPCC, 2003), emissions from grassland remaining grassland previously calculated on the basis of changes in area surfaces and not changes in management practices have been deleted, because not related to a real change in carbon content in soils. Recalculations of emissions and removals have been carried out on the basis of LULUCF GPG (IPCC, 2003). No differences are observable between the old and the new estimates, except for an increase of 16% in the year 2003, due to the updating of activity data by the National Institute of Statistics (ISTAT).

7.4.4 Source-specific planned improvements

Concerning land in transition to grassland, further investigation is planned 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[35], 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 1990-2005, no land has been in transition to wetlands.

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 and from land converted in settlements have been also reported. In the period 1990-2005 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 estimate the carbon stocks changes in living biomass, dead organic matter and soil for this category. Only activity data have been reported. Settlements time series has been developed through a linear interpolation between the 1990 and 2000 data, obtained by the Corine Land Cover[36] maps, relatively to the class "*Artificial surfaces*". Assuming that the defined trend may well be represent the near future, it was possible to extrapolate data for the years 2001-2005.

Land converted to Settlements

The average area of land undergoing a transition from non-settlements to settlements during each year, from 1990 to 2005, 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 1990-2005 period. Concerning grassland converted to settlements, no change in carbon stocks has been computed, as in Tier 1 no change in carbon stocks in the grassland living biomass pool has been assumed. Regarding 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.

[35] Ramsar Convention on Wetlands: http://www.ramsar.org/ (Ramsar, 2005)
[36] Corine Land Cover, http://www.clc2000.sinanet.apat.it/cartanetclc2000/ (APAT, 2004)

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

Table 7.21 Stock change factors for cropland (t C ha^{-1})

As indicated in the land use matrices of Table 7.3, the conversion of lands into settlements have taken place only in a few years during the period 1990-2005. 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.

	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	0.0
1991	2.17	-10.9	6.1	-383.4	-394.3
1992	2.16	-10.8	6.1	-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	6.3	-396.0	-405.9
1997	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	6.2	-392.4	-402.5
2002	2.03	-10.2	6.2	-392.4	-402.6
2003	2.03	-10.2	6.2	-392.3	-402.4
2005	0	0	0	0	0.0
2005	0	0	0	0	0.0

Table 7.22 Change in carbon stocks in living biomass in cropland converted to settlements (Gg C)

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.

7.6.3 Source-specific recalculations

Estimates of soil carbon stock changes resulting from transition of cropland and grassland to settlement have been provided. No differences are observable between the old and the new estimates, except for a difference of 0.36% in the year 2003, due to the updating of activity data by the National Institute of Statistics (ISTAT).

7.6.4 Source-specific planned improvements

Further investigation is planned 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 probed 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.

	annual crops to settlements		perennial crops to settlements		grassland to settlements	
Year	*Conversion Area k ha*	*Carbon stock Gg C*	*Conversion Area k ha*	*Carbon stock Gg C*	*Conversion Area k ha*	*Carbon stock 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	2.03	-68.25	6.23	-227	0	0
2004	0	0	0	0	8.26	-349.17
2005	0	0	0	0	8.26	-349.17

Table 7.23 Change in carbon stocks in soil in cropland and grassland converted to settlements (Gg C)

7.7 Other Land (5F)

Under this category, CO_2 emissions from living biomass, dead organic matter and soils and 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))

For 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 LULUCF GPG (IPCC, 2003) are reported. N_2O emissions from cropland remaining cropland are included in the agriculture sector. The GPG 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 2005, has been estimated with the land use change matrices; as abovementioned, only conversion from grassland to cropland has occurred in the Italian territory. The LULUCF 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 and 0.0125 kg N_2O-N/kg N for the C/N ratio and for calculating N_2O emissions from N in the soil respectively, 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	$N_{net\text{-}min}$	N_2O $_{net\text{-}min}$ -N	N_2O emissions
	k ha	*Gg C*	*kt N*	*kt N_2O-N*	*Gg N_20*
1990	7	40	3	0.034	0.053
1991	0	0	0	0	0
1992	0	0	0	0	0
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
1997	9	50	3	0.04155	0.065
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	0
2002	0	0	0	0	0
2003	0	0	0	0	0
2004	369	2,135	142	1.779	2.80
2005	54	310	21	0.258	0.41

Table 7.24 N_2O emissions from land-use conversion to cropland (Gg)

7.10.3 Source-specific recalculations

No significant differences are perceptible in the comparison between 2006 and 2007 submission. An exception has to be made for the 1990, where the variation is caused by a reporting mistake of 1990 activity data (in 2006 submission), and for 2004 where the increase of 10.6% is due to the updating of activity data by the National Institute of Statistics (ISTAT).

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.
IPCC method was followed for CH_4 and N_2O emissions, multiplying the amount of C released from 1990 to 2005 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:

	CH_4 emissions	N_2O emissions
year	*Gg*	*Gg*
1990	6.80	0.047
1991	1.74	0.012
1992	2.88	0.020
1993	7.18	0.049
1994	2.90	0.020
1995	1.30	0.009
1996	1.06	0.007
1997	3.53	0.024
1998	4.11	0.028
1999	2.02	0.014
2000	4.14	0.028
2001	2.63	0.018
2002	1.47	0.010
2003	3.09	0.021
2004	1.65	0.011
2005	1.63	0.011

Table 7.25 CH_4 and N_2O emissions from biomass burning (Gg)

7.12.3 Source-specific planned improvements

An expert panel on forest fires has been set up, in order to obtain geographically reference data on burned area; the overlapping of land use map and georeferenced data should assure the estimates of burned areas in the different land uses, with a particular focus on grassland fires in order to provide estimate of CO_2 emissions.

7.12.4 Source-specific recalculations

No variations are noticeable between previous and current submission CH_4 and N_2O emissions from forest fires.

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 3.34% (and was 3.47% 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	2000	2001	2002	2003	2004	2005
CO_2 (Gg)								
6C. Waste incineration	536.90	483.02	201.57	222.26	244.97	215.76	199.23	165.46
CH_4 (Gg)								
6A. Solid waste disposal on land	633.22	750.21	801.15	793.42	765.11	733.44	690.02	687.46
6B. Wastewater handling	93.74	104.46	108.66	109.77	110.23	109.56	109.98	110.58
6C. Waste incineration	7.65	12.91	11.94	12.98	12.59	12.85	16.20	14.14
6D. Other (compost production)	0.01	0.02	0.10	0.12	0.16	0.18	0.18	0.20
N_2O (Gg)								
6B. Wastewater handling	6.01	5.85	6.34	6.25	6.26	6.29	6.34	6.38
6C. Waste incineration	0.28	0.42	0.36	0.39	0.38	0.38	0.47	0.41

Table 8.1 Trend in greenhouse gas emissions from the waste sector 1990 – 2005 (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 at level assessment calculated with Tier 1 and Tier 2, whereas at trend assessment taking into account uncertainty; methane and nitrous oxide emission from wastewater handling is a key source at level and trend assessment, when taking into account 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, T2)
6B	CH_4	Emissions from wastewater handling	Key (L2, T2)
6B	N_2O	Emissions from wastewater handling	Key (L2, 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 36.3% (and was 31.9% 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 (MSW) 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.

The classification of landfills is changing from the old to the new definition, but almost for the municipal and inert wastes, landfill categories are the same. Methane emissions are expected only from non hazardous waste landfills due to biodegradability of wastes disposed; in the past, law's disposition forced only this category to have a collecting gas system. 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 municipal solid waste landfills have been found.

For the year 2005, the MSW landfills in Italy are 340, disposing 20,461 Mt of wastes.

Since 1999, the number of MSW landfills is diminished from 786 to 340, despite to the increase of the amount of wastes disposed of. In fact, both uncontrolled landfills and small controlled landfills have been progressively closed, especially in the south of the country, preferring the use of modern and larger plants, which cover large territorial areas.

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 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.

Since 1999, APAT yearly publishes a report, in which waste production data, as well as data concerning landfilling, incineration, composting and generally waste life-cycle data, are reported (APAT-ONR, several years).

As reported above, it has been assumed that waste landfilling started in 1950.

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 (MATTM, several years; FEDERAMBIENTE, 1992; AUSITRA-Assoambiente, 1995; ANPA-ONR, 1999 [a], [b]; APAT, 2002; APAT-ONR, several years;), national legislation

(Legislative Decree 5 February 1997, n.22), and regression models based on population (Colombari et al, 1998).
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 [a]) and a correlation function between GDP and waste production has been derived from 1975; 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 (MATTM, 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 P. 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 – 2005) 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.
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 – 2005), 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 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

Waste composition landfilled by weight ($KgRSUi\ 100Kg^{-1} wet\ RSU$)	1950 - 1970	1971 - 1990	1991 - 2005
Rapidly biodegradable	36.9%	45.4%	35.8%
Moderately biodegradable	3.6%	3.7%	3.9%
Slowly biodegradable	29.7%	19.6%	30.7%
Non biodegradable	29.8%	31.3%	29.6%
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 - 2005
Rapidly biodegradable			
- Managed landfill	90.5	85.1	81.8
- Unmanaged landfill	54.3	51.1	49.1
Moderately biodegradable			
- Managed landfill	118.2	118.2	118.2
- Unmanaged landfill	70.9	70.9	70.9
Slowly biodegradable			
- Managed landfill	224.1	224.1	205.9
- Unmanaged landfill	134.5	134.5	123.5

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 (TERNA, 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**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
MSW Production (Gg)	22,231	25,780	28,959	29,409	29,864	30,034	31,150	31,677
MSW Landfilled (%)	91.1	85.5	75.7	68.0	63.1	59.9	57.0	54.4
- in managed landfills	62.1	70.6	75.7	68.0	63.1	59.9	57.0	54.4
Sewage Sludge Landfilled (Gg)	2,764	3,170	3,170	3,194	3,022	3,117	3,258	3,235
Total MSW to landfills (Gg)	23,023	25,214	25,087	23,197	21,870	21,113	21,000	20,461

Table 8.8 Activity Data Solid Waste Disposal on Land, 1990 – 2005 (Gg)

EMISSIONS	**1990**	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Managed Landfills								
Methane produced (Gg)	575.1	770.1	965.7	1013.1	1027.5	1029.7	1030.9	1038.2
Methane recovered (Gg)	108.9	144.1	203.4	245.2	281.6	311.9	355.8	360.5
Methane recovered (%)	18.9	18.7	21.1	24.2	27.4	30.3	34.5	34.7
CH_4 net emissions (Gg)	414.2	556.0	677.2	682.1	662.6	637.6	599.7	602.0
NMVOC net emissions (Gg)	5.5	7.3	8.9	9.0	8.7	8.4	7.9	7.9
Unmanaged Landfills								
Methane produced (Gg)	222.0	196.7	125.6	112.8	103.9	97.1	91.5	86.6
Methane recovered (Gg)	0	0	0	0	0	0	0	1
CH_4 net emissions (Gg)	219.1	194.2	124.0	111.3	102.6	95.9	90.3	85.5
NMVOC net emissions (Gg)	2.9	2.6	1.6	1.5	1.4	1.3	1.2	1.1

Table 8.9 Methane produced, recovered and CH_4 and NMVOC net emissions, 1990 – 2005 (Gg)

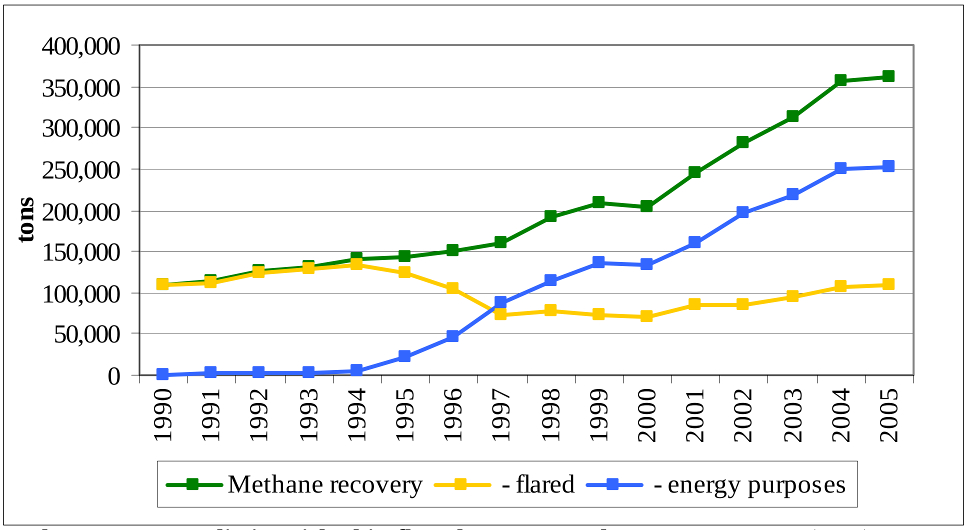

Figure 8.1 Methane recovery distinguished in flared amount and energy purposes (tons)

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.
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.
Moreover, the methodology, as well the parameters used in the calculation of the emissions from landfills, has been presented and discussed at the 10th International Trade Fair on Material and Energy Recovery and Sustainable Development, Ecomondo 2006 (Ecomondo, 2006).

8.2.5. Source-specific recalculations

Small differences occur in methane production and consequently in methane and NMVOC emissions, both for managed and unmanaged landfills, due to the influence of sludge disposed of. In fact, literature waste compositions, for each slot considered, do not include sludge component, which has been added in waste composition as a percentage of sludge disposed of into landfills on the total amount of waste landfilled in the period at which the waste composition refer (i.e. 1991 – 2005).
Since the amount of sludge for 2004 and 2005 has been updated and, a slightly difference in the percentage of sludge in the waste composition occurred.
A comparison with the previous estimation, in percentage terms, is reported in Table 8.10.

	1990	1991	1992	1995	1996	1997	2000	2001	2002	2003	2004
Managed Landfills											
Methane produced	0.00%	0.00%	-0.07%	-0.10%	-0.08%	-0.07%	-0.04%	-0.03%	-0.01%	0.00%	0.01%
Methane recovered	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CH_4 net emissions	0.00%	0.00%	0.07%	0.10%	0.08%	0.07%	0.04%	0.03%	0.01%	0.00%	-0.01%
NMVOC net emissions	0.00%	0.00%	-0.09%	-0.12%	-0.10%	-0.09%	-0.05%	-0.04%	-0.02%	0.00%	0.02%
Unmanaged Landfills											
Methane produced	0.00%	0.00%	-0.05%	-0.06%	-0.04%	-0.02%	0.05%	0.07%	0.09%	0.09%	0.10%
Methane recovered	-	-	-	-	-	-	-	-	-	-	-
CH_4 net emissions	0.00%	0.00%	-0.05%	-0.06%	-0.04%	-0.02%	0.05%	0.07%	0.09%	0.09%	0.10%
NMVOC net emissions	0.00%	0.00%	-0.05%	-0.06%	-0.04%	-0.02%	0.05%	0.07%	0.09%	0.09%	0.10%

Table 8.10 Differences in percentages between time series reported in the updated time series and 2006 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 2.7% 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 time series of the protein intake is from the yearly FAO Food Balance (FAO, several years).
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 IPCC 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, several years [a], [b] and [c]), 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, several years), organic chemicals (FEDERCHIMICA, several years), beer (Assobirra, several years), wine, milk and sugar sectors (ANPA-ONR, 2001), pulp and paper sector (ANPA-FLORYS, 2001; Assocarta, several years), and leather sector (ANPA-FLORYS, 2000; UNIC, several years).
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 0.6 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 2005 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); 3.35 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.
The CH_4 emission trend from wastewater and sludge generated by domestic and commercial wastewater treatment is reported in Table 8.14.

Wastewater production (1000 m^3)	1990	1995	2000	2001	2002	2003	2004	2005
Iron and steel	9,534	7,778	6,756	7,244	6,098	5,741	6,093	6,861
Oil refinery	NA	NA	NA	NA	NA	NA	NA	NA
Organic chemicals	210,936	212,317	215,049	214,670	214,525	214,573	214,869	214,735
Food and beverage	170,621	168,998	173,942	175,692	173,972	169,388	176,493	176,707
Pulp and paper	377,167	402,952	387,285	325,024	339,015	344,689	351,975	366,045
Textile industry	108,460	103,047	101,572	100,120	93,714	86,021	79,079	75,492
Leather industry	23,623	25,002	27,218	25,580	24,875	22,310	19,706	19,267
Total	900,341	920,095	911,822	848,330	852,198	842,721	848,214	859,108

Table 8.11 Total industrial wastewater production by sector, 1990 – 2005 (1000 m^3)

CH_4 Emissions (Gg)	1990	1995	2000	2001	2002	2003	2004	2005
Iron and steel	0.036	0.029	0.025	0.027	0.023	0.022	0.023	0.026
Oil refinery	5.850	5.625	4.250	4.750	4.750	4.750	4.750	4.750
Organic chemicals	23.794	23.911	24.173	24.205	24.210	24.172	24.204	24.177
Food and beverage	22.022	21.200	21.915	22.362	22.579	21.700	22.250	22.022
Pulp and paper	0.923	0.986	1.055	0.885	0.923	0.939	0.958	0.997
Textile industry	4.067	3.864	3.809	3.755	3.514	3.226	2.965	2.831
Leather industry	3.192	3.378	3.678	3.456	3.361	3.368	2.975	2.909
Total	59.88	58.99	58.90	59.44	59.36	58.18	58.13	57.71

Table 8.12 CH_4 emissions from anaerobic industrial wastewater treatment, 1990 – 2005 (Gg)

N_2O Emissions (Gg)	1990	1995	2000	2001	2002	2003	2004	2005
Industrial Wastewater	0.225	0.230	0.228	0.212	0.213	0.211	0.212	0.215
Human Sewage	5.787	5.619	6.115	6.040	6.042	6.079	6.123	6.162
Total	6.01	5.85	6.34	6.25	6.26	6.29	6.34	6.38

Table 8.13 N_2O emissions from industrial wastewater handling and human sewage, 1990 – 2005 (Gg)

Domestic and Commercial Wastewater	1990	1995	2000	2001	2002	2003	2004	2005
Wastewater (5% treated anaerobically)								
Organic loading in wastewater (t $year^{-1}$)	49.83	63.83	68.84	69.94	71.05	72.17	73.30	75.42
CH_4 emissions (Gg)	29.90	38.30	41.31	41.97	42.63	43.30	43.98	45.25
Sludge (generated by Imhoff tanks)								
Eq. inhabitants treated in Imhoff tanks (10^3 millions)	1,005	1,818	2,144	2,123	2,091	2,050	1,999	1,880
Organic loading in sludge (t $year^{-1}$)	6,606	11,942	14,087	13,946	13,739	13,468	13,132	12,352
CH_4 emissions (Gg)	3.96	7.17	8.45	8.37	8.24	8.08	7.88	7.41

Table 8.14 CH_4 emissions from sludge generated by domestic and commercial wastewater treatment, 1990 – 2005 (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).
Moreover, the methodology, as well the parameters used in the calculation of the emissions from wastewater handling, has been presented and discussed at the 10th International Trade Fair on Material and Energy Recovery and Sustainable Development, Ecomondo 2006 (Ecomondo, 2006).

8.3.5. Source-specific recalculations

Paper, leather and some food industrial productions, for specific years, have been update on the basis of new updated data published this year. However, the recalculation is not relevant.

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 2005, nearly 96% 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, several years).
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 (MATTM, several years; ANPA-ONR, 1999 [a] and [b]; APAT, 2002; APAT-ONR, several years; AUSITRA-Assoambiente, 1995; Morselli, 1998; FEDERAMBIENTE, 1998; FEDERAMBIENTE, 2001; AMA-Comune di Roma, 1996; Ambiente S.p.A., 2001; COOU, several years).
For each plant a lot of information is reported, among which the year of the construction and possible upgrade, the typology of combustion chamber and gas treatment section, if it is provided of energy recovery (thermal or electric), and the type and amount of waste incinerated (municipal, industrial, etc.).
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, both accounting nearly for 100% of the whole emissions from waste incineration. 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 8.15; CO_2 emission trends for each type of waste category are reported in Table 8.16, both for plants without energy recovery, reported under 6C, and plants with energy recovery, reported under 1A4a.
In Table 8.17 N_2O and CH_4 emissions are summarized, including those from open burning.
In the period 1990-2005, total CO_2 emissions have more than doubled, but whereas emissions from plants with energy recovery have increased by nearly 400%, emissions from plants without energy recovery decreased by nearly 70%.
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	2000	2001	2002	2003	2004	2005
MSW Production (Gg)	22,231	25,780	28,959	29,409	29,864	30,034	31,150	31,677
MSW Incinerated (%)	4.6%	5.6%	8.0%	8.8%	9.0%	9.5%	9.9%	10.2%
- in energy recovery plants	2.8%	4.6%	7.5%	8.3%	8.7%	9.3%	9.7%	10.0%
MSW to incineration (Gg)	1,026	1,437	2,325	2,599	2,698	2,853	3,088	3,221
Industrial, Sanitary, Sewage Sludge and Waste Oil to incineration (Gg)	691	773	737	930	883	1,134	1,637	1,707
Total Waste to incineration (6C and 1A4a) (Gg)	**1,716**	**2,209**	**3,062**	**3,528**	**3,581**	**3,987**	**4,725**	**4,927**

Table 8.15 Waste incineration activity data, 1990 – 2005 (Gg)

SUBSOURCE	1990	1995	2000	2001	2002	2003	2004	2005
Incineration of domestic or municipal wastes (Gg)	115.47	72.64	47.30	43.63	31.04	18.21	15.61	15.23
Incineration of industrial wastes (except flaring) (Gg)	283.31	272.85	113.09	140.84	183.64	151.11	138.35	104.82
Incineration of hospital wastes (Gg)	135.46	136.12	40.36	37.11	29.86	45.78	44.76	44.88
Incineration of waste oil (Gg)	2.66	1.41	0.82	0.67	0.43	0.65	0.51	0.53
Waste incineration (6C) (Gg)	**537**	**483**	**202**	**222**	**245**	**216**	**199**	**165**
Waste incineration reported under 1A4a (Gg)	569	835	1,331	1,598	1,546	1,923	2,634	2,789
Total waste incineration (Gg)	**1,105**	**1,318**	**1,532**	**1,820**	**1,791**	**2,139**	**2,833**	**2,955**

Table 8.16 CO_2 emissions from waste incineration (without and with energy recovery), 1990 – 2005 (Gg)

GAS/SUBSOURCE	1990	1995	2000	2001	2002	2003	2004	2005
N_2O (Gg)								
Waste incineration (6C)	0.28	0.42	0.36	0.39	0.38	0.38	0.47	0.41
MSW incineration reported under 1A4a	0.05	0.08	0.13	0.16	0.16	0.19	0.25	0.27
CH_4 (Gg)								
Waste incineration (6C)	7.65	12.91	11.94	12.98	12.59	12.85	16.20	14.14
MSW incineration reported under 1A4a	0.03	0.05	0.08	0.10	0.09	0.11	0.15	0.16

Table 8.17 N_2O and CH_4 emissions from waste incineration, 1990 – 2005 (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.
Moreover, the methodology, as well the parameters used in the calculation of the emissions from incineration, has been presented and discussed at the 10th International Trade Fair on Material and Energy Recovery and Sustainable Development, Ecomondo 2006 (Ecomondo, 2006).

8.4.5. Source-specific recalculations

For the year 2004, activity data from the incineration plants, which treat industrial waste, not previously available, have been published by APAT (APAT-ONR, several years) and so update.
In 2005, three new incineration plants that treat both municipal and industrial waste started their activity.
Moreover, in the framework of the implementing of local air emissions inventories, updated information on incineration plants previous to 1996 has been collected: as a consequence, some changes regarding the existence of energy recovery system have been occurred. Emissions have been reallocated between the sectors 6C and 1A4a: total emissions, especially for the base year are not changed.
In Table 8.18 differences with GHG emissions reported last year in percentages are reported.

GAS/SUBSOURCE	1990	1991	1992	1995	1996	1997	2000	2001	2002	2003	2004
CO_2											
Waste incineration (6C)	8.2%	8.0%	8.2%	1.7%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	-5.4%
MSW incineration reported under 1A4a	-6.7%	-6.3%	-6.5%	-0.9%	-0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	6.1%
N_2O											
Waste incineration (6C)	1.2%	0.7%	0.9%	0.2%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%	-0.2%
MSW incineration reported under 1A4a	-5.9%	-5.5%	-5.7%	-0.8%	-0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	5.3%
CH_4											
Waste incineration (6C)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
MSW incineration reported under 1A4a	-5.9%	-5.5%	-5.7%	-0.8%	-0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	5.3%

Table 8.18 Differences in percentages between the updated time series and the 2006 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 2005 (363,319 tons to 6,819,624 tons).
Information on input waste to composting plants are published yearly by APAT since 1996, including data for 1993 and 1994 (ANPA, 1998; APAT-ONR, several years), while for 1987 and 1995 only data on compost production are available (MATTM, several years; 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 8.19 CH_4 and NMVOC emissions are reported.

GAS	1990	1995	2000	2001	2002	2003	2004	2005
CH_4 (Gg)								
Compost production (6D)	0.011	0.023	0.097	0.125	0.157	0.179	0.176	0.200
NMVOC (Gg)								
Compost production (6D)	0.018	0.040	0.168	0.216	0.272	0.309	0.305	0.346

Table 8.19 CH_4 and NMVOC emissions from compost production, 1990 – 2005 (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.
Moreover, the methodology, as well as the parameters used in the calculation of the emissions from compost production, has been presented and discussed at the 10th International Trade Fair on Material and Energy Recovery and Sustainable Development, Ecomondo 2006 (Ecomondo, 2006).

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, changes due to error corrections and in consideration of new available information.
The complete revised CRFs from 1990 to 2004 have been submitted as well as the CRF for the year 2005 and recalculation tables of the CRF have been filled in. Explanatory information on the major recalculations between the 2006 and 2007 submissions are reported in Table 9.1.
The revisions that lead to relevant changes in GHG emissions are 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 2006 submission and the series reported this year (2007 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 LULUCF, the emission levels of the base year have not changed in comparison with the last year submission, whereas emissions for the year 2004 showed a decrease by 0.04%. Considering the national total with the LULUCF, the base year has decreased by 0.02, whereas the 2004 emission levels increased by 0.2%.
Detailed explanations of these recalculations are provided in the sectoral chapters. Changes affected estimates for the energy sector, due to a revision for 2004 of CO_2 emission factors related to coal and natural gas and more generally an update of the national energy balance for 2004. Other recalculations regarded the agriculture sector, principally for a revision of some parameters used to calculate CH_4 emission factor for rice cultivation and the waste sector for an update of information used to allocate emissions from waste incineration in plant with energy recovery.
Before the submission of the 2007 National Inventory Report, Italy was subjected to the in-country review of the Initial report under the Kyoto Protocol and 2006 Inventory. Following the recommendations of the review team the 2006 and 2007 submissions were revised and communicated again. These revisions affected CH_4 and N_2O emissions from Stationary combustion in the energy sector and N_2O emissions from human sewage in the waste sector.

Specify the sector and source/sink category(1) where changes in estimates have occurred:		GHG	RECALCULATION DUE TO CHANGES IN: Methods	Emission factors	Activity data	Addition/removal/ reallocation of source/sink categories	Other changes in data (e.g. statistical or editorial changes, correction of errors)
1.AA.1	Energy Industries	CO2		Coal and natural gas EFs have been updated	AD reported in the National energy balance have been updated		
1.AA.1	Energy Industries	CH4			AD reported in the National energy balance have been updated		
1.AA.1	Energy Industries	N2O			AD reported in the National energy balance have been updated		
1.AA.2	Manufacturing Industries and Construction	CO2		Coal, natural gas and LPG EFs have been updated	AD reported in the National energy balance have been updated		
1.AA.2	Manufacturing Industries and Construction	CH4			AD reported in the National energy balance have been updated		
1.AA.2	Manufacturing Industries and Construction	N2O			AD reported in the National energy balance have been updated		
1.AA.3	Transport	CO2			AD reported in the National energy balance have been updated		
1.AA.3	Transport	CH4			AD reported in the National energy balance have been updated		
1.AA.3	Transport	N2O			Update of railways activity data to avoid a double counting		
1.AA.4	Other Sectors	CO2		Coal and natural gas EFs have been updated	AD reported in the National energy balance have been updated		
1.AA.4	Other Sectors	CH4			AD reported in the National energy balance have been updated		
1.AA.4	Other Sectors	N2O			AD reported in the National energy balance have been updated		
1.B.2	Oil and Natural Gas	CO2			Basic data regarding the losses of crude oil used to balance CO2 emissions reported on the National Energy Balance have been updated		
1.B.2	Oil and Natural Gas	CH4		EFs for gas production have been updated			Some parameter of gas distribution and trasmission have been updated on the basis of new information
1.C1	International Bunkers	CO2			Update of activity data		
1.C1	International Bunkers	CH4			Update of activity data		
1.C1	International Bunkers	N2O			Update of activity data		
1.C3	CO2 Emissions from Bior	CO2			Update of wood and biomass combustion activity data		
2.F	Consumption of Halocarbons and SF6	HFC-23			Update of data supplied by the national industry that elaborates consumption data of HFCs		
2.F	Consumption of Halocarbons and SF6	HFC-32			Update of data supplied by the national industry that elaborates consumption data of HFCs		
2.F	Consumption of Halocarbons and SF6	HFC-32			Update of data supplied by the national industry that elaborates consumption data of HFCs		
2.F	Consumption of Halocarbons and SF6	HFC-125			Update of data supplied by the national industry that elaborate consumption data of HFCs		
2.F	Consumption of Halocarbons and SF6	HFC-125			Update of data supplied by the national industry that elaborates consumption data of HFCs		
2.F	Consumption of Halocarbons and SF6	HFC-134a			Update of data supplied by the national industry that elaborates consumption data of HFCs		
2.F	Consumption of Halocarbons and SF6	HFC-134a			Update of data supplied by the national industry that elaborates consumption data of HFCs		
2.F	Consumption of Halocarbons and SF6	HFC-143a			Update of data supplied by the national industry that elaborate consumption data of HFCs		
2.F	Consumption of Halocarbons and SF6	HFC-143a			Update of data supplied by the national industry that elaborates consumption data of HFCs		
2.F	Consumption of Halocarbons and SF6	HFC-227ea			Update of data supplied by the national industry that elaborates consumption data of HFCs		

2.F	Consumption of Halocarbons and SF6	CF4	Since no production occurs in Italy, imports and exports are assumed negligible, whereas imports are treated by semiconductor manufactors that use these substances				Potential emissions have been estimated
2.F	Consumption of Halocarbons and SF6	C2F6					Update due to an error in the estimating file
2.F	Consumption of Halocarbons and SF6	C2F6	Since no production occurs in Italy, imports and exports are assumed negligible, whereas imports are treated by semiconductor manufactors that use these substances				Potential emissions have been estimated
2.F	Consumption of Halocarbons and SF6	C3F8					Update due to an error in the estimating file
2.F	Consumption of Halocarbons and SF6	C3F8	Since no production occurs in Italy, we assume that import and exports are negligible, whereas imports are treated by semiconductor manufators that use these substances				Potential emissions have been estimated
2.F	Consumption of Halocarbons and SF6	C4F10	Since no production occurs in Italy, we assume that import and exports are negligible, whereas imports are treated by semiconductor manufators that use these substances				Potential emissions have been estimated
2.F	Consumption of Halocarbons and SF6	c-C4F8					Update due to an error in the estimating file
2.F	Consumption of Halocarbons and SF6	c-C4F8	Since no production occurs in Italy, we assume that import and exports are negligible, whereas imports are treated by semiconductor manufators that use these substances				Potential emissions have been estimated
2.F	Consumption of Halocarbons and SF6	C5F12	Since no production occurs in Italy, we assume that import and exports are negligible, whereas imports are treated by semiconductor manufators that use these substances				Potential emissions have been estimated
2.F	Consumption of Halocarbons and SF6	C6F14	Since no production occurs in Italy, imports and exports are assumed negligible, whereas imports are treated by semiconductor manufactors that use these substances				Potential emissions have been estimated
2.F	Consumption of Halocarbons and SF6	Unspecified m	Since no production occurs in Italy, we assume that import and exports are negligible, whereas imports are treated by semiconductor manufators that use these substances				Potential emissions have been estimated
2.F	Consumption of Halocarbons and SF6	SF6			SF6 imported by electrical industry have been added		
2.F	Consumption of Halocarbons and SF6	SF6					Update due to an error in the estimating file

3.00	Solvent and Other Product Use	CO2		NMVOC emission factor from olives oil extraction has been revised.	The time series of oil extraction has been revised due to the updating of data supplied by FAO.		Glues emissions have been revised because of an error
4.A	Enteric Fermentation	CH4			Updated milk production data from buffalo		
4.B	Manure Management	CH4			Update number of rabbits		
4.B	Manure Management	N2O			Update number of rabbits		
4.C	Rice Cultivation	CH4			Updated days of cultivation of rice		
4.D	Agricultural Soils	N2O			Updated livestock data, other nitrogenous fertilizers, surface/production data		
4.F	Field Burning of Agricultural Residues	CH4			Updated surface/production data		
4.F	Field Burning of Agricultural Residues	N2O			Updated surface/production data		
5.A	Forest Land	CO2			Activity data for forest have been updated, with data from forest fires and harvesting		
5.B	Cropland	CO2				The soils category subdivision was absent in previous Reporter release; data were submitted in previous Reporter release	
5.B	Cropland	N2O			Update of activity data		
6.A	Solid Waste Disposal on Land	CH4			Waste composition in landfills isreconstructed including sludge, but an error has been corrected: the percentage of sludge has slightly changed and consequently the content of DOC		
6.B	Wastewater Handling	CH4			Differences are due to the updating of activity data for some industrial sector		
6.B	Wastewater Handling	N2O			Differences are due to the updating of activity data for some industrial sector		
6.C	Waste Incineration	CO2			Differences in emissions for 2004 are due to the updating of activity data of industrial plants, that burn also municipal waste		
6.C	Waste Incineration	CH4			Differences in emissions for 2004 are due to the updating of activity data of industrial plants, that burn also municipal waste		
6.C	Waste Incineration	N2O			Differences in emissions for 2004 are due to the updating of activity data of industrial plants, that burn also municipal waste		

Table 9.1 Explanations of the main recalculations in the 2007 submission (CRF 2005)

TABLE 10 EMISSION TRENDS (SUMMARY) Italy
(Sheet 5 of 5) 2005

GREENHOUSE GAS EMISSIONS	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	CO2 equivalent (Gg)															
CO2 emissions including net CO2 from LULUCF	354,789.83	332,953.00	336,482.25	345,102.76	322,516.32	342,380.07	332,996.49	344,362.37	358,470.13	355,927.16	366,169.88	359,431.38	357,133.47	374,369.95	386,088.18	383,195.29
CO2 emissions excluding net CO2 from LULUCF	434,781.95	434,226.01	433,892.72	427,710.54	420,709.36	445,712.15	439,194.84	443,434.08	454,391.31	459,386.47	463,607.36	469,298.43	471,144.22	486,618.11	490,932.60	493,371.53
CH4 emissions including CH4 from LULUCF	41,711.64	42,908.99	42,303.53	42,693.06	43,272.45	44,085.64	44,138.57	44,526.07	44,236.46	44,272.01	44,367.40	43,331.00	41,744.14	41,089.10	39,910.98	39,755.62
CH4 emissions excluding CH4 from LULUCF	41,568.75	42,872.46	42,243.14	42,542.23	43,211.61	44,058.27	44,116.39	44,451.99	44,150.23	44,229.55	44,280.40	43,275.81	41,713.21	41,024.13	39,876.37	39,721.46
N2O emissions including N2O from LULUCF	38,039.53	39,001.66	38,442.82	39,009.05	38,167.78	38,813.20	38,546.70	39,823.67	39,969.38	40,740.10	41,111.00	41,233.89	40,700.76	40,407.91	42,563.97	40,498.32
N2O emissions excluding N2O from LULUCF	38,008.60	38,997.95	38,436.69	38,954.09	38,061.37	38,730.01	38,544.45	39,795.91	39,800.37	40,508.37	40,881.17	41,228.29	40,697.62	40,401.32	41,693.71	40,366.05
HFCs	351.00	355.43	358.78	355.42	481.90	671.29	450.33	755.74	1,181.72	1,523.65	1,985.67	2,549.75	3,099.90	3,795.82	4,515.13	5,267.21
PFCs	1,807.65	1,451.54	849.56	707.47	476.84	490.80	243.39	252.08	270.43	258.00	345.85	451.24	423.74	497.63	350.00	361.23
SF6	332.92	356.39	358.26	370.40	415.66	601.45	682.56	728.64	604.81	404.51	493.43	794.96	737.65	464.69	491.57	460.17
Total (including LULUCF)	**437,032.58**	**417,027.01**	**418,795.20**	**428,238.15**	**405,330.95**	**427,042.46**	**417,058.03**	**430,448.57**	**444,732.93**	**443,125.42**	**454,473.22**	**447,792.21**	**443,839.66**	**460,625.11**	**473,919.84**	**469,537.86**
Total (excluding LULUCF)	**516,850.89**	**518,259.78**	**516,139.14**	**510,640.15**	**503,356.73**	**530,263.99**	**523,231.95**	**529,418.43**	**540,398.87**	**546,310.56**	**551,593.87**	**557,598.47**	**557,816.34**	**572,801.70**	**577,859.38**	**579,547.66**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	CO2 equivalent (Gg)															
1. Energy	419,419.26	419,276.19	418,589.52	415,280.07	409,178.01	432,499.67	428,441.97	432,728.20	444,090.83	449,172.27	452,771.94	457,442.05	459,394.07	474,122.05	477,768.73	480,113.79
2. Industrial Processes	36,544.50	36,164.73	35,572.01	32,735.90	31,399.43	34,589.69	31,555.69	32,031.99	32,489.50	32,888.85	34,959.49	36,993.23	37,001.79	38,153.57	40,630.85	40,792.17
3. Solvent and Other Product Use	2,394.46	2,334.44	2,334.44	2,293.12	2,216.35	2,179.77	2,279.45	2,279.79	2,367.00	2,348.44	2,284.53	2,210.51	2,219.20	2,166.67	2,114.18	2,097.80
4. Agriculture	40,577.10	41,372.10	40,863.01	41,163.32	40,641.17	40,349.16	40,096.97	41,150.09	40,418.20	40,794.77	39,939.48	39,428.43	38,249.50	38,098.97	37,892.35	37,214.06
5. Land Use, Land-Use Change and Forestry(5)	-79,818.31	-101,232.78	-97,343.94	-82,402.00	-98,025.78	-103,221.53	-106,173.92	-98,969.87	-95,665.94	-103,185.13	-97,120.65	-109,806.26	-113,976.68	-112,176.59	-103,939.54	-110,009.81
6. Waste	17,915.56	19,112.33	18,780.16	19,167.74	19,921.76	20,645.71	20,857.87	21,228.37	21,033.33	21,106.22	21,638.43	21,524.26	20,951.77	20,260.43	19,453.27	19,329.84
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)(5)	**437,032.58**	**417,027.01**	**418,795.20**	**428,238.15**	**405,330.95**	**427,042.46**	**417,058.03**	**430,448.57**	**444,732.93**	**443,125.42**	**454,473.22**	**447,792.21**	**443,839.66**	**460,625.11**	**473,919.84**	**469,537.86**

Italy
2004

GREENHOUSE GAS EMISSIONS	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	CO2 equivalent (Gg)														
CO2 emissions including net CO2 from LULUCF	354,868.22	332,973.96	336,498.57	345,109.67	322,492.53	342,397.29	333,055.77	344,005.11	358,122.89	355,565.08	365,804.74	359,102.85	356,788.65	375,050.26	383,998.02
CO2 emissions excluding net CO2 from LULUCF	434,781.95	434,229.43	433,895.85	427,712.18	420,709.87	445,714.27	439,185.50	443,424.87	454,381.85	459,364.43	463,598.01	469,319.73	471,157.71	486,462.78	489,918.23
CH4 emissions including CH4 from LULUCF	41,711.64	42,909.08	42,316.45	42,708.52	43,290.02	44,096.90	44,185.07	44,614.68	44,339.97	44,407.92	44,375.63	43,330.01	41,727.50	41,100.09	39,920.59
CH4 emissions excluding CH4 from LULUCF	41,568.75	42,872.54	42,256.05	42,557.70	43,229.18	44,069.52	44,162.90	44,540.60	44,253.74	44,365.47	44,288.63	43,274.82	41,696.57	41,035.12	39,885.98
N2O emissions including N2O from LULUCF	38,057.86	39,001.66	38,442.82	39,009.05	38,167.78	38,823.32	38,553.36	39,832.15	39,991.15	40,771.94	41,103.75	41,233.47	40,716.26	40,141.70	42,380.20
N2O emissions excluding N2O from LULUCF	38,008.60	38,997.95	38,436.69	38,954.09	38,061.37	38,740.14	38,551.11	39,804.39	39,822.15	40,540.21	40,873.92	41,227.87	40,713.12	40,135.10	41,602.10
HFCs	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	1,451.54	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	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 (including LULUCF)	**437,129.30**	**417,048.06**	**418,824.43**	**428,260.52**	**405,324.73**	**427,081.06**	**417,170.32**	**430,187.98**	**444,510.22**	**442,859.27**	**454,128.89**	**447,675.45**	**443,952.36**	**461,852.03**	**473,007.12**
Total (excluding LULUCF)	**516,850.89**	**518,263.29**	**516,155.19**	**510,657.25**	**503,374.81**	**530,287.49**	**523,275.63**	**529,505.90**	**540,513.93**	**546,384.44**	**551,605.34**	**557,831.53**	**558,287.35**	**573,192.98**	**578,114.60**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	CO2 equivalent (Gg)														
1. Energy	419,460.89	419,318.75	418,635.10	415,302.11	409,196.39	432,512.65	428,446.30	432,739.95	444,081.80	449,150.60	452,756.73	457,455.40	459,423.14	473,960.10	476,706.63
2. Industrial Processes	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	2,337.86	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	40,577.10	41,372.19	40,863.10	41,163.34	40,641.19	40,349.18	40,125.95	41,210.45	40,530.28	40,949.36	39,928.53	39,421.27	38,221.72	37,840.53	37,838.56
5. Land Use, Land-Use Change and Forestry(5)	-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	-97,476.45	-110,156.09	-114,334.99	-111,340.95	-105,107.49
6. Waste	17,873.93	19,069.77	18,747.41	19,161.15	19,920.94	20,654.10	20,863.62	21,240.00	21,042.51	21,113.04	21,643.36	21,527.79	20,952.45	20,258.28	19,462.66
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)(5)	**437,129.30**	**417,048.06**	**418,824.43**	**428,260.52**	**405,324.73**	**427,081.06**	**417,170.32**	**430,187.98**	**444,510.22**	**442,859.27**	**454,128.89**	**447,675.45**	**443,952.36**	**461,852.03**	**473,007.12**
Total (excluding LULUCF)	**516,850.89**	**518,263.29**	**516,155.19**	**510,657.25**	**503,374.81**	**530,287.49**	**523,275.63**	**529,505.90**	**540,513.93**	**546,384.44**	**551,605.34**	**557,831.53**	**558,287.35**	**573,192.98**	**578,114.60**

Table 9.2 Comparison between the 2006 and 2007 submitted time series by gas and sector

		Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Net CO_2 emissions/removals (Gg CO_2 eq.)	2006 subm	354,868	332,974	336,499	345,110	322,493	342,397	333,056	344,005	358,123	355,565	365,805	359,103	356,789	375,050	383,998
	2007 subm	354,790	332,953	336,482	345,103	322,516	342,380	332,996	344,362	358,470	355,927	366,170	359,431	357,133	374,370	386,088
Difference		*-0.02%*	*-0.01%*	*0.00%*	*0.00%*	*0.01%*	*-0.01%*	*-0.02%*	*0.10%*	*0.10%*	*0.10%*	*0.10%*	*0.09%*	*0.10%*	*-0.18%*	*0.54%*
CO_2 emissions (without LULUCF) (Gg CO2-eq.)	2006 subm	434,782	434,229	433,896	427,712	420,710	445,714	439,186	443,425	454,382	459,364	463,598	469,320	471,158	486,463	489,918
	2007 subm	434,782	434,226	433,893	427,711	420,709	445,712	439,195	443,434	454,391	459,386	463,607	469,298	471,144	486,618	490,933
Difference		*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%*	*0.03%*	*0.21%*
CH_4 emissions (Gg CO_2-eq.)	2006 subm	41,712	42,909	42,316	42,709	43,290	44,097	44,185	44,615	44,340	44,408	44,376	43,330	41,727	41,100	39,921
	2007 subm	41,712	42,909	42,304	42,693	43,272	44,086	44,139	44,526	44,236	44,272	44,367	43,331	41,744	41,089	39,911
Difference		*0.00%*	*0.00%*	*-0.03%*	*-0.04%*	*-0.04%*	*-0.03%*	*-0.11%*	*-0.20%*	*-0.23%*	*-0.31%*	*-0.02%*	*0.00%*	*0.04%*	*-0.03%*	*-0.02%*
CH_4 emissions (without LULUCF) (Gg CO_2-eq.)	2006 subm	41,569	42,873	42,256	42,558	43,229	44,070	44,163	44,541	44,254	44,365	44,289	43,275	41,697	41,035	39,886
	2007 subm	41,569	42,872	42,243	42,542	43,212	44,058	44,116	44,452	44,150	44,230	44,280	43,276	41,713	41,024	39,876
Difference		*0.00%*	*0.00%*	*-0.03%*	*-0.04%*	*-0.04%*	*-0.03%*	*-0.11%*	*-0.20%*	*-0.23%*	*-0.31%*	*-0.02%*	*0.00%*	*0.04%*	*-0.03%*	*-0.02%*
N_2O emissions (Gg CO_2-eq.)	2006 subm	38,058	39,002	38,443	39,009	38,168	38,823	38,553	39,832	39,991	40,772	41,104	41,233	40,716	40,142	42,380
	2007 subm	38,040	39,002	38,443	39,009	38,168	38,813	38,547	39,824	39,969	40,740	41,111	41,234	40,701	40,408	42,564
Difference		*-0.05%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.03%*	*-0.02%*	*-0.02%*	*-0.05%*	*-0.08%*	*0.02%*	*0.00%*	*-0.04%*	*0.66%*	*0.43%*
N_2O emissions (without LULUCF) (Gg CO_2-eq.)	2006 subm	38,009	38,998	38,437	38,954	38,061	38,740	38,551	39,804	39,822	40,540	40,874	41,228	40,713	40,135	41,602
	2007 subm	38,009	38,998	38,437	38,954	38,061	38,730	38,544	39,796	39,800	40,508	40,881	41,228	40,698	40,401	41,694
Difference		*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.03%*	*-0.02%*	*-0.02%*	*-0.05%*	*-0.08%*	*0.02%*	*0.00%*	*-0.04%*	*0.66%*	*0.22%*
HFCs (Gg CO_2-eq.)	2006 subm	351	355	359	355	482	671	450	755	1,181	1,452	2,005	2,761	3,568	4,590	5,699
	2007 subm	351	355	359	355	482	671	450	756	1,182	1,524	1,986	2,550	3,100	3,796	4,515
Difference		*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.04%*	*0.05%*	*0.06%*	*4.95%*	*-0.99%*	*-7.67%*	*-13.12%*	*-17.30%*	*-20.78%*
PFCs (Gg CO_2-eq.)	2006 subm	1,808	1,452	850	707	477	491	243	252	270	258	346	452	414	484	407
	2007 subm	1,808	1,452	850	707	477	491	243	252	270	258	346	451	424	498	350
Difference		*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.25%*	*2.46%*	*2.72%*	*-13.92%*
SF_6 (Gg CO_2-eq.)	2006 subm	333	356	358	370	416	601	683	729	605	405	493	795	738	486	602
	2007 subm	333	356	358	370	416	601	683	729	605	405	493	795	738	465	492
Difference		*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.05%*	*-0.09%*	*-4.31%*	*-18.40%*
Total (with LULUCF) (Gg CO2-eq.)	2006 subm	437,129	417,048	418,824	428,261	405,325	427,081	417,170	430,188	444,510	442,859	454,129	447,675	443,952	461,852	473,007
	2007 subm	437,033	417,027	418,795	428,238	405,331	427,042	417,058	430,449	444,733	443,125	454,473	447,792	443,840	460,625	473,920
Difference		*-0.02%*	*-0.01%*	*-0.01%*	*-0.01%*	*0.00%*	*-0.01%*	*-0.03%*	*0.06%*	*0.05%*	*0.06%*	*0.08%*	*0.03%*	*-0.03%*	*-0.27%*	*0.19%*
Total (without LULUCF) (Gg CO2-eq.)	2006 subm	516,851	518,263	516,155	510,657	503,375	530,287	523,276	529,506	540,514	546,384	551,605	557,832	558,287	573,193	578,115
	2007 subm	516,851	518,260	516,139	510,640	503,357	530,264	523,232	529,418	540,399	546,311	551,594	557,598	557,816	572,802	577,859
Difference		*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.01%*	*-0.02%*	*-0.02%*	*-0.01%*	*0.00%*	*-0.04%*	*-0.08%*	*-0.07%*	*-0.04%*

Table 9.3 Differences in time series between the 2007 and 2006 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 2006, emission levels of the base year, total emissions in CO_2 equivalent without CO_2 emissions from LULUCF, have not changed.

If considering CO_2 emission levels with LULUCF, a decrease by 0.02% is observed between the 2006 and 2007 total figures in CO_2 equivalent, mainly due to the addition of CO_2 emissions from organic soils and to the revision of land use change matrices.

For the year 2004, changes affected negatively CH_4 (-0.02%) as well as HFCs (-20.8), PFCs (-13.9%) and SF_6 (–18.4%) whereas CO_2 and N_2O show an increase (+0.21% and 0.22%, respectively).
The trend ‘base year- year 2004’ does not show a significant change from the previous to this year 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 2006 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 2004 is reported in Table 8(a) of the CRF (year 2004).
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 - Industrial sector. No major recalculations occurred for these two sectors. A different allocation between energy and waste sector for emissions from incineration plants with energy recovery has been done for the years 1990-1995; PFCs potential emissions have been estimated.
Solvent and other product use sector. A revision of the time series for oil extraction due to the update of FAO statistics has been carried out.
Agriculture. Besides the update of different basic data, the main revision concerned some parameters used to calculate CH_4 emission factor for rice cultivation.
LULUCF. CO_2 emissions from organic soil have been added; land use change matrices have ben revised on the basis of a complete time series of soil surfaces and taking in account data reported in the CORINE land cover database.
Waste. A different allocation between energy and waste sector for emissions from incineration plants with energy recovery has been attributed for the years 1990-1995.

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. In 2007, before this submission Italy was also subject to the in-country review of the Initial report under the Kyoto protocol and the 2006 Inventory submission

Following the recommendations of the review processes different improvements have been carried out. The main improvement regards the completion of a National System in order to comply with the additional requirements of the Kyoto Protocol and the European Monitoring Mechanism. A QA/QC procedures manual has been compiled and QA/QC activities implemented.

Specifically, for inventory related issues, for the energy sector recalculations are due to a revision in the distribution between the energy and waste sectors on the basis of updated information on the facilities with the energy recovery in 1990. Revisions also affected CH_4 and N_2O emissions from Stationary combustion in the energy sector. In the waste sector, N_2O emissions from human sewage in the waste sector were revised. Potential PFCs have been estimate in this year submission.

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 2007submission.
Figures to draw up uncertainty analysis have been referenced and 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 officialization of a National System by the Ministry for the Environment, Land and Sea by the finalization of the institutional and legal arrangements required under the Kyoto Protocol.
A 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.

TABLE 8(a) RECALCULATION - RECALCULATED DATA — Italy

Recalculated year: 2003 — 2003

(Sheet 1 of 2) — 2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		CO2 Previous submission	CO2 Latest submission	CO2 Difference(1)	CH4 Previous submission	CH4 Latest submission	CH4 Difference(1)	N2O Previous submission	N2O Latest submission	N2O 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 — Italy

Recalculated year: 2003 — 2003

(Sheet 2 of 2) — 2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		CO2 Previous submission	CO2 Latest submission	CO2 Difference(1)	CH4 Previous submission	CH4 Latest submission	CH4 Difference(1)	N2O Previous submission	N2O Latest submission	N2O 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 Previous submission	HFCs Latest submission	HFCs Difference(1)	PFCs Previous submission	PFCs Latest submission	PFCs Difference(1)	SF_6 Previous submission	SF_6 Latest submission	SF_6 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 2004

Chapter 10: REFERENCES

References for the main chapters and the annexes are listed here and are organised by chapter and annex.

10.1 INTRODUCTION

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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 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 IPCC Good Practice Guidance 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 have 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, excluding and including the LULUCF sector. 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. For the base year, the level assessment of key categories has been carried out.

Summary of the results of the key category analysis, for the base year and 2005, is reported in Tables 1.3– 1.6 of chapter 1. The tables indicate whether a key category derives from the level assessment or the trend assessment, according to Tier 1, Tier 2 or both the methods.

For the base year, 18 sources were individuated according to the Tier 1 approach, whereas 21 sources were carried out by the Tier 2. Including the LULUCF categories in the analysis, 24 categories were selected jointly by the Tier 1 and the Tier 2.

For the year 2005, 17 sources were individuated by the Tier 1 approach accounting for 95% of the total emissions, without LULUCF; for the trend 14 key sources were selected. Jointly for both the Tier 1 level and trend, 21 key sources were totally individuated.

Repeating the *key category* analysis for the full inventory including the LULUCF categories, 19 categories were individuated accounting for 95% of the total emissions and removals in 2005, and, in trend assessment, 18 key categories are observed. Jointly for both the Tier 1 level and trend, 23 key categories were totally individuated.

The application of the Tier 2 to the 2005 emission levels gives as a result 21 key categories accounting for the 95% of the total levels uncertainty; when applying the trend analysis the key categories decreased to 20 with differences with respect to the previous list.
The application of the Tier 2 including the LULUCF categories results in 21 key categories, for the year 2005, accounting for the 95% of the total levels uncertainty; for the trend analysis including LULUCF categories, the key categories decreased to 19. Jointly for both the level and trend, 22 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:

$$\text{Key Category Level Assessment} = \frac{\left|\text{Source or Sink Category Estimate}\right|}{\text{Total Contribution}}$$

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:

$$\begin{aligned}&\text{Source or Sink Category Trend Assessment} = \\ &(\text{Source or Sink Category Level Assessment}) \cdot \left|\text{Source or Sink Category Trend - Total Trend}\right|\end{aligned}$$

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. For the base year, a level assessment is computed.
In this section, detailed results are reported only for the 2005 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	2005 Gg CO_2eq	Level assessment	Cumulative Percentage	CATEGORIES	% Contribution to trend	Cumulative Percentage
CO2 stationary combustion gaseous fuels	163,917	0.283	0.28	CO2 stationary combustion gaseous fuels	0.38	0.38
CO2 Mobile combustion: Road Vehicles	117,042	0.202	0.48	CO2 stationary combustion liquid fuels	0.37	0.75
CO2 stationary combustion liquid fuels	105,797	0.183	0.67	CO2 Mobile combustion: Road Vehicles	0.07	0.82
CO2 stationary combustion solid fuels	65,092	0.112	0.78	HFC, PFC substitutes for ODS	0.03	0.85
CO2 Cement production	17,886	0.031	0.81	CH4 Enteric Fermentation in Domestic Livestock	0.02	0.86
CH4 from Solid waste Disposal Sites	14,437	0.025	0.84	CH4 Fugitive emissions from Oil and Gas Operations	0.01	0.87
CH4 Enteric Fermentation in Domestic Livestock	10,852	0.019	0.85	CO2 Iron and Steel production	0.01	0.89
Direct N2O Agricultural Soils	8,997	0.016	0.87	N2O Mobile combustion: Road Vehicles	0.01	0.90
Indirect N2O from Nitrogen used in agriculture	7,513	0.013	0.88	Direct N2O Agricultural Soils	0.01	0.91
CO2 Mobile combustion: Waterborne Navigation	6,143	0.011	0.89	PFC Aluminium production	0.01	0.92
N2O Adipic Acid	6,073	0.010	0.90	CO2 Fugitive emissions from Oil and Gas Operations	0.01	0.93
CH4 Fugitive emissions from Oil and Gas Operations	5,644	0.010	0.91	Indirect N2O from Nitrogen used in agriculture	0.01	0.93
HFC, PFC substitutes for ODS	5,240	0.009	0.92	CO2 stationary combustion solid fuels	0.01	0.94
N2O stationary combustion	3,893	0.007	0.93	CO2 Ammonia production	0.01	0.95
N2O Mobile combustion: Road Vehicles	3,891	0.007	0.94	N2O Adipic Acid	0.01	0.96
N2O Manure Management	3,688	0.006	0.94	CO2 Mobile combustion: Aircraft	0.00	0.96
CH4 Manure Management	3,150	0.005	0.95	CH4 Manure Management	0.00	0.96
CO2 Lime production	2,674	0.005	0.95	N2O Manure Management	0.00	0.97
CO2 Mobile combustion: Aircraft	2,652	0.005	0.96	N2O Nitric Acid	0.00	0.97
CO2 Limestone and Dolomite Use	2,548	0.004	0.96	CH4 from Solid waste Disposal Sites	0.00	0.97
CH4 Emissions from Wastewater Handling	2,322	0.004	0.97	CO2 Emissions from solvent use	0.00	0.98
CO2 Mobile combustion: Other	2,251	0.004	0.97	CO2 Emissions from Waste Incineration	0.00	0.98
CO2 Fugitive emissions from Oil and Gas Operations	2,112	0.004	0.97	N2O from animal production	0.00	0.98
N2O Emissions from Wastewater Handling	1,977	0.003	0.98	CO2 Lime production	0.00	0.98
CO2 Other industrial processes	1,844	0.003	0.98	HFC-23 from HCFC-22 Manufacture and HFCs fugitiv	0.00	0.99
N2O Nitric Acid	1,688	0.003	0.98	CO2 Other industrial processes	0.00	0.99
N2O from animal production	1,532	0.003	0.99	CH4 from Rice production	0.00	0.99
CH4 from Rice production	1,464	0.003	0.99	CH4 Mobile combustion: Road Vehicles	0.00	0.99
CO2 Emissions from solvent use	1,320	0.002	0.99	PFC, HFC, SF6 Semiconductor manufacturing	0.00	0.99
CO2 Iron and Steel production	1,221	0.002	0.99	CO2 Cement production	0.00	0.99
CH4 stationary combustion	796	0.001	0.99	SF6 Production of SF6	0.00	0.99
N2O Emissions from solvent use	777	0.001	0.99	CO2 Mobile combustion: Other	0.00	0.99
CO2 Ammonia production	705	0.001	1.00	CH4 Emissions from Waste Incineration	0.00	0.99
CH4 Mobile combustion: Road Vehicles	571	0.001	1.00	N2O Emissions from solvent use	0.00	1.00
SF6 Electrical Equipment	318	0.001	1.00	CH4 Emissions from Wastewater Handling	0.00	1.00
CH4 Emissions from Waste Incineration	297	0.001	1.00	CO2 Limestone and Dolomite Use	0.00	1.00
PFC, HFC, SF6 Semiconductor manufacturing	245	0.000	1.00	N2O Emissions from Wastewater Handling	0.00	1.00
PFC Aluminium production	181	0.000	1.00	CO2 Mobile combustion: Waterborne Navigation	0.00	1.00
CO2 Emissions from Waste Incineration	165	0.000	1.00	SF6 Magnesium production	0.00	1.00
N2O Mobile combustion: Other	140	0.000	1.00	SF6 Electrical Equipment	0.00	1.00
N2O Emissions from Waste Incineration	128	0.000	1.00	CH4 stationary combustion	0.00	1.00
SF6 Magnesium production	85	0.000	1.00	CH4 Fugitive emissions from Coal Mining and Handlin	0.00	1.00
CH4 Fugitive emissions from Coal Mining and Handling	69	0.000	1.00	CH4 Industrial Processes	0.00	1.00
CH4 Industrial Processes	64	0.000	1.00	N2O stationary combustion	0.00	1.00
N2O Mobile combustion: Waterborne Navigation	45	0.000	1.00	N2O Emissions from Waste Incineration	0.00	1.00
CH4 Mobile combustion: Waterborne Navigation	32	0.000	1.00	N2O Other industrial processes	0.00	1.00
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	20	0.000	1.00	N2O Mobile combustion: Other	0.00	1.00
N2O Mobile combustion: Aircraft	19	0.000	1.00	N2O Mobile combustion: Aircraft	0.00	1.00
CH4 Agricultural Residue Burning	13	0.000	1.00	CH4 Emissions from Other Waste	0.00	1.00
CH4 Mobile combustion: Other	4.4	0.000	1.00	CH4 Agricultural Residue Burning	0.00	1.00
CH4 Emissions from Other Waste	4.2	0.000	1.00	N2O Mobile combustion: Waterborne Navigation	0.00	1.00
N2O Agricultural Residue Burning	4.1	0.000	1.00	CH4 Mobile combustion: Other	0.00	1.00
CH4 Mobile combustion: Aircraft	1.7	0.000	1.00	CH4 Mobile combustion: Aircraft	0.00	1.00
N2O Fugitive emissions from Oil and Gas Operations	1.5	0.000	1.00	CH4 Mobile combustion: Waterborne Navigation	0.00	1.00
N2O Other industrial processes	0.0	0.000	1.00	N2O Agricultural Residue Burning	0.00	1.00
SF6 Production of SF6	0.0	0.000	1.00	N2O Fugitive emissions from Oil and Gas Operations	0.00	1.00

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Table A1.1 Results of the key categories analysis (Tier1) without LULUCF categories

TIER 1

CATEGORIES	2005 Gg CO_2eq	Level assessment	Cumulative Percentage
CO2 stationary combustion gaseous fuels	163,917	0.236	0.24
CO2 Mobile combustion: Road Vehicles	117,042	0.169	0.40
CO2 stationary combustion liquid fuels	105,797	0.152	0.56
CO2 Forest land remaining Forest land	77,498	0.112	0.67
CO2 stationary combustion solid fuels	65,092	0.094	0.76
CO2 Cropland remaining Cropland	20,007	0.029	0.79
CO2 Cement production	17,886	0.026	0.82
CO2 Land converted to Forest Land	14,832	0.021	0.84
CH4 from Solid waste Disposal Sites	14,437	0.021	0.86
CH4 Enteric Fermentation in Domestic Livestock	10,852	0.016	0.87
Direct N2O Agricultural Soils	8,997	0.013	0.89
Indirect N2O from Nitrogen used in agriculture	7,513	0.011	0.90
CO2 Mobile combustion: Waterborne Navigation	6,143	0.009	0.91
N2O Adipic Acid	6,073	0.009	0.92
CH4 Fugitive emissions from Oil and Gas Operations	5,644	0.008	0.92
HFC, PFC substitutes for ODS	5,240	0.008	0.93
N2O stationary combustion	3,893	0.006	0.94
N2O Mobile combustion: Road Vehicles	3,891	0.006	0.94
N2O Manure Management	3,688	0.005	0.95
CH4 Manure Management	3,150	0.005	0.95
CO2 Lime production	2,674	0.004	0.96
CO2 Mobile combustion: Aircraft	2,652	0.004	0.96
CO2 Limestone and Dolomite Use	2,548	0.004	0.96
CH4 Emissions from Wastewater Handling	2,322	0.003	0.97
CO2 Mobile combustion: Other	2,251	0.003	0.97
CO2 Fugitive emissions from Oil and Gas Operations	2,112	0.003	0.97
N2O Emissions from Wastewater Handling	1,977	0.003	0.98
CO2 Other industrial processes	1,844	0.003	0.98
N2O Nitric Acid	1,688	0.002	0.98
N2O from animal production	1,532	0.002	0.98
CH4 from Rice production	1,464	0.002	0.99
CO2 Emissions from solvent use	1,320	0.002	0.99
CO2 Land converted to Settlements	1,280	0.002	0.99
CO2 Iron and Steel production	1,221	0.002	0.99
CO2 Land converted to Cropland	880	0.001	0.99
CH4 stationary combustion	796	0.001	0.99
N2O Emissions from solvent use	777	0.001	1.00
CO2 Ammonia production	705	0.001	1.00
CH4 Mobile combustion: Road Vehicles	571	0.001	1.00
SF6 Electrical Equipment	318	0.000	1.00
CH4 Emissions from Waste Incineration	297	0.000	1.00
PFC, HFC, SF6 Semiconductor manufacturing	245	0.000	1.00
PFC Aluminium production	181	0.000	1.00
CO2 Emissions from Waste Incineration	165	0.000	1.00
N2O Mobile combustion: Other	140	0.000	1.00
N2O Emissions from Waste Incineration	128	0.000	1.00
N2O Land converted to Cropland	126	0.000	1.00
SF6 Magnesium production	85	0.000	1.00
CH4 Fugitive emissions from Coal Mining and Handling	69	0.000	1.00
CH4 Industrial Processes	64	0.000	1.00
N2O Mobile combustion: Waterborne Navigation	45	0.000	1.00
CH4 Forest land remaining Forest land	34	0.000	1.00
CH4 Mobile combustion: Waterborne Navigation	32	0.000	1.00
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	20	0.000	1.00
N2O Mobile combustion: Aircraft	19	0.000	1.00
CH4 Agricultural Residue Burning	13	0.000	1.00
N2O Forest land remaining Forest land	6.6	0.000	1.00
CH4 Mobile combustion: Other	4.4	0.000	1.00
CH4 Emissions from Other Waste	4.2	0.000	1.00
N2O Agricultural Residue Burning	4.1	0.000	1.00
CH4 Mobile combustion: Aircraft	1.7	0.000	1.00
N2O Fugitive emissions from Oil and Gas Operations	1.5	0.000	1.00
N2O Other industrial processes	0.0	0.000	1.00
SF6 Production of SF6	0.0	0.000	1.00
SF6 Other sources of SF6	0.0	0.000	1.00
CH4 from Other agriculture	0.0	0.000	1.00

CATEGORIES	% Contribution to trend	Cumulative Percentage
CO2 stationary combustion liquid fuels	0.35	0.35
CO2 stationary combustion gaseous fuels	0.31	0.66
CO2 Forest land remaining Forest land	0.06	0.72
CO2 Mobile combustion: Road Vehicles	0.04	0.76
CO2 Cropland remaining Cropland	0.04	0.80
HFC, PFC substitutes for ODS	0.02	0.82
CO2 stationary combustion solid fuels	0.02	0.84
CH4 Enteric Fermentation in Domestic Livestock	0.02	0.85
CO2 Land converted to Forest Land	0.01	0.87
CH4 Fugitive emissions from Oil and Gas Operations	0.01	0.88
CO2 Iron and Steel production	0.01	0.89
Direct N2O Agricultural Soils	0.01	0.90
N2O Mobile combustion: Road Vehicles	0.01	0.91
Indirect N2O from Nitrogen used in agriculture	0.01	0.92
PFC Aluminium production	0.01	0.93
CO2 Fugitive emissions from Oil and Gas Operations	0.01	0.94
CO2 Ammonia production	0.01	0.94
CH4 from Solid waste Disposal Sites	0.00	0.95
CH4 Manure Management	0.00	0.95
N2O Manure Management	0.00	0.96
CO2 Mobile combustion: Aircraft	0.00	0.96
N2O Adipic Acid	0.00	0.96
CO2 Cement production	0.00	0.97
N2O Nitric Acid	0.00	0.97
CO2 Land converted to Cropland	0.00	0.97
CO2 Emissions from solvent use	0.00	0.98
N2O from animal production	0.00	0.98
CO2 Emissions from Waste Incineration	0.00	0.98
CO2 Land converted to Settlements	0.00	0.98
CO2 Other industrial processes	0.00	0.98
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	0.00	0.99
CH4 from Rice production	0.00	0.99
CO2 Lime production	0.00	0.99
CH4 Mobile combustion: Road Vehicles	0.00	0.99
PFC, HFC, SF6 Semiconductor manufacturing	0.00	0.99
CO2 Limestone and Dolomite Use	0.00	0.99
N2O Emissions from Wastewater Handling	0.00	0.99
N2O Emissions from solvent use	0.00	0.99
SF6 Production of SF6	0.00	1.00
CH4 Forest land remaining Forest land	0.00	1.00
CH4 Emissions from Waste Incineration	0.00	1.00
CO2 Mobile combustion: Waterborne Navigation	0.00	1.00
N2O Land converted to Cropland	0.00	1.00
SF6 Magnesium production	0.00	1.00
N2O stationary combustion	0.00	1.00
CH4 Fugitive emissions from Coal Mining and Handlin	0.00	1.00
SF6 Electrical Equipment	0.00	1.00
CO2 Mobile combustion: Other	0.00	1.00
CH4 Industrial Processes	0.00	1.00
CH4 stationary combustion	0.00	1.00
CH4 Emissions from Wastewater Handling	0.00	1.00
N2O Emissions from Waste Incineration	0.00	1.00
N2O Other industrial processes	0.00	1.00
N2O Forest land remaining Forest land	0.00	1.00
N2O Mobile combustion: Other	0.00	1.00
N2O Mobile combustion: Aircraft	0.00	1.00
CH4 Emissions from Other Waste	0.00	1.00
CH4 Agricultural Residue Burning	0.00	1.00
CH4 Mobile combustion: Waterborne Navigation	0.00	1.00
CH4 Mobile combustion: Other	0.00	1.00
N2O Mobile combustion: Waterborne Navigation	0.00	1.00
N2O Agricultural Residue Burning	0.00	1.00
CH4 Mobile combustion: Aircraft	0.00	1.00
N2O Fugitive emissions from Oil and Gas Operations	0.00	1.00
SF6 Other sources of SF6	0.00	1.00
CH4 from Other agriculture	0.00	1.00

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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 17 key sources accounting for the 95% of the total levels; when applying the trend analysis, excluding LULUCF categories, the key sources decreased to 15 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 19 key categories (sources and sinks) and 18 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 for the base year and the last submitted year. In this section, detailed results are reported only for the 2005 inventory.
The results of the approach are reported in Table A1.3, for the year 2005, 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.

Base year emissions 1990	Year t emissions 2005	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
155,077	105,797	3%	3%	0.042	0.008	-0.131	0.205	-0.004	0.009	0.010
59,395	65,092	3%	3%	0.042	0.005	-0.003	0.126	0.000	0.005	0.005
85,065	163,917	3%	3%	0.042	0.012	0.132	0.317	0.004	0.013	0.014
645	796	3%	50%	0.501	0.001	0.000	0.002	0.000	0.000	0.000
3,434	3,893	3%	50%	0.501	0.003	0.000	0.008	0.000	0.000	0.000
93,616	117,042	3%	3%	0.042	0.009	0.023	0.226	0.001	0.010	0.010
743	571	3%	10%	0.104	0.000	-0.001	0.001	0.000	0.000	0.000
1,605	3,891	3%	50%	0.501	0.003	0.004	0.008	0.002	0.000	0.002
5,401	6,143	3%	3%	0.042	0.000	0.000	0.012	0.000	0.001	0.001
29	32	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
39	45	3%	100%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
1,597	2,652	3%	3%	0.042	0.000	0.002	0.005	0.000	0.000	0.000
1	2	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
12	19	3%	100%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
1,888	2,251	3%	5%	0.058	0.000	0.000	0.004	0.000	0.000	0.000
5	4	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
131	140	3%	100%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
122	69	3%	300%	3.000	0.000	0.000	0.000	0.000	0.000	0.000
3,341	2,112	3%	25%	0.252	0.001	-0.003	0.004	-0.001	0.000	0.001
7,273	5,644	3%	25%	0.252	0.002	-0.005	0.011	-0.001	0.000	0.001
1	1	3%	25%	0.252	0.000	0.000	0.000	0.000	0.000	0.000
16,084	17,886	3%	10%	0.104	0.003	0.000	0.035	0.000	0.001	0.001
2,042	2,674	3%	10%	0.104	0.000	0.001	0.005	0.000	0.000	0.000
2,375	2,548	3%	10%	0.104	0.000	0.000	0.005	0.000	0.000	0.000
3,124	1,221	3%	10%	0.104	0.000	-0.004	0.002	0.000	0.000	0.000
1,710	705	3%	10%	0.104	0.000	-0.002	0.001	0.000	0.000	0.000
1,933	1,844	3%	10%	0.104	0.000	-0.001	0.004	0.000	0.000	0.000
4,579	6,073	3%	10%	0.104	0.001	0.002	0.012	0.000	0.000	0.001
2,086	1,688	3%	10%	0.104	0.000	-0.001	0.003	0.000	0.000	0.000
11	0	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.000
108	64	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
1,673	181	5%	10%	0.112	0.000	-0.003	0.000	0.000	0.000	0.000
0	85	5%	5%	0.071	0.000	0.000	0.000	0.000	0.000	0.000
213	318	5%	10%	0.112	0.000	0.000	0.001	0.000	0.000	0.000
0	0					0.000	0.000	0.000	0.000	0.000
120	0	5%	10%	0.112	0.000	0.000	0.000	0.000	0.000	0.000
0	245	30%	50%	0.583	0.000	0.000	0.000	0.000	0.000	0.000
134	5,240	30%	50%	0.583	0.005	0.010	0.010	0.005	0.004	0.007
351	20	5%	10%	0.112	0.000	-0.001	0.000	0.000	0.000	0.000
12,178	10,852	20%	20%	0.283	0.005	-0.005	0.021	-0.001	0.006	0.006
3,462	3,150	20%	100%	1.020	0.006	-0.001	0.006	-0.001	0.002	0.002
3,921	3,688	20%	100%	1.020	0.006	-0.001	0.007	-0.001	0.002	0.002
13	13	50%	20%	0.539	0.000	0.000	0.000	0.000	0.000	0.000
4	4	50%	20%	0.539	0.000	0.000	0.000	0.000	0.000	0.000
9,590	8,997	20%	100%	1.020	0.016	-0.003	0.017	-0.003	0.005	0.006
8,111	7,513	20%	100%	1.020	0.013	-0.003	0.015	-0.003	0.004	0.005
1,562	1,464	3%	20%	0.202	0.001	-0.001	0.003	0.000	0.000	0.000
0	0					0.000	0.000	0.000	0.000	0.000
1,736	1,532	20%	100%	1.020	0.003	-0.001	0.003	-0.001	0.001	0.001
13,298	14,437	20%	30%	0.361	0.009	-0.001	0.028	0.000	0.008	0.008
1,969	2,322	100%	30%	1.044	0.004	0.000	0.004	0.000	0.006	0.006
1,864	1,977	30%	30%	0.424	0.001	0.000	0.004	0.000	0.002	0.002
537	165	5%	25%	0.255	0.000	-0.001	0.000	0.000	0.000	0.000
161	297	5%	20%	0.206	0.000	0.000	0.001	0.000	0.000	0.000
88	128	5%	100%	1.001	0.000	0.000	0.000	0.000	0.000	0.000
0	4	10%	100%	1.005	0.000	0.000	0.000	0.000	0.000	0.000
1,598	1,320	30%	50%	0.583	0.001	-0.001	0.003	0.000	0.001	0.001
796	777	50%	10%	0.510	0.001	0.000	0.002	0.000	0.001	0.001
516,851	**579,548**				***0.032***					***0.026***

Table A1.3 Results of the uncertainty analysis excluding LULUCF (Tier1)

Tier 1 Uncertainty calculation and reporting: CO_2												
IPCC Sorce category	Gas	Base year emissions 1990	Year t emissions 2005	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	-59,226	-92,330	*30%*	*54%*	62%	51%	13%	115%	7%	49%	49%
B. Cropland	CO_2	-22,047	-19,787	*75%*	*75%*	106%	19%	-13%	25%	-10%	26%	28%
- *living biomass*	CO_2	*-22,525*	*-20,592*	*75%*	*75%*	*106%*	20%	-13%	26%	-10%	27%	29%
- *soils*	CO_2	*478*	*1,465*	*75%*	*75%*	*106%*	1%	-1%	2%	-1%	2%	2%
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		**-79,992**	**-110,836**				**55%**					**57%**

[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 2005**	**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	-59,068	-92,289	-	-	*62%*	54%	51%	14%	115%	7%	49%
B. Cropland	CO_2	-22,690	-19,661	*75%*	*75%*	*106%*	14%	19%	-14%	24%	-11%	26%
- *living biomass*	CO_2	-22,525	-20,592	*75%*	*75%*	*106%*	22%	20%	-13%	26%	-10%	27%
- *soils*	CO_2	-165	931	*75%*	*75%*	*106%*	8%	1%	-1%	1%	-1%	1%
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%	1%	2%	0%	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		**-80,478**	-110,670				**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 2005	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	155,077	105,797	3%	3%	0.042	0.006	-0.123	0.176	-0.004	0.007	0.008
CO2 stationary combustion solid fuels	CO2	59,395	65,092	3%	3%	0.042	0.004	-0.006	0.109	0.000	0.005	0.005
CO2 stationary combustion gaseous fuels	CO2	85,065	163,917	3%	3%	0.042	0.010	0.109	0.273	0.003	0.012	0.012
CH4 stationary combustion	CH4	645	796	3%	50%	0.501	0.001	0.000	0.001	0.000	0.000	0.000
N2O stationary combustion	N2O	3,434	3,893	3%	50%	0.501	0.003	0.000	0.006	0.000	0.000	0.000
CO2 Mobile combustion: Road Vehicles	CO2	93,616	117,042	3%	3%	0.042	0.007	0.014	0.195	0.000	0.008	0.008
CH4 Mobile combustion: Road Vehicles	CH4	743	571	3%	10%	0.104	0.000	0.000	0.001	0.000	0.000	0.000
N2O Mobile combustion: Road Vehicles	N2O	1,605	3,891	3%	50%	0.501	0.003	0.003	0.006	0.002	0.000	0.002
CO2 Mobile combustion: Waterborne Navigation	CO2	5,401	6,143	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	2,652	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	2,251	3%	5%	0.058	0.000	0.000	0.004	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	140	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	69	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	3,341	2,112	3%	25%	0.252	0.001	-0.003	0.004	-0.001	0.000	0.001
CH4 Fugitive emissions from Oil and Gas Operations	CH4	7,273	5,644	3%	25%	0.252	0.002	-0.005	0.009	-0.001	0.000	0.001
N2O Fugitive emissions from Oil and Gas Operations	N2O	1	1	3%	25%	0.252	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Cement production	CO2	16,084	17,886	3%	10%	0.104	0.003	-0.001	0.030	0.000	0.001	0.001
CO2 Lime production	CO2	2,042	2,674	3%	10%	0.104	0.000	0.001	0.004	0.000	0.000	0.000
CO2 Limestone and Dolomite Use	CO2	2,375	2,548	3%	10%	0.104	0.000	0.000	0.004	0.000	0.000	0.000
CO2 Iron and Steel production	CO2	3,124	1,221	3%	10%	0.104	0.000	-0.004	0.002	0.000	0.000	0.000
CO2 Ammonia production	CO2	1,710	705	3%	10%	0.104	0.000	-0.002	0.001	0.000	0.000	0.000
CO2 Other industrial processes	CO2	1,933	1,844	3%	10%	0.104	0.000	-0.001	0.003	0.000	0.000	0.000
N2O Adipic Acid	N2O	4,579	6,073	3%	10%	0.104	0.001	0.001	0.010	0.000	0.000	0.000
N2O Nitric Acid	N2O	2,086	1,688	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	64	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
PFC Aluminium production	PFC	1,673	181	5%	10%	0.112	0.000	-0.003	0.000	0.000	0.000	0.000
SF6 Magnesium production	SF6	0	85	5%	5%	0.071	0.000	0.000	0.000	0.000	0.000	0.000
SF6 Electrical Equipment	SF6	213	318	5%	0.1	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	245	30%	50%	0.583	0.000	0.000	0.000	0.000	0.000	0.000
HFC, PFC substitutes for ODS	HFC	134	5,240	30%	50%	0.583	0.004	0.008	0.009	0.004	0.004	0.006
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	HFC	351	20	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	10,852	20%	20%	0.283	0.004	-0.005	0.018	-0.001	0.005	0.005
CH4 Manure Management	CH4	3,462	3,150	20%	100%	1.020	0.005	-0.001	0.005	-0.001	0.001	0.002
N2O Manure Management	N2O	3,921	3,688	20%	100%	1.020	0.005	-0.001	0.006	-0.001	0.002	0.002
CH4 Agricultural Residue Burning	CH4	13	13	50%	20%	0.539	0.000	0.000	0.000	0.000	0.000	0.000
N2O Agricultural Residue Burning	N2O	4	4	50%	20%	0.539	0.000	0.000	0.000	0.000	0.000	0.000
Direct N2O Agricultural Soils	N2O	9,590	8,997	20%	100%	1.020	0.013	-0.004	0.015	-0.004	0.004	0.006
Indirect N2O from Nitrogen used in agriculture	N2O	8,111	7,513	20%	100%	1.020	0.011	-0.003	0.013	-0.003	0.004	0.005
CH4 from Rice production	CH4	1,562	1,464	3%	20%	0.202	0.000	-0.001	0.002	0.000	0.000	0.000
CH4 from Other agriculture	CH4	0	0			0.000	0.000	0.000	0.000	0.000	0.000	0.000
N2O from animal production	N2O	1,736	1,532	20%	100%	1.020	0.002	-0.001	0.003	-0.001	0.001	0.001
CH4 from Solid waste Disposal Sites	CH4	13,298	14,437	20%	30%	0.361	0.007	-0.002	0.024	0.000	0.007	0.007
CH4 Emissions from Wastewater Handling	CH4	1,969	2,322	100%	30%	1.044	0.003	0.000	0.004	0.000	0.005	0.005
N2O Emissions from Wastewater Handling	N2O	1,864	1,977	30%	30%	0.424	0.001	0.000	0.003	0.000	0.001	0.001
CO2 Emissions from Waste Incineration	CO2	537	165	5%	25%	0.255	0.000	-0.001	0.000	0.000	0.000	0.000
CH4 Emissions from Waste Incineration	CH4	161	297	5%	20%	0.206	0.000	0.000	0.000	0.000	0.000	0.000
N2O Emissions from Waste Incineration	N2O	88	128	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	1,320	30%	50%	0.583	0.001	-0.001	0.002	0.000	0.001	0.001
N2O Emissions from solvent use	N2O	796	777	50%	10%	0.510	0.001	0.000	0.001	0.000	0.001	0.001
CO2 Forest land	CO2	45,782	77,498	30%	54%	0.618	0.069	0.041	0.129	0.022	0.055	0.059
CH4 Forest land	CH4	143	34	30%	54%	0.618	0.000	0.000	0.000	0.000	0.000	0.000
N2O Forest land	N2O	15	7	30%	54%	0.618	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Cropland	CO2	22,162	20,007	75%	75%	1.061	0.031	-0.009	0.033	-0.007	0.035	0.036
CO2 Land converted to Forest Land	CO2	13,443	14,832	75%	75%	1.061	0.023	-0.001	0.025	-0.001	0.026	0.026
CO2 Land converted to Cropland	CO2	115	880	75%	75%	1.061	0.001	0.001	0.001	0.001	0.002	0.002
N2O Land converted to Cropland	N2O	16	126	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		**599,807**	**694,211**				**0.083**					***0.077***

Table A1.6 Results of the uncertainty analysis (Tier1)

Emission sources of the Italian inventory are disaggregated into a detailed level, 56 sources, according to the IPCC list in the Good Practice Guidance and taking into account national circumstances and importance. Considering the LULUCF, sources and sinks of the Italian inventory are disaggregated into 64 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 asumptions on which uncertainty estimations are based on are documented for eaach category. Figures to draw up uncertainty are checked with the relevant analyst experts and literature references and they are consistent with the IPCC Good Practice Guidance (IPCC, 2000).

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 or when appropriate, low values are attributed to measured data whereas the uncertainty values are high in all other cases.
For the base year, the uncertainty deriving by the Tier 1 approach is equal to 3.5%; if considering the LULUCF sector the overall uncertaint increases to 7.2%.
In 2005, the Tier 1 approach suggests an uncertainty of 3.2% in the combined GWP total emissions. The analysis also estimates an uncertainty of 2.6 % in the trend between 1990 and 2005.
Specifically, for the LULUCF sector, the uncertainty value resulting from Tier 1 approach is 55% in the combined GWP total emissions for the year 2005, whereas the uncertainty in the trend is 57%. Similar values result from Tier 1 approach in uncertainty related to CO_2 total emissions for the year 2005, 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 2005, whereas the uncertainty in the trend between 1990 and 2005 is equal to 7.7%.

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 Tier 2 analysis has been applied both to the base and the current year submission; in this section detailed results are reported only for the 2005 inventory.
The results of the Tier 2 key category analysis, without LULUCF categories, are provided in Table A1.7, for 2005, while in Table A1.8 results of the analysis, including LULUCF categories, are shown.
The application of the Tier 2 to the base year gives as a result 22 key categories accounting for the 95% of the total levels uncertainty. The application of the Tier 2 to full inventory including the LULUCF categories results in 20 key categories accounting for the 95% of the total levels uncertainty.
For the year 2005, 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 decreased to 20 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 19 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	0.0158	0.016	0.13	CO2 stationary combustion gaseous fuels	0.014	0.145	0.14
Indirect N2O from Nitrogen used in agriculture	0.0132	0.013	0.23	CO2 Mobile combustion: Road Vehicles	0.010	0.099	0.24
CO2 stationary combustion gaseous fuels	0.0119	0.012	0.33	CO2 stationary combustion liquid fuels	0.010	0.098	0.34
CH4 from Solid waste Disposal Sites	0.0089	0.009	0.40	CH4 from Solid waste Disposal Sites	0.008	0.081	0.42
CO2 Mobile combustion: Road Vehicles	0.0085	0.009	0.47	HFC, PFC substitutes for ODS	0.007	0.067	0.49
CO2 stationary combustion liquid fuels	0.0077	0.008	0.53	CH4 Emissions from Wastewater Handling	0.006	0.065	0.56
N2O Manure Management	0.0065	0.006	0.59	CH4 Enteric Fermentation in Domestic Livestock	0.006	0.062	0.62
CH4 Manure Management	0.0062	0.006	0.63	Direct N2O Agricultural Soils	0.006	0.062	0.68
CH4 Enteric Fermentation in Domestic Livestock	0.0055	0.005	0.67	CO2 stationary combustion solid fuels	0.005	0.055	0.74
HFC, PFC substitutes for ODS	0.0053	0.005	0.72	Indirect N2O from Nitrogen used in agriculture	0.005	0.053	0.79
CO2 stationary combustion solid fuels	0.0052	0.005	0.75	N2O Manure Management	0.002	0.025	0.81
CH4 Emissions from Wastewater Handling	0.0047	0.004	0.79	CH4 Manure Management	0.002	0.023	0.84
N2O stationary combustion	0.0042	0.003	0.82	N2O Mobile combustion: Road Vehicles	0.002	0.021	0.86
N2O Mobile combustion: Road Vehicles	0.0033	0.003	0.84	N2O Emissions from Wastewater Handling	0.002	0.017	0.87
CO2 Cement production	0.0032	0.003	0.87	CO2 Cement production	0.001	0.015	0.89
N2O from animal production	0.0027	0.003	0.89	CH4 Fugitive emissions from Oil and Gas Operations	0.001	0.013	0.90
CH4 Fugitive emissions from Oil and Gas Operations	0.0024	0.002	0.91	CO2 Emissions from solvent use	0.001	0.012	0.91
N2O Emissions from Wastewater Handling	0.0013	0.001	0.92	N2O from animal production	0.001	0.012	0.93
CO2 Emissions from solvent use	0.0011	0.001	0.93	N2O Emissions from solvent use	0.001	0.011	0.94
N2O Adipic Acid	0.0009	0.001	0.94	CO2 Fugitive emissions from Oil and Gas Operations	0.001	0.008	0.95
CO2 Fugitive emissions from Oil and Gas Operations	0.0009	0.001	0.95	N2O Adipic Acid	0.001	0.005	0.95
CH4 stationary combustion	0.0008	0.001	0.95	CO2 Mobile combustion: Waterborne Navigation	0.001	0.005	0.96
N2O Emissions from solvent use	0.0007	0.001	0.96	CO2 Iron and Steel production	0.000	0.005	0.96
CH4 from Rice production	0.0005	0.001	0.96	CH4 Fugitive emissions from Coal Mining and Handl	0.000	0.004	0.97
CO2 Lime production	0.0005	0.000	0.97	PFC Aluminium production	0.000	0.003	0.97
CO2 Limestone and Dolomite Use	0.0005	0.000	0.97	N2O stationary combustion	0.000	0.003	0.97
CO2 Mobile combustion: Waterborne Navigation	0.0004	0.000	0.98	PFC, HFC, SF6 Semiconductor manufacturing	0.000	0.003	0.98
CH4 Fugitive emissions from Coal Mining and Handl	0.0004	0.000	0.98	CO2 Ammonia production	0.000	0.002	0.98
CO2 Other industrial processes	0.0003	0.000	0.98	CO2 Lime production	0.000	0.002	0.98
N2O Nitric Acid	0.0003	0.000	0.98	CO2 Mobile combustion: Aircraft	0.000	0.002	0.98
PFC, HFC, SF6 Semiconductor manufacturing	0.0002	0.000	0.99	CO2 Emissions from Waste Incineration	0.000	0.002	0.98
N2O Mobile combustion: Other	0.0002	0.000	0.99	CO2 Limestone and Dolomite Use	0.000	0.002	0.99
CO2 Mobile combustion: Other	0.0002	0.000	0.99	N2O Nitric Acid	0.000	0.002	0.99
N2O Emissions from Waste Incineration	0.0002	0.000	0.99	CO2 Mobile combustion: Other	0.000	0.002	0.99
CO2 Iron and Steel production	0.0002	0.000	0.99	CO2 Other industrial processes	0.000	0.002	0.99
CO2 Mobile combustion: Aircraft	0.0002	0.000	0.99	CH4 from Rice production	0.000	0.002	0.99
CO2 Ammonia production	0.0001	0.000	1.00	CH4 stationary combustion	0.000	0.001	1.00
CH4 Emissions from Waste Incineration	0.0001	0.000	1.00	HFC-23 from HCFC-22 Manufacture and HFCs fugit	0.000	0.001	1.00
CH4 Mobile combustion: Road Vehicles	0.0001	0.000	1.00	CH4 Mobile combustion: Road Vehicles	0.000	0.001	1.00
N2O Mobile combustion: Waterborne Navigation	0.0001	0.000	1.00	CH4 Emissions from Waste Incineration	0.000	0.001	1.00
CO2 Emissions from Waste Incineration	0.0001	0.000	1.00	N2O Emissions from Waste Incineration	0.000	0.001	1.00
SF6 Electrical Equipment	0.0001	0.000	1.00	CH4 Industrial Processes	0.000	0.001	1.00
CH4 Industrial Processes	0.0001	0.000	1.00	SF6 Electrical Equipment	0.000	0.000	1.00
PFC Aluminium production	0.0000	0.000	1.00	SF6 Production of SF6	0.000	0.000	1.00
N2O Mobile combustion: Aircraft	0.0000	0.000	1.00	CH4 Agricultural Residue Burning	0.000	0.000	1.00
CH4 Mobile combustion: Waterborne Navigation	0.0000	0.000	1.00	N2O Mobile combustion: Other	0.000	0.000	1.00
CH4 Agricultural Residue Burning	0.0000	0.000	1.00	SF6 Magnesium production	0.000	0.000	1.00
SF6 Magnesium production	0.0000	0.000	1.00	N2O Mobile combustion: Aircraft	0.000	0.000	1.00
CH4 Emissions from Other Waste	0.0000	0.000	1.00	CH4 Emissions from Other Waste	0.000	0.000	1.00
HFC-23 from HCFC-22 Manufacture and HFCs fugiti	0.0000	0.000	1.00	N2O Agricultural Residue Burning	0.000	0.000	1.00
CH4 Mobile combustion: Other	0.0000	0.000	1.00	N2O Mobile combustion: Waterborne Navigation	0.000	0.000	1.00
N2O Agricultural Residue Burning	0.0000	0.000	1.00	CH4 Mobile combustion: Waterborne Navigation	0.000	0.000	1.00
CH4 Mobile combustion: Aircraft	0.0000	0.000	1.00	N2O Other industrial processes	0.000	0.000	1.00
N2O Fugitive emissions from Oil and Gas Operations	0.0000	0.000	1.00	CH4 Mobile combustion: Other	0.000	0.000	1.00
SF6 Production of SF6	0.0000	0.000	1.00	CH4 Mobile combustion: Aircraft	0.000	0.000	1.00
N2O Other industrial processes	0.0000	0.000	1.00	N2O Fugitive emissions from Oil and Gas Operations	0.000	0.000	1.00
SF6 Other sources of SF6	0.0000	0.000	1.00	SF6 Other sources of SF6	0.000	0.000	1.00
CH4 from Other agriculture	0.0000	0.000	1.00	CH4 from Other agriculture	0.000	0.000	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 remaining Forest land	0.0690	0.301	0.30	CO2 Forest land	0.059	0.280	0.28
CO2 Cropland remaining Cropland	0.0306	0.133	0.43	CO2 Cropland	0.036	0.171	0.45
CO2 Land converted to Forest Land	0.0227	0.099	0.53	CO2 Land converted to Forest Land	0.026	0.124	0.58
Direct N2O Agricultural Soils	0.0132	0.058	0.59	CO2 stationary combustion gaseous fuels	0.012	0.057	0.63
Indirect N2O from Nitrogen used in agriculture	0.0110	0.048	0.64	CO2 stationary combustion liquid fuels	0.008	0.040	0.67
CO2 stationary combustion gaseous fuels	0.0100	0.044	0.68	CO2 Mobile combustion: Road Vehicles	0.008	0.039	0.71
CH4 from Solid waste Disposal Sites	0.0075	0.033	0.71	CH4 from Solid waste Disposal Sites	0.007	0.032	0.74
CO2 Mobile combustion: Road Vehicles	0.0072	0.031	0.75	HFC, PFC substitutes for ODS	0.006	0.027	0.77
CO2 stationary combustion liquid fuels	0.0065	0.028	0.77	Direct N2O Agricultural Soils	0.006	0.026	0.80
N2O Manure Management	0.0054	0.024	0.80	CH4 Emissions from Wastewater Handling	0.005	0.026	0.82
CH4 Manure Management	0.0046	0.020	0.82	CH4 Enteric Fermentation in Domestic Livestock	0.005	0.025	0.85
CH4 Enteric Fermentation in Domestic Livestock	0.0044	0.019	0.84	Indirect N2O from Nitrogen used in agriculture	0.005	0.022	0.87
HFC, PFC substitutes for ODS	0.0044	0.019	0.86	CO2 stationary combustion solid fuels	0.005	0.022	0.89
CO2 stationary combustion solid fuels	0.0040	0.017	0.87	CO2 Land converted to Settlements	0.002	0.011	0.90
CH4 Emissions from Wastewater Handling	0.0035	0.015	0.89	N2O Manure Management	0.002	0.011	0.91
N2O stationary combustion	0.0028	0.012	0.90	CH4 Manure Management	0.002	0.010	0.92
N2O Mobile combustion: Road Vehicles	0.0028	0.012	0.91	CO2 Land converted to Cropland	0.002	0.009	0.93
CO2 Cement production	0.0027	0.012	0.93	N2O Mobile combustion: Road Vehicles	0.002	0.008	0.94
N2O from animal production	0.0023	0.010	0.94	N2O Emissions from Wastewater Handling	0.001	0.007	0.95
CH4 Fugitive emissions from Oil and Gas Operations	0.0020	0.009	0.94	CO2 Cement production	0.001	0.006	0.95
CO2 Land converted to Settlements	0.0020	0.009	0.95	CH4 Fugitive emissions from Oil and Gas Operations	0.001	0.006	0.96
CO2 Land converted to Cropland	0.0013	0.006	0.96	N2O from animal production	0.001	0.005	0.96
N2O Emissions from Wastewater Handling	0.0012	0.005	0.96	CO2 Emissions from solvent use	0.001	0.005	0.97
CO2 Emissions from solvent use	0.0011	0.005	0.97	N2O Emissions from solvent use	0.001	0.004	0.97
N2O Adipic Acid	0.0009	0.004	0.97	CO2 Fugitive emissions from Oil and Gas Operations	0.001	0.004	0.98
CO2 Fugitive emissions from Oil and Gas Operations	0.0008	0.003	0.98	N2O Adipic Acid	0.000	0.002	0.98
CH4 stationary combustion	0.0006	0.003	0.98	CO2 Mobile combustion: Waterborne Navigation	0.000	0.002	0.98
N2O Emissions from solvent use	0.0006	0.002	0.98	CO2 Iron and Steel production	0.000	0.002	0.98
CH4 from Rice production	0.0004	0.002	0.98	CH4 Fugitive emissions from Coal Mining and Handlin	0.000	0.002	0.98
CO2 Lime production	0.0004	0.002	0.98	PFC Aluminium production	0.000	0.001	0.99
CO2 Limestone and Dolomite Use	0.0004	0.002	0.99	N2O stationary combustion	0.000	0.001	0.99
CO2 Mobile combustion: Waterborne Navigation	0.0004	0.002	0.99	PFC, HFC, SF6 Semiconductor manufacturing	0.000	0.001	0.99
CH4 Fugitive emissions from Coal Mining and Handlin	0.0003	0.001	0.99	N2O Land converted to Cropland	0.000	0.001	0.99
CO2 Other industrial processes	0.0003	0.001	0.99	CO2 Ammonia production	0.000	0.001	0.99
N2O Nitric Acid	0.0003	0.001	0.99	CO2 Lime production	0.000	0.001	0.99
PFC, HFC, SF6 Semiconductor manufacturing	0.0002	0.001	0.99	CO2 Mobile combustion: Aircraft	0.000	0.001	0.99
N2O Mobile combustion: Other	0.0002	0.001	0.99	CO2 Emissions from Waste Incineration	0.000	0.001	0.99
N2O Land converted to Cropland	0.0002	0.001	0.99	CO2 Limestone and Dolomite Use	0.000	0.001	0.99
CO2 Mobile combustion: Other	0.0002	0.001	0.99	N2O Nitric Acid	0.000	0.001	0.99
N2O Emissions from Waste Incineration	0.0002	0.001	1.00	CO2 Mobile combustion: Other	0.000	0.001	1.00
CO2 Iron and Steel production	0.0002	0.001	1.00	CH4 from Rice production	0.000	0.001	1.00
CO2 Mobile combustion: Aircraft	0.0002	0.001	1.00	CO2 Other industrial processes	0.000	0.001	1.00
CO2 Ammonia production	0.0001	0.000	1.00	CH4 Forest land	0.000	0.001	1.00
CH4 Emissions from Waste Incineration	0.0001	0.000	1.00	CH4 stationary combustion	0.000	0.000	1.00
CH4 Mobile combustion: Road Vehicles	0.0001	0.000	1.00	HFC-23 from HCFC-22 Manufacture and HFCs fugitiv	0.000	0.000	1.00
N2O Mobile combustion: Waterborne Navigation	0.0001	0.000	1.00	CH4 Mobile combustion: Road Vehicles	0.000	0.000	1.00
CO2 Emissions from Waste Incineration	0.0001	0.000	1.00	CH4 Industrial Processes	0.000	0.000	1.00
SF6 Electrical Equipment	0.0001	0.000	1.00	CH4 Emissions from Waste Incineration	0.000	0.000	1.00
CH4 Industrial Processes	0.0000	0.000	1.00	N2O Emissions from Waste Incineration	0.000	0.000	1.00
CH4 Forest land remaining Forest land	0.0000	0.000	1.00	SF6 Electrical Equipment	0.000	0.000	1.00
PFC Aluminium production	0.0000	0.000	1.00	SF6 Production of SF6	0.000	0.000	1.00
N2O Mobile combustion: Aircraft	0.0000	0.000	1.00	N2O Mobile combustion: Other	0.000	0.000	1.00
CH4 Mobile combustion: Waterborne Navigation	0.0000	0.000	1.00	CH4 Agricultural Residue Burning	0.000	0.000	1.00
CH4 Agricultural Residue Burning	0.0000	0.000	1.00	SF6 Magnesium production	0.000	0.000	1.00
SF6 Magnesium production	0.0000	0.000	1.00	N2O Forest land	0.000	0.000	1.00
CH4 Emissions from Other Waste	0.0000	0.000	1.00	N2O Mobile combustion: Aircraft	0.000	0.000	1.00
N2O Forest land remaining Forest land	0.0000	0.000	1.00	CH4 Emissions from Other Waste	0.000	0.000	1.00
HFC-23 from HCFC-22 Manufacture and HFCs fugitiv	0.0000	0.000	1.00	N2O Agricultural Residue Burning	0.000	0.000	1.00
CH4 Mobile combustion: Other	0.0000	0.000	1.00	N2O Mobile combustion: Waterborne Navigation	0.000	0.000	1.00
N2O Agricultural Residue Burning	0.0000	0.000	1.00	CH4 Mobile combustion: Waterborne Navigation	0.000	0.000	1.00
CH4 Mobile combustion: Aircraft	0.0000	0.000	1.00	N2O Other industrial processes	0.000	0.000	1.00
N2O Fugitive emissions from Oil and Gas Operations	0.0000	0.000	1.00	CH4 Mobile combustion: Other	0.000	0.000	1.00
SF6 Production of SF6	0.0000	0.000	1.00	CH4 Mobile combustion: Aircraft	0.000	0.000	1.00
N2O Other industrial processes	0.0000	0.000	1.00	N2O Fugitive emissions from Oil and Gas Operations	0.000	0.000	1.00
SF6 Other sources of SF6	0.0000	0.000	1.00	SF6 Other sources of SF6	0.000	0.000	1.00
CH4 from Other agriculture	0.0000	0.000	1.00	CH4 from Other agriculture	0.000	0.000	1.00

L, T
L, T2
L, T1
L2,T2
L2
T2
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T1
L1
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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 2004 and 2005 is reported in the attached tables A2.1 and A2.2. Data for year 2004 have been updated according to new additional information submitted by GRTN (from October 2006, the corporate name is “Gestore dei Servizi Elettrici - GSE S.p.A.”), 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 CO_2 emissions from this source, see table 3.7. Energy data of previous years (1990, 1995, 1999-2003) have not been changed, please refer to NIR 2006 for them.

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% in 2004 and -0.5% in 2005 (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 2005 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 2004

Fuels		Model output			GRTN			BEN		
		Gwe, gross	kt	TJ	Gwe, gross	kt	T.o.e./TJ	Gwe, gross	kt / Mmc	kcal / TJ
Coal		**45498.25**	**16672.57**	**442807965.38**	**45518.40**	**17031.00**	**442834560.00**	**45518.60**	**16668.00**	**105843.00**
Coke oven gas		1548.00	669.98	12838597.44	1547.80	686.00	12844880.00	1522.09	708.00	3011.00
Blast furnace gas		3501.80	9146.09	32144499.24	3502.80	9497.00	32091280.00	3502.33	8527.00	7674.00
Oxi converter gas		342.00	456.97	3007497.01	331.40	457.00	3004112.00	406.98		1019.92
sum		**5391.80**	**10273.04**	**47990593.69**	**5382.00**	**10640.00**	**47948640.00**	**5431.40**	**8690.00**	**44707059.92**
Coal, sum				**490798559.07**			**490783200.00**			**481034480.00**
Light distillates		68.00	9.53	438600.00	111.30	15.00	669440.00	111.63	15.00	157.00
Light fuel oil		976.63	217.71	9176569.97	967.20	214.00	9162960.00	967.44	215.00	2189.00
Fuel oil	atz	41776.99	9498.44	387116768.70	41787.70	9327.00	386685280.00	15546.51	2733.00	26785.00
	btz							38210.47	8598.00	84258.00
Refinery gas		2133.00	357.37	15700013.00	2137.30	336.00	15899200.00	2065.12	308.00	3691.00
Petroleum coke		1068.00	238.96	8298360.00	1068.10	240.00	8326160.00	1068.60	240.00	1990.00
Oriemulsion		1109.04	384.79	10567842.55	1181.00	391.00	10794720.00			
sum		**47131.66**	**10706.80**	**431298154.23**	**47252.70**	**10522.00**	**431495920.00**	**57969.77**	**12109.00**	**498188880.00**
Gas from chemical proc.		699.00	1305.89	5849332.48	691.60	1326.00	6150480.00	539.02		
Heavy residuals/ tar		10760.16	7524.04	67683267.62	10715.90	7493.00	66692960.00			
Others		207.69	302.99	2149142.94	205.80	162.00	2510400.00			
sum		**11666.85**	**9132.92**	**75681743.03**	**11613.30**		**75353840.00**	**539.02**	**0.00**	**0.00**
Oil+residuals, sum		58798.50	19839.73	506979897.26	58866.00		506849760.00	58508.79	12109.00	495469280.00
Natural gas		**129848.54**	**26906.93**	**936562508.61**	**129772.10**	**27061.00**	**936634424.00**	**129772.09**	**27134.70**	**936634424.00**
Biogas		1179.00		12175711.79	1170.40	924.00	12091760.00			
Biomass		2184.99		28003653.37	2190.40	2730.00	28116480.00	3360.47	3319.00	40266816.00
Municipal waste		2277.55		36182839.92	2276.60	3351.00	36107920.00	2276.74	3453.00	36116288.00
Grand total		**245178.64**		**2010703170.01**	**245175.90**		**2010583544.00**	**242591.35**		**1998760579.92**
BEN/ GRTN differences								1.1%		0.6%

Table A2.2 - Energy consumption for electricity production, year 2005

Fuels		Model output			TERNA			BEN		
		Gwe, gross	kt	TJ	Gwe, gross	kt	T.o.e./TJ	Gwe, gross	kt / Mmc	kcal / TJ
Coal		**43634.05**	**16002.79**	**425019268.03**	**43606.30**	**16253.00**	**425052560.00**	**43605.81**	**15999.00**	**101591.00**
Coke oven gas		1344.00	625.94	11994703.53	1365.60	653.00	12175440.00	1341.86	672.00	11949504.00
Blast furnace gas		3971.80	10352.26	36383642.81	3971.00	10815.00	36777360.00	3970.93	9766.00	36773176.00
Oxi converter gas		523.00	648.05	4989039.82	500.20	635.00	4435040.00	524.42		4664963.34
sum		**5838.80**	**11626.25**	**53367386.17**	**5836.90**	**12104.00**	**53387840.00**	**5837.21**	**8690.00**	**53387643.34**
Coal, sum				**478386654.20**			**478440400.00**			**478444387.34**
Light distillates		30.00	4.20	193500.00	27.30	3.00	125520.00	26.74	3.00	33.00
Light fuel oil		840.83	197.11	8308191.49	836.00	197.00	8451680.00	836.05	198.00	2020.00
Fuel oil	atz	31587.87	7214.59	294138614.67	31573.60	7117.00	294720960.00	11298.84	1868.00	18306.00
	btz							30748.84	6919.00	67806.00
Refinery gas		2273.00	399.12	17534237.90	2270.10	365.00	17447280.00	2204.65	337.00	4046.00
Petroleum coke		1129.00	255.86	8885230.00	1132.70	256.00	8870080.00	1132.56	256.00	2125.00
Oriemulsion		8.05	2.76	75926.96	6.60	2.00	83680.00			
sum		**35868.75**	**8073.65**	**329135701.02**	**35846.30**	**7941.00**	**329741040.00**	**46247.67**	**9581.00**	**394701824.00**
Gas from chemical proc.		609.00	1332.52	5696484.77	611.40	1427.00	5564720.00	1966.49	2274.00	19121076.66
Heavy residuals/ tar		10405.20	7324.23	65885861.39	10402.00	7397.00	64977520.00			
Others		231.34	459.27	3124711.22	240.00	204.00	3305360.00			
sum		**11245.54**	**9116.02**	**74707057.38**	**11253.40**		**73847600.00**	**1966.49**	**0.00**	**19121076.66**
Oil + residuals, sum		47114.29	17189.67	403842758.40	47099.70		403588640.00	48214.17	9581.00	495469280.00
Natural gas		**149244.42**	**30170.67**	**1058386005.76**	**149258.60**	**30544.00**	**1057882560.00**	**149258.14**	**30646.00**	**1057874192.00**
Biogas		1195.52		12202231.32	1197.90	946.00	12091760.00			
Biomass		2346.39		30300191.58	2337.20	2897.00	30501360.00	3817.44	4987.00	52166112.00
Municipal waste		2618.58		39351211.36	2619.80	3566.00	39831680.00	2337.21	2916.00	30501360.00
Grand total		**251992.05**		**2022469052.63**	**251956.40**		**2022336400.00**	**250732.77**		**2032808952.00**
BEN/ Terna differences								0.5%		-0.5%

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 2005, 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 3.7 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 about 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
9,590			For blast furnace
0	2,856	8,789	For electricity production
27,013	174	174	For steel industries
294	0	0	For other industries use
0	0		For domestic use
36,897	3,030	8,963	Total consumption
2,583	114	21	Consumption for production of secondary fuels
0	0	0	Losses of transformation
39,480	3,144	8,983	Total consumption + losses and prod.
Energy balance coke ovens		Energy balance, blast furnace	
2,780		-606.6	Difference in energy consumption
7.9%		-6.8%	Unbalance in %
34,965			Coke oven output
2,479			Transformation losses, coke ovens
1,635			non energy use
39,079			sub total
39,079			Coking coal input to coke ovens
10,832			Blast furnace coal input
4,879			import + stock change

Table A3.1 Energy balance, 2005, 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 A3.2 column “total according to BEN”. A second step foresees 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 A3.2. 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.

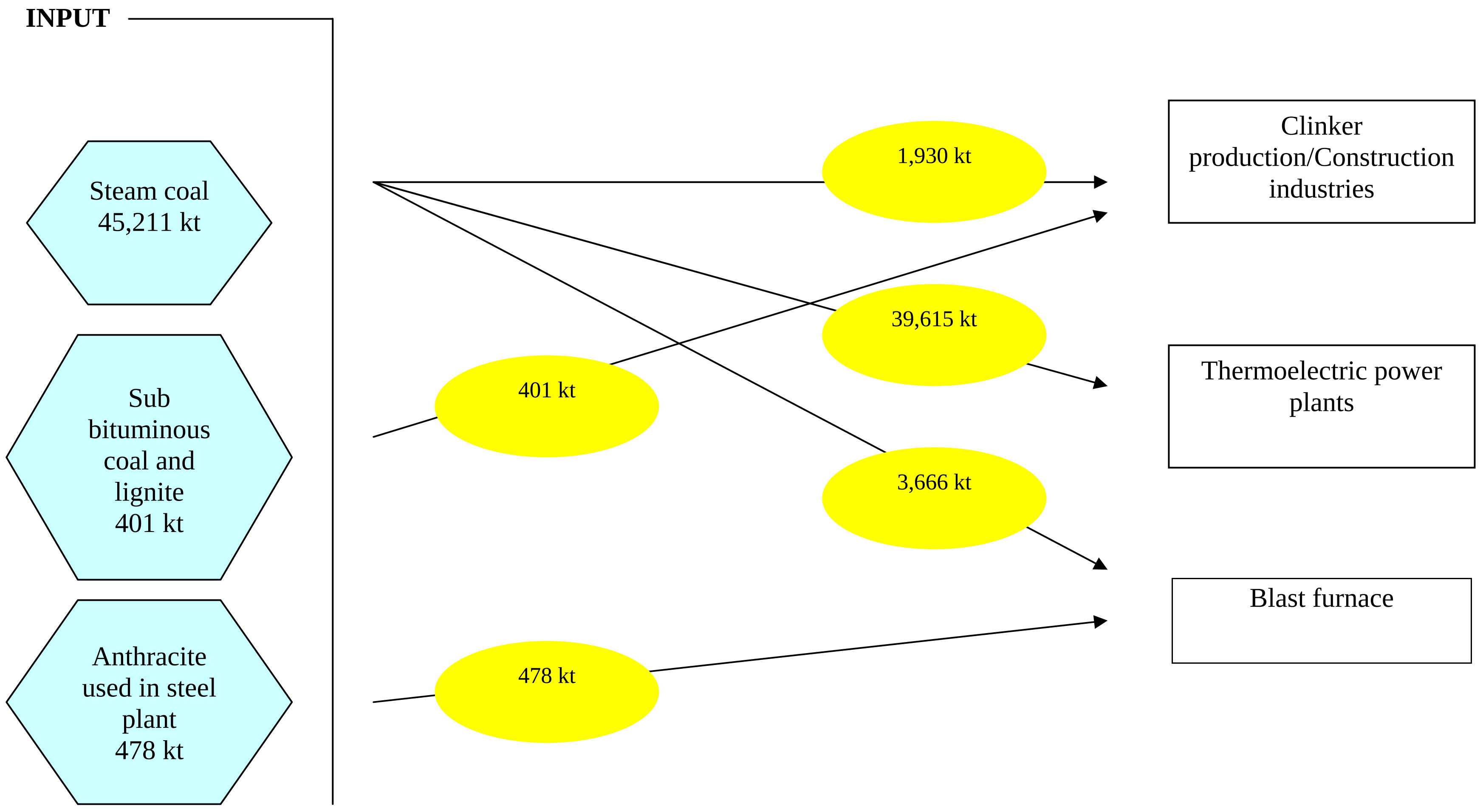
Further investigations are planned, with a verification of the carbon content of the imported coals and of the coal gasses produced at various stages of the process, coke gas, blast furnace gas and BOF gas.

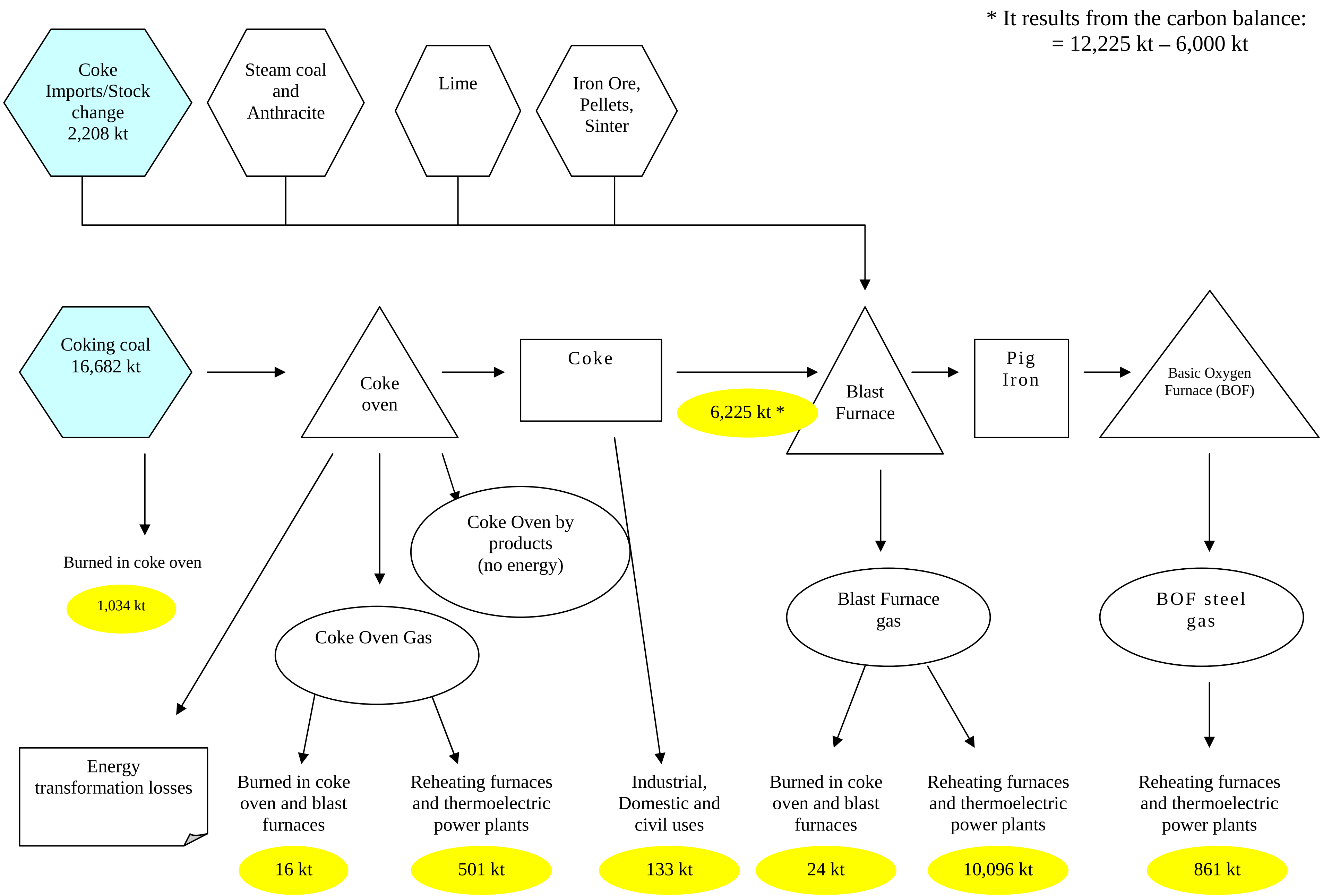
coke	coke gas	Blast furnace gas + oxi gas	NOTES	Total according to BEN	Total used for CRF
4.25			Emission factor, t CO2 / tep		
0.00	0.56	9.80	From blast furnace (no direct emissions, transformed in coal gasses)		
11.97	0.19	0.19	From electricity prod.	10.36	13.00
0.13	0.00	0.00	From steel industries	12.36	8.31
0.00	0.00		From other industries use	0.13	0.13
16.35	0.75	9.99	From domestic use	0.00	0.00
			Total emissions, final uses	27.10	21.43
1.00	0.04	0.02	Consumption for production of secondary fuels	1.07	-
0.00	0.00	0.00	Losses of transformation	0.00	-
17.35	0.80	10.02	Total consumption + losses and prod.	28.17	
Carbon balance, coke ovens		Carbon balance, blast furnace			
2.0		5.8	Difference in physical emissions		
14%		58%	Unbalance in %		
Emissions	EFs				
14.00	4.525		Carbon in produced coke		
0.99	4.004		Transformation losses		
0.65	4.004		non energy use	0.65	0.65
15.65			sub total		
15.15	4.004		Coal input to coke ovens		
4.78	4.004		Coal input to blast furnace		
2.16	4.525		Coke import + stock change		
22.09			Total carbon input	28.82	22.09

Table A3.2 Carbon balance, 2005, Mt CO_2

The flowchart of carbon cycle for the year 2005 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 2005.

CO2 emission calculation
Year 2005




* It results from the carbon balance:
= 12,225 kt – 6,000 kt
Coke Imports/Stock change 2,208 kt
Steam coal and Anthracite
Lime
Iron Ore, Pellets, Sinter
Coking coal 16,682 kt
Coke oven
Coke
6,225 kt *
Blast Furnace
Pig Iron
Basic Oxygen Furnace (BOF)
Burned in coke oven
1,034 kt
Coke Oven by products (no energy)
Coke Oven Gas
Blast Furnace gas
BOF steel gas
Energy transformation losses
Burned in coke oven and blast furnaces
16 kt
Reheating furnaces and thermoelectric power plants
501 kt
Industrial, Domestic and civil uses
133 kt
Burned in coke oven and blast furnaces
24 kt
Reheating furnaces and thermoelectric power plants
10,096 kt
Reheating furnaces and thermoelectric power plants
861 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 (MSE, 2007 [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 2005 and to the web site of the Ministry of Production Activities for the whole time series http://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 2005, 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 (MSE, 2007 [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]).

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 2005 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 2005, pending further investigations; the inventory follows the same methodology.

The following additional information is needed to complete table 1.A(b) of CRF 2005 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 (MSE, 2007 [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

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[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 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.

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 in 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	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Sectoral approach	402.04	415.16	411.22	415.14	426.22	431.92	435.39	440.44	442.55	456.48	460.50	462.89
Reference approach	396.17	406.41	404.35	406.80	416.35	415.85	429.95	430.15	436.48	448.48	455.78	460.39
Δ %	-1.46	-2.11	-1.67	-2.01	-2.32	-3.72	-1.25	-2.34	-1.37	-1.75	-1.02	-0.54

Table A4.1 Reference and sectoral approach CO_2 emission estimates 1990-2005 (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 (MSE, 2007 [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 2005

The following table reproduces the part expressed in amount of energy consumed of the National Energy Balance (BEN) of the year 2005.

The complete balance, containing the physical quantities as well as the amount of energy and a consistent time series from the year 1998 onwards, is also available on the web site: http://dgerm.attivitaproduttive.gov.it/dgerm/ben.asp

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 2 to page 10 the energy vectors are represented in physical quantities (kt) while from page 12 to page 20 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 2 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 were 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 8 and 9 of BEN (see Tables A5.9-10), mirror sheet of the tables, page 18 and 19 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 2005, Primary fuel losses, “Enclosure 2/a”, 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 (b)	*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 (c)		603			5,685	99,586	61,110	20,810	79,347	11,714	5,164	7,290	23,800	315,109
2. IMPORTS	42,802	114,687	2,257	20		606,045	893,150	61,080					7,375	1,727,416
3. EXPORTS						3,267	8,010	8,050					10	19,337
4. Stock changes (d)	1,140	-940	-7			-9,323	5,200	5,010						1,080
5. TOTAL RESOURCES	**41,662**	**116,230**	**2,264**	**20**	**5,685**	**711,687**	**941,050**	**68,830**	**79,347**	**11,714**	**5,164**	**7,290**	**31,165**	**2,022,108**
6. Transformations (Enclosure 1/a)	39,079	101,591			5,685	252,838	1,009,880		79,347	11,714	5,164	7,290	14,188	1,526,776
7. Consumptions and Losses (Encl.2/a)	2,583	2				8,362							-2	10,945
8. Final Consumptions (Enclosure 3/a)		14,637	2,264	20		450,486							16,979	484,386
a) Agriculture						1,708							1,528	3,236
b) Industry		14,637	2,183	20		169,697							2,293	188,830
c) Services						3,836							1,573	5,409
d) Domestic and civil uses			81			265,246							11,585	276,912
Total (a+b+c+d)		14,637	2,264	20		440,487							16,979	474,387
e) Non energy uses						9,999								9,999
TOTAL ENERGY CONSUMPTIONS (7+8)	**2,583**	**14,639**	**2,264**	**20**		**458,848**							**16,977**	**495,331**
9. Non energy final uses														
10. BUNKERS														
12. TOTAL USES	**41,662**	**116,230**	**2,264**	**20**	**5,685**	**711,686**	**1,009,880**		**79,347**	**11,714**	**5,164**	**7,290**	**31,165**	**2,022,107**

(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.
(b) - Lower heat value has been adopted for all fuels
(c) - Oil products include: returns from petrolchimical industry, some reclassification of feedstocks and regeneration of lubricant oils.

Table A5.2 -National Energy Balance, year 2005, Secondary fuels, 10^9kcal

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 (e)**	**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 (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*	*5.977*	
1. PRODUCTIONS (c)	255,258	855	32,018	2,950	8,984	2,243		27,687	38,280	32,417	222,726	40,664	340	406,409	100,421	86,093	13,977	35,101	1,306,423
2. IMPORTS	43,227	428	5,936					18,920		18,533	3,381	1,654	6,551	15,545	5,870	29,655	25,091	4,309	179,100
3. EXPORTS	954		1,603			358.0		6,567		11,315	78,824	4,014	3,255	97,634	47,295	6,135	1,602	16,334	275,890
4. Stock changes (d)			-546					495		-416	-1,250	-1,019	381	-1,336	3,734	-4,273	-2,764	-394	-7,388
5. TOTAL RESOURCES	**297,531**	**1,283**	**36,897**	**2,950**	**8,984**	**1,885**		**39,545**	**38,280**	**40,051**	**148,533**	**39,323**	**3,255**	**325,656**	**55,262**	**113,886**	**40,230**	**23,470**	**1,217,021**
6. Transformations (Encl.1/a)			9,590	2,856	8,789				4,046	33				2,020	18,306	67,806	2,125		115,571
7. Consumptions and Losses (Encl.2/a)	38,861			94	21			572	28,318	560	229	1		2,705	9,498	8,460	9,794	24	99,137
8. Final Consumptions (Encl.3/a)	258,670	1,283	27,307		174	1,885		38,973	5,916	39,458	148,304	39,322	3,255	314,444	6,074	31,662	28,311	1,094	946,132
a) Agriculture	4,613							737			190			25,245					30,785
b) Industry	118,993	353	27,307		174			4,510	840		3,014	208	41	5,140	4,918	26,870	28,311	1,094	221,773
c) Services	36,056							11,352			141,950	39,114		239,179					467,651
d) Domestic and civil uses	99,008	930						22,209					196	35,476		2,450			160,269
Total (a+b+c+d)	258,670	1,283	27,307		174			38,808	840		145,154	39,322	237	305,040	4,918	29,320	28,311	1,094	880,478
e) No energetic uses						1,885		165	5,076	39,458	3,150		3,018	9,404	1,156	2,342		21,958	87,612
TOTAL ENERGY CONSUMPTIONS (7+8)	**297,531**	**1,283**	**27,307**	**94**	**195**	**1,885**		**39,545**	**34,234**	**40,018**	**148,533**	**39,323**	**3,255**	**317,149**	**15,572**	**40,122**	**38,105**	**1,118**	**1,045,269**
9. Non energy final uses																		21,958	21,958
10. BUNKERS														6,487	21,384	5,958		394	34,223
12. TOTAL USES	**297,531**	**1,283**	**36,897**	**2,950**	**8,984**	**1,885**		**39,545**	**38,280**	**40,051**	**148,533**	**39,323**	**3,255**	**325,656**	**55,262**	**113,886**	**40,230**	**23,470**	**1,217,021**

(d) - In the "TOTAL RESOURCES", this entry is considered negative.

(e) - Including residuals gas of chemical processes

Table A5.3 -National Energy Balance, year 2005, Primary fuels used by transformation industries, "Enclosure 1/a", 10^9kcal

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	2.500	8.250	10.000	10.000	2.200	2.200	2.200	2.500	2.500	
1) INPUT QUANTITY														
a) Charcoal pit													1,720	1,720
b) Coking	39,079													39,079
c) Town gas Workshop														
d) Blast furnaces														
e) Petroleum refineries							1,009,880							1,009,880
f) Hydroelectric power plants									79,347					79,347
g) Geothermal power plants										11,714				11,714
h) Thermoelectric power plants		101,591			5,685	252,838						7,290	12,468	379,872
i) Wind / Photovoltaic power plants						-					5,164			5,164
TOTAL	**39,079**	**101,591**			**5,685**	**252,838**	**1,009,880**		**79,347**	**11,714**	**5,164**	**7,290**	**14,188**	**1,526,776**
2) OUTPUT QUANTITY (b)														
A) Obtained sources														
a) Charcoal pit													860	860
b) Coking	34,965													34,965
c) Town gas Workshop														
d) Blast furnaces														
e) Petroleum refineries							969,019							969,019
f) Hydroelectric power plants									31,017					31,017
g) Geothermal power plants										4,579				4,579
h) Thermoelectric power plants		37,501			2,143	128,362						2,010	3,283.0	173,299
i) Wind / Photovoltaic power plants											2,019			2,019
Sub-Total A	**34,965**	**37,501**			**2,143**	**128,362**	**969,019**		**31,017**	**4,579**	**2,019**	**2,010**	**4,143**	**1,215,758**
B) Losses of transformation														
a) Charcoal pit													860	860
b) Coking	2,479													2,479
c) Town gas Workshop														
d) Blast furnaces														
e) Petroleum refineries							5,760							5,760
f) Hydroelectric power plants									48,330					48,330
g) Geothermal power plants										7,135				7,135
h) Thermoelectric power plants		64,090			3,542	124,476						5,280	9,185	206,573
i) Wind / Photovoltaic power plants											3,145			3,145
Sub-Total B	**2,479**	**64,090**			**3,542**	**124,476**	**5,760**		**48,330**	**7,135**	**3,145**	**5,280**	**10,045**	**274,282**
C) Non energy products														
a) Coke ovens (c)	1,635													1,635
b) Town Gas Workshop														
c) Petroleum refineries (d)							35,101							35,101
Sub-Total C	**1,635**						**35,101**							**36,736**
TOTAL A+B+C	39,079	101,591			5,685	252,838	1,009,880		79,347	11,714	5,164	7,290	14,188	1,526,776

(a) - See note (a) in the table of the Balance

(b) - Lower heat value has been adopted for all fuels

(c) - Including tars, benzol and ammonic sulphate.

(d) - Including solvent gasoline, turpentine, lubricants, white oils, insulating oils, vaseline, paraffin, bitumen and other products.

Table A5.4 -National Energy Balance, year 2005, Secondary fuels used by transformation industries, "Enclosure 1/a", 10^9kcal

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	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 (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	5.977	
1) INPUT QUANTITY																			
a) Charcoal pit																			
b) Coking																			
c) Town gas Workshop																			
d) Blast furnaces			9,590																9,590
e) Petroleum refineries																			
f) Hydroelectr.power plants																			
g) Geothermal power plants																			
h) Thermoelectr.power plants				2,856	8,789				4,046	33				2,020	18,306	67,806	2,125		105,981
i) Wind/Photovoltaic power pl.																			
TOTAL			**9,590**	**2,856**	**8,789**				**4,046**	**33**				**2,020**	**18,306**	**67,806**	**2,125**		**115,571**
2) OUTPUT QUANTITY (b)																			
A) Obtained sources																			
a) Charcoal pit																			
b) Coking																			
c) Town gas Workshop																			
d) Blast furnaces			9,590																9,590
e) Petroleum refineries																			
f) Hydroelectric power plants																			
g) Geothermal power plants																			
h) Thermoelectric power plants				1,154	3,415				1,896	23				719	9,717	26,444	974		44,342
i) Wind / Photovoltaic power pl.																			
Sub-Total A			**9,590**	**1,154**	**3,415**				**1,896**	**23**				**719**	**9,717**	**26,444**	**974**		**53,932**
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	5,374				2,150	10				1,301	8,589	41,362	1,151		61,639
i) Wind / Photovoltaic power plants																			
Sub-Total B				**1,702**	**5,374**				**2,150**	**10**				**1,301**	**8,589**	**41,362**	**1,151**		**61,639**
C) Non energy products																			
a) Coking																			
b) Town Gas Workshop																			
c) Petroleum refineries																			
Sub-Total C																			
TOTAL A+B+C			**9,590**	**2,856**	**8,789**				**4,046**	**33**				**2,020**	**18,306**	**67,806**	**2,125**		**115,571**

Table A5.5 -National Energy Balance, year 2005, Primary fuels losses, "Enclosure 2/a", 10^9kcal

CONSUMPTIONS AND LOSSES (d)	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*	*2.500*	*8.250*	*10.000*	*10.000*	*2.200*	*2.200*			*2.500*	
1) Consumptions for production of primary sources														
a) Biomass														
b) Coal														
c) Lignite														
d) Nuclear fuels														
e) Natural Gas						767								767
f) Natural gas liquids														
g) Crude oil														
h) Hydraulic Energy														
i) Geothermal Energy														
Sub-total						**767**								**767**
2) Consumptions for production of secondary sources (c)														
a) Charcoal pit														
b) Coke ovens	2,583													2,583
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	**2,583**													**2,583**
3) Consumptions and Losses of transport and distribution						7,598								7,598
4) Differences :														
- Statistics														
- of conversion		2				-4							-2	-4
TOTAL (1+2+3+4)	**2,583**	**2**				**8,361**							**-2**	**10,944**

(a) - See note (a) in the table of the Balance
(b) Lower heat value has been adopted for all fuels
(c) Consumptions for internal uses of energy industries
(d) Excluding losses of transformation considered in the balance of transformations

Table A5.6 -National Energy Balance, year 2005, Secondary fuels losses, "Enclosure 2/a", 10^9kcal

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	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 (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*	*5.977*	
1) Consumptions for production of primary sources																			
a) Biomass																			
b) Coal	35																		35
c) Lignite	-																		
d) Nuclear fuels	4																		4
e) Natural Gas	281																		281
f) Natural gas liquids																			
g) Crude oil																			
h) Hydraulic Energy	2,115																		2,115
i) Geothermal Energy	-																		
Sub-total	**2,435**																		**2,435**
2) Consumptions for production of secondary sources (c)																			
a) Charcoal pit																			
b) Coke ovens	141			94	21														256
c) Town Gas Workshop	203																		203
d) Blast furnaces	65																		65
e) Petroleum refineries	5,114							572	28,320	562	231			2,703	9,496	8,457	9,794	24	65,273
f) Hydraulic power plants	490																		490
g) Geothermal power plants	260																		260
h) Thermoelectric power plants	10,480																		10,480
i) Wind / Photovoltaic power plants	5																		
Sub-total	**16,758**			**94**	**21**			**572**	**28,320**	**562**	**231**			**2,703**	**9,496**	**8,457**	**9,794**	**24**	**77,027**
3) Consumptions and Losses of transport and distribution	19,670																		19,670
4) Differences :																			
- Statistics	-1																	-1	-2
- of conversion	-1								-2	-2	-2	1		2	2	3		1	2
TOTAL (1+2+3+4)	**38,861**			**94**	**21**			**572**	**28,318**	**560**	**229**	**1**		**2,705**	**9,498**	**8,460**	**9,794**	**24**	**99,137**

Table A5.7 -National Energy Balance, year 2005, Primary fuels used by end use sectors, "Enclosure 3/a", 10^9kcal

FINAL CONSUMPTIONS	PRIMARY SOURCES Coking coal	Steam coal	Coal other uses	Lignite	Subproducts	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*	*2.500*	
1) AGRICULTURE AND FISHING														
I- Agriculture						1,708							1,528	3,236
II- Fishing														
Sub-Total						**1,708**							**1,528**	**3,236**
2) INDUSTRY														
I- Iron and steel industry		9,589	1,243			19,668								30,500
II- Other industry		5,048	940	20		150,029							2,293	158,330
a) Mining industry						314								314
b) Non-Ferrous Metals			15			4,026								4,041
c) Metal works factories						23,290								23,290
d) Food Processing, Beverages						18,158								18,158
e) Textile and clothing						12,829								12,829
f) Construction industries (cement, bricks)		5,048	903	20		11,105							2,293	19,369
g) Glass and pottery						25,889								25,889
h) Chemical			22			28,537								28,559
i) Petrochemical														
l) Pulp, paper and print						17,020								17,020
m) Other industries						8,861								8,861
n) Building and civil works														
Sub-Total		**14,637**	**2,183**	**20**		**169,697**							**2,293**	**188,830**
3) SERVICES														
I - Railways														
II - Navigation														
III - Road transportation						3,836							1,573	5,409
IV - Civil aviation														
V - Other transportation														
VI - Public Service														
Sub-Total						**3,836**							**1,573**	**5,409**
4) DOMESTIC AND COMMERCIAL USES			81			265,246							11,585	276,912
TOTAL (1+2+3+4)		**14,637**	**2,264**	**20**		**440,487**							**16,979**	**474,387**
5) NON ENERGY USE (b)														
I - Chemical industry														
II - Petrochemical						9,999								9,999
III - Agriculture														
IV - Other sectors														
Sub-Total						**9,999**								**9,999**
TOTAL (1+2+3+4+5)		**14,637**	**2,264**	**20**		**450,486**							**16,979**	**484,386**

(a) - Lower heat value has been adopted for all fuels

(b) - Non energy uses of energetic sources

Table A5.8-National Energy Balance, year 2005, Secondary fuels used by end use sectors, "Enclosure 3/a", 10^9kcal

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	22	23	24	25	26	27	28	29	30	31	32	33
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*	*9.800*	*8.300*	*5.977*	
1) AGRICULTURE AND FISHING																			
I- Agriculture	4,613							715			179			22,756					28,263
II- Fishing								22			11			2,489					2,522
Sub-Total	**4,613**							**737**			**190**			**25,245**					**30,785**
2) INDUSTRY																			
I- Iron and steel industry	17,475		27,013		174			275						92		755	25		45,809
II- Other industry	101,518	353	294					4,235	840		3,014	208	41	5,048	4,918	26,115	28,287	1,094	175,965
a) Mining industry	940							44						235	59	137			1,415
b) Non-Ferrous Metals	4,823		56					220					10	71		441			5,621
c) Metal works factories	23,896							803			315	208	31	1,244	1,107	3,234			30,838
d) Food Processing, Beverages	11,184	270						484						571	235	6,419			19,163
e) Textile and clothing	8,550							319						500	78	2,254			11,701
f) Construction industries (cement, bricks)	7,642		98					913						418	1,019	284	28,162	1,094	39,630
g) Glass and pottery	4,981							759						184		2,773			8,697
h) Chemical	21,007	83	35					66						398		1,519	125		23,233
i) Petrochemical	1,465							242	840		2,699				1,264	5,125			11,635
l) Pulp, paper and print	9,408							99						275		1,842			11,624
m) Other industries	6,154		105					286						520	1,156	2,087			10,308
n) Building and civil works	1,470													632					2,102
Sub-Total	**118,993**	**353**	**27,307**		**174**			**4,510**	**840**		**3,014**	**208**	**41**	**5,140**	**4,918**	**26,870**	**28,311**	**1,094**	**221,773**
3) SERVICES																			
I - Railways	4,737													989					5,726
II - Navigation	25													2,499					2,524
III - Road transportation	3,675							11,319			141,435			231,815					388,244
IV - Civil aviation	94										147	37,471							37,712
V - Other transportation	18,633																		18,633
VI - Public Service	8,892							33			368	1,643		3,876 (c)					14,812
Sub-Total	**36,056**							**11,352**			**141,950**	**39,114**		**239,179**					**467,651**
4) DOMESTIC AND COMMERCIAL USES	**99,008**	**930**						**22,209**					**196**	**35,476**		**2,450**			**160,269**
TOTAL (1+2+3+4)	**258,670**	**1,283**	**27,307**		**174**			**38,808**	**840**		**145,154**	**39,322**	**237**	**305,040**	**4,918**	**29,320**	**28,311**	**1,094**	**880,478**
5) NON ENERGY USE (b)																			
I - Chemical industry																			
II - Petrochemical								165	5,076	39,458	3,150		3,018	9,404	1,156	2,342		269	64,038
III - Agriculture						209													209
IV - Other sectors						1,676												21,689	23,365
Sub-Total						1,885		165	5,076	39,458	3,150		3,018	9,404	1,156	2,342		21,958	87,612
TOTAL (1+2+3+4+5)	**258,670**	**1,283**	**27,307**		**174**	**1,885**		**38,973**	**5,916**	**39,458**	**148,304**	**39,322**	**3,255**	**314,444**	**6,074**	**31,662**	**28,311**	**23,052**	**968,090**

(c) 612 10^9 kcal of diesel used for heating for Public Service

Table A5.9 -National Energy Balance, year 2005, Primary fuels used by end use sectors, "Enclosure 3/a", quantity

							PRIMARY SOURCES							
FINAL CONSUMPTIONS	Coking coal	Steam coal	Coal other uses	Lignite	Subproducts	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						207							611	
II- Fishing														
Sub-Total						**207**							**611**	
2) INDUSTRY														
I- Iron and steel industry		1,510	168			2,384								
II- Other industry		795	127	8		18,185							917	
a) Mining industry						38								
b) Non-Ferrous Metals			2			488								
c) Metal works factories						2,823								
d) Food Processing, Beverages						2,201								
e) Textile and clothing						1,555								
f) Construction industries (cement, bricks)		795	122	8		1,346							917	
g) Glass and pottery						3,138								
h) Chemical			3			3,459								
i) Petrochemical						0								
l) Pulp, paper and print						2,063								
m) Other industries						1,074								
n) Building and civil works						0								
Sub-Total		**2,305**	**295**	**8**		**20,569**							**917**	
3) SERVICES														
I - Railways														
II - Navigation														
III - Road transportation						465							185 (b)	
IV - Civil aviation														
V - Other transportation														
VI - Public Service														
Sub-Total						**465**							**185**	
4) DOMESTIC AND COMMERCIAL USES			11			32,151							4,598 (b)	
TOTAL (1+2+3+4)		**2,305**	**306**	**8**		**53,392**							**6,311**	
5) NON ENERGY USE (a)														
I - Chemical industry						1,212								
II - Petrochemical														
III - Agriculture														
IV - Other sectors														
Sub-Total						**1,212**								
TOTAL (1+2+3+4+5)		**2,305**	**306**	**8**		**54,604**							**6,311**	

(a) - Non energy uses of energetic sources

(b) - Biodiesel for road transport: 185 kt; biodiesel for domestic and commercial uses: 15 kt

Table A5.10 -National Energy Balance, year 2005, Secondary fuels used by end use sectors, "Enclosure 3/a", quantity

FINAL CONSUMPTIONS	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	TOTAL SECONDARY SOURCES
	SECONDARY SOURCES																		
	15	16	17	18	20	21	19	22	23	24	25	26	27	28	29	30	31	32	33
Unit of measurement	GWh	kt	kt	Mmc	Mmc	kt	Mmc	kt	kt	kt		kt	kt	kt	kt	kt	kt	kt	
1) AGRICULTURE AND FISHING																			
I- Agriculture	5,364							65			17			2,231					
II- Fishing								2			1			244					
Sub-Total	**5,364**							**67**			**18**			**2,475**					
2) INDUSTRY																			
I- Iron and steel industry	20,320		3,859		193			25						9		77	3		
II- Other industry	118,046	47	42					385	70		287	20	4	495	502	2,665	3,408	183	
a) Mining industry	1,093							4						23	6	14			
b) Non-Ferrous Metals	5,608		8					20					1	7		45			
c) Metal works factories	27,786							73			30	20	3	122	113	330			
d) Food Processing, Beverages	13,005	36						44						56	24	655			
e) Textile and clothing	9,942							29						49	8	230			
f) Construction industries (cement, bricks)	8,886		14					83						41	104	29	3,393	183	
g) Glass and pottery	5,792							69						18		283			
h) Chemical	24,426	11	5					6						39		155	15		
i) Petrochemical	1,704							22	70		257				129	523			
l) Pulp, paper and print	10,939							9						27		188			
m) Other industries	7,156		15					26						51	118	213			
n) Building and civil works	1,709													62					
Sub-Total	**138,365**	**47**	**3,901**		**193**			**410**	**70**	**0**	**287**	**20**	**4**	**504**	**502**	**2,742**	**3,411**	**183**	
3) SERVICES																			
I - Railways	5,508													97					
II - Navigation	29													245					
III - Road transportation	4,273							1,029			13,470			22,727					
IV - Civil aviation	109										14	3,603							
V - Other transportation	21,666																		
VI - Public Service	10,340							3 (c)			35	158		380 (c)					
Sub-Total	**41,924**							**1,032**			**13,519**	**3,761**		**23,449**					
4) DOMESTIC AND COMMERCIAL USES	115,126	124						2,019					30	3,478		250			
TOTAL (1+2+3+4)	**300,779**	**171**	**3,901**		**193**			**3,528**	**70**		**13,824**	**3,781**	**34**	**29,906**	**502**	**2,992**	**3,411**	**183**	
5) NON ENERGY USE																			
I - Chemical industry																			
II - Petrochemical								15	423	3,745	300		299	922	118	239		45	
III - Agriculture						24													
IV - Other sectors						192												3,629	
Sub-Total						**216**		**15**	**423**	**3,745**	**300**		**299**	**922**	**118**	**239**		**3,674**	
TOTAL (1+2+3+4+5)	**300,779**	**171**	**3,901**		**193**	**216**		**3,543**	**493**	**3,745**	**14,124**	**3,781**	**333**	**30,828**	**620**	**3,231**	**3,411**	**3,857**	

(c) 60 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 market 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 / 10^3 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) 1998	55.272	1.965	2.313
Natural gas (dry) 1999	55.284	1.965	2.313
Natural gas (dry) 2000	55.315	1.966	2.314
Natural gas (dry) 2001	55.273	1.955	2.313
Natural gas (dry) 2002	55.599	1.952	2.326
Natural gas (dry) 2003	55.287	1.950	2.313
Natural gas (dry) 2004	55.700	1.996	2.330
Natural gas (dry) 2005	56.438	2.016	2.361

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, IPCC / OECD	68.559	3.071	2.868
Petrol, IPCC Europe	72.270	3.148	3.024
Petrol (Italian National Energy Balance), interpolated emission factor	71.034	3.121	2.972
Petrol, 1990 - 1999	68.631	3.015	2.872
Petrol, experimental averages	71.145	3.109	2.977
Gas oil, IPCC / OECD	73.274	3.175	3.066
Gas oil, IPCC Europe	73.260	3.108	3.065
Gas oil, 1990 - 1999	73.274	3.127	3.066
Gas oil, engines, experimental averages	73.153	3.138	3.061
Gas oil, heating, experimental averages	73.693	3.141	3.083
LPG, IPCC / OECD	62.392	2.952	2.610
LPG, 1990 - 1999	62.392	2.872	2.610
LPG, experimental averages	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 / T	T CO_2 / TEP
Fuel oil, average 1990	76.565	3.111	3.203
Fuel oil, average 1995	76.650	3.127	3.207
Fuel oil, average 1998	76.741	3.139	3.211
Fuel oil, average 1999	76.749	3.130	3.211
Fuel oil, average 2000	76.699	3.174	3.209
Fuel oil, average 2001	76.704	3.179	3.209
Fuel oil, average 2002	76.696	3.183	3.209
Fuel oil, average 2003	76.695	3.177	3.209
Fuel oil, average 2004	76.696	3.163	3.209
Fuel oil, average 2005	76.700	3.163	3.209

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 / t	t CO_2 / tep
Sub bituminous coal, IPCC	96.234	2.557	4.026
Steam coal 1990	94.582	2.502	3.960
Steam coal 1995	94.007	2.519	3.936
Steam coal 1998	94.582	2.437	3.957
Steam coal 1999	93.844	2.400	3.926
Steam coal 2000	91.446	2.404	3.826
Steam coal 2001	93.398	2.434	3.908
Steam coal 2002	92.832	2.423	3.884
Steam coal 2003	93.478	2.435	3.911
Steam coal 2004	93.509	2.431	3.912
Steam coal 2005	93.196	2.423	3.899

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 2005, submitted in 2007, 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 2005

TABLE 10 EMISSION TRENDS Italy
(CO_2)
(Sheet 1 of 5) 2005

2007

Greenhouse gas source and sink categories	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
1. Energy	**405,378.85**	**405,252.71**	**404,383.42**	**401,166.08**	**395,108.88**	**418,330.84**	**414,252.35**	**418,382.42**	**429,339.91**	**434,326.25**	**437,978.89**	**442,875.30**	**444,811.31**	**459,311.99**	**462,647.91**	**465,006.42**
A. Fuel Combustion (Sectoral Approach)	402,037.89	401,987.94	401,171.80	397,786.19	391,882.81	415,156.77	411,217.12	415,139.01	426,221.39	431,921.80	435,393.91	440,435.22	442,550.78	456,477.90	460,495.76	462,894.31
1. Energy Industries	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	147,769.95	150,930.41	157,781.46	158,591.88	157,732.36	159,876.51
2. Manufacturing Industries and Construction	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	86,115.95	81,960.31
3. Transport	101,460.54	104,331.10	108,652.13	110,377.89	110,204.84	112,005.28	113,187.59	114,911.72	118,723.47	119,993.98	120,458.18	122,760.82	124,883.18	126,202.46	128,352.54	126,890.70
4. Other Sectors	76,507.63	82,070.11	78,631.88	78,307.53	69,150.58	75,919.68	77,766.18	75,098.63	78,055.13	82,619.59	78,470.89	81,251.75	78,463.99	85,018.38	87,203.93	92,969.10
5. Other	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	1,197.69
B. Fugitive Emissions from Fuels	3,340.96	3,264.77	3,211.62	3,379.89	3,226.07	3,174.07	3,035.22	3,243.41	3,118.52	2,404.46	2,584.98	2,440.08	2,260.52	2,834.10	2,152.15	2,112.11
1. Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2. Oil and Natural Gas	3,340.96	3,264.77	3,211.62	3,379.89	3,226.07	3,174.07	3,035.22	3,243.41	3,118.52	2,404.46	2,584.98	2,440.08	2,260.52	2,834.10	2,152.15	2,112.11
2. Industrial Processes	**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**	**26,879.20**
A. Mineral Products	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	23,908.28
B. Chemical Industry	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	1,316.92
C. Metal Production	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	1,654.00
D. Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Production of Halocarbons and SF_6																
F. Consumption of Halocarbons and SF_6																
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas source and sink categories	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
3. Solvent and Other Product Use	**1,598.05**	**1,584.54**	**1,586.70**	**1,535.12**	**1,469.09**	**1,423.99**	**1,378.75**	**1,378.90**	**1,328.15**	**1,330.94**	**1,273.82**	**1,295.07**	**1,306.03**	**1,309.87**	**1,315.15**	**1,320.46**
4. Agriculture																
A. Enteric Fermentation																
B. Manure Management																
C. Rice Cultivation																
D. Agricultural Soils																
E. Prescribed Burning of Savannas																
F. Field Burning of Agricultural Residues																
G. Other																
5. Land Use, Land-Use Change and Forestry	**-80,652.12**	**-101,933.02**	**-98,070.47**	**-83,267.79**	**-98,853.03**	**-103,992.09**	**-106,858.34**	**-99,731.70**	**-96,581.18**	**-104,119.31**	**-98,097.48**	**-110,527.05**	**-114,670.75**	**-112,908.16**	**-105,504.42**	**-110,836.24**
A. Forest Land	-59,225.71	-80,870.58	-77,216.14	-62,781.75	-79,072.49	-84,418.95	-87,356.35	-79,987.53	-77,887.22	-85,586.06	-79,511.89	-88,094.49	-94,562.70	-84,672.24	-92,546.35	-92,329.64
B. Cropland	-22,706.71	-22,579.15	-22,336.60	-21,766.33	-21,060.84	-20,853.42	-20,480.90	-21,024.46	-19,974.26	-19,813.55	-19,865.88	-21,270.90	-21,129.49	-20,341.31	-14,238.36	-19,786.89
C. Grassland	NO	-1,010.75	-1,048.27	NO	NO	NO	-1,593.17	NO	NO	NO	NO	-3,720.99	-1,538.07	-10,453.51	NO	NO
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
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	2,558.90	1,280.29	1,280.29
F. Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	**536.90**	**562.22**	**562.44**	**521.18**	**524.10**	**483.02**	**472.13**	**507.76**	**504.42**	**393.47**	**201.57**	**222.26**	**244.97**	**215.76**	**199.23**	**165.46**
A. Solid Waste Disposal on Land	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
B. Waste-water Handling																
C. Waste Incineration	536.90	562.22	562.44	521.18	524.10	483.02	472.13	507.76	504.42	393.47	201.57	222.26	244.97	215.76	199.23	165.46
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Greenhouse gas source and sink categories	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
Total CO_2 emissions including net CO_2 from LULUCF	**354,129.83**	**332,293.00**	**335,822.25**	**344,442.76**	**321,856.32**	**341,720.07**	**332,336.49**	**343,702.37**	**357,810.13**	**355,267.16**	**365,509.88**	**358,771.38**	**356,473.47**	**373,709.95**	**385,428.18**	**382,535.29**
Total CO_2 emissions excluding net CO_2 from LULUCF	**434,781.95**	**434,226.01**	**433,892.72**	**427,710.54**	**420,709.36**	**445,712.15**	**439,194.84**	**443,434.08**	**454,391.31**	**459,386.47**	**463,607.36**	**469,298.43**	**471,144.22**	**486,618.11**	**490,932.60**	**493,371.53**
Memo Items:																
International Bunkers	**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**	**14,068.13**	**14,752.74**
Aviation	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	8,543.18
Marine	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	5,999.93	6,209.56
Multilateral Operations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 Emissions from Biomass	5,243.86	5,962.78	6,286.98	6,210.29	7,215.92	7,076.58	7,063.49	7,702.89	7,572.41	8,897.95	9,362.29	10,318.00	9,940.73	11,990.42	14,397.94	14,048.30

Table A7.2 CH_4 emission trends, CRF year 2005

TABLE 10 EMISSIONS TRENDS (CH_4) Italy

(Sheet 2 of 5) 2005

2007

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
1. Energy	**419.92**	**420.94**	**425.87**	**420.55**	**414.66**	**404.95**	**399.37**	**398.62**	**400.91**	**393.02**	**381.99**	**360.91**	**346.72**	**343.33**	**340.80**	**338.94**
A. Fuel Combustion (Sectoral Approach)	67.79	71.18	74.20	74.13	77.00	79.08	78.97	80.02	78.40	80.21	75.59	69.72	63.96	64.50	69.65	66.89
1. Energy Industries	9.27	8.93	8.59	8.14	8.39	8.63	8.41	8.60	8.52	8.26	6.86	5.94	5.92	6.14	6.01	6.10
2. Manufacturing Industries and Construction	6.74	6.62	6.35	6.67	6.62	7.03	6.56	6.74	6.40	6.02	5.73	5.79	5.74	5.88	5.68	6.24
3. Transport	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	29.52	31.29	28.85
4. Other Sectors	14.73	16.33	16.95	15.99	17.54	18.01	17.82	19.56	19.72	22.04	22.81	23.82	21.21	22.85	26.53	25.54
5. Other	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	0.16
B. Fugitive Emissions from Fuels	352.13	349.75	351.67	346.42	337.66	325.86	320.40	318.60	322.51	312.80	306.40	291.19	282.76	278.83	271.15	272.05
1. Solid Fuels	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	3.27
2. Oil and Natural Gas	346.34	344.43	346.36	342.52	334.27	322.79	317.52	315.75	319.88	310.28	302.92	287.33	279.05	274.33	268.11	268.78
2. Industrial Processes	**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**	**3.05**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. 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	0.33
C. 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	2.72
D. Other Production																
E. Production of Halocarbons and SF6																
F. Consumption of Halocarbons and SF6																
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use																
4. Agriculture	**819.75**	**829.35**	**807.95**	**805.14**	**807.03**	**820.11**	**821.59**	**823.10**	**816.87**	**823.18**	**801.73**	**780.72**	**748.82**	**751.42**	**738.80**	**737.13**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
A. 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	515.98	516.77
B. Manure Management	164.86	164.82	158.67	158.32	153.34	156.48	156.90	156.26	157.94	159.48	156.10	158.85	155.39	154.84	150.26	150.00
C. Rice Cultivation	74.39	71.09	73.86	77.48	79.22	78.90	77.27	76.91	72.99	71.27	65.80	65.80	67.63	69.60	71.88	69.74
D. Agricultural Soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. 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	0.62
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	**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**	**1.63**
A. Forest Land	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	1.63
B. Cropland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	**734.63**	**786.32**	**772.92**	**795.26**	**830.94**	**867.60**	**876.83**	**891.82**	**881.50**	**886.92**	**921.85**	**916.29**	**888.09**	**856.02**	**816.38**	**812.38**
A. Solid Waste Disposal on Land	633.22	673.99	660.75	678.80	714.56	750.21	760.43	771.55	762.21	764.72	801.15	793.42	765.11	733.44	690.02	687.46
B. Waste-water Handling	93.74	97.53	100.55	103.83	104.54	104.46	105.49	106.98	107.47	107.74	108.66	109.77	110.23	109.56	109.98	110.58
C. Waste Incineration	7.65	14.78	11.61	12.61	11.81	12.91	10.89	13.24	11.76	14.38	11.94	12.98	12.59	12.85	16.20	14.14
D. Other	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	0.20
7. Other (as specified in Summary 1.A)	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CH4 emissions including CH4 from LULUCF	**1,986.27**	**2,043.29**	**2,014.45**	**2,033.00**	**2,060.59**	**2,099.32**	**2,101.84**	**2,120.29**	**2,106.50**	**2,108.19**	**2,112.73**	**2,063.38**	**1,987.82**	**1,956.62**	**1,900.52**	**1,893.12**
Total CH4 emissions excluding CH4 from LULUCF	**1,979.46**	**2,041.55**	**2,011.58**	**2,025.82**	**2,057.70**	**2,098.01**	**2,100.78**	**2,116.76**	**2,102.39**	**2,106.17**	**2,108.59**	**2,060.75**	**1,986.34**	**1,953.53**	**1,898.87**	**1,891.50**
Memo Items:																
International Bunkers	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	0.87	0.91
Aviation	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	0.32
Marine	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	0.57	0.59
Multilateral Operations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO2 Emissions from Biomass																

Table A7.3 N_2O emission trends, CRF year 2005

TABLE 10 EMISSIONS TRENDS (N_2O) Italy

(Sheet 3 of 5) 2005

2007

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
1. Energy	**16.85**	**16.72**	**16.98**	**17.04**	**17.29**	**18.27**	**18.72**	**19.27**	**20.43**	**21.27**	**21.84**	**22.54**	**23.55**	**24.52**	**25.69**	**25.77**
A. Fuel Combustion (Sectoral Approach)	16.84	16.72	16.97	17.04	17.29	18.27	18.71	19.27	20.42	21.26	21.84	22.54	23.55	24.51	25.69	25.77
1. Energy Industries	1.63	1.55	1.51	1.44	1.46	1.64	1.59	1.59	1.61	1.52	1.61	1.70	1.78	1.81	1.89	1.90
2. Manufacturing Industries and Construction	4.93	4.89	4.90	4.51	4.47	4.52	4.42	4.47	4.49	4.51	4.66	4.74	4.77	4.93	5.03	5.01
3. Transport	5.54	5.61	5.79	6.03	6.44	7.01	7.59	8.11	9.16	9.96	10.32	10.76	11.83	12.24	12.90	12.92
4. Other Sectors	4.52	4.44	4.53	4.78	4.66	4.88	4.94	4.89	4.99	5.13	5.11	5.30	5.15	5.41	5.59	5.65
5. Other	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	0.29
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	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2. Oil and Natural Gas	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
2. Industrial Processes	**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**	**25.03**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. 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	25.03
C. Metal Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other Production																
E. Production of Halocarbons and SF6																
F. Consumption of Halocarbons and SF6																
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	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	2.51
4. Agriculture	**75.36**	**77.28**	**77.08**	**78.24**	**76.43**	**74.60**	**73.69**	**76.98**	**75.04**	**75.83**	**74.53**	**74.30**	**72.66**	**72.00**	**72.19**	**70.11**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
A. Enteric Fermentation																
B. Manure Management	12.65	12.63	12.09	11.98	11.93	12.20	12.34	12.44	12.70	12.89	12.46	13.11	12.41	12.31	12.03	11.90
C. Rice Cultivation																
D. Agricultural Soils	62.70	64.64	64.98	66.25	64.48	62.39	61.34	64.53	62.33	62.93	62.06	61.18	60.24	59.68	60.14	58.20
E. Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
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	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	**0.10**	**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**	**2.81**	**0.43**
A. Forest Land	0.05	0.01	0.02	0.05	0.02	0.01	0.01	0.02	0.03	0.01	0.03	0.02	0.01	0.02	0.01	0.02
B. Cropland	0.05	NO	NO	0.13	0.32	0.26	NO	0.07	0.52	0.73	0.71	NO	NO	NO	2.80	0.41
C. Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	**6.30**	**6.57**	**6.41**	**6.28**	**6.28**	**6.27**	**6.36**	**6.43**	**6.51**	**6.73**	**6.70**	**6.64**	**6.64**	**6.67**	**6.81**	**6.79**
A. Solid Waste Disposal on Land																
B. Waste-water Handling	6.01	6.08	6.01	5.86	5.89	5.85	6.01	5.99	6.12	6.28	6.34	6.25	6.26	6.29	6.34	6.38
C. Waste Incineration	0.28	0.49	0.40	0.42	0.40	0.42	0.36	0.43	0.39	0.45	0.36	0.39	0.38	0.38	0.47	0.41
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other (as specified in Summary 1.A)	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total N2O emissions including N2O from LULUCF	**122.71**	**125.81**	**124.01**	**125.84**	**123.12**	**125.20**	**124.34**	**128.46**	**128.93**	**131.42**	**132.62**	**133.01**	**131.29**	**130.35**	**137.30**	**130.64**
Total N2O emissions excluding N2O from LULUCF	**122.61**	**125.80**	**123.99**	**125.66**	**122.78**	**124.94**	**124.34**	**128.37**	**128.39**	**130.67**	**131.87**	**132.99**	**131.28**	**130.33**	**134.50**	**130.21**
Memo Items:																
International Bunkers	**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**	**0.30**
Aviation	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	0.15
Marine	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	0.15	0.16
Multilateral Operations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO2 Emissions from Biomass																

Table A7.4 HFC, PFC and SF_6 emission trends, CRF year 2005

TABLE 10 EMISSION TRENDS (HFCs, PFCs and SF_6)

(Sheet 4 of 5)

Italy

2005

2007

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
Emissions of HFCs(3) - (Gg CO2 equivalent)	**351.00**	**355.43**	**358.78**	**355.42**	**481.90**	**671.29**	**450.33**	**755.74**	**1,181.72**	**1,523.65**	**1,985.67**	**2,549.75**	**3,099.90**	**3,795.82**	**4,515.13**	**5,267.21**
HFC-23	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	0.00
HFC-32	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.00	0.00	0.02	0.05	0.08	0.12	0.17	0.23	0.29	0.36
HFC-41	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-43-10mee	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-125	NA,NO	0.00	0.00	0.00	0.00	0.01	0.01	0.04	0.05	0.08	0.13	0.20	0.28	0.38	0.48	0.59
HFC-134	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-134a	NA,NO	0.00	0.00	0.00	0.10	0.20	0.29	0.43	0.68	0.85	1.01	1.19	1.31	1.50	1.67	1.83
HFC-152a	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-143	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-143a	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.01	0.01	0.02	0.03	0.03	0.06	0.08	0.11	0.15	0.19	0.24
HFC-227ea	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.03
HFC-236fa	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-245ca	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Unspecified mix of listed HFCs(4) - (Gg CO2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO

Emissions of PFCs(3) - (Gg CO2 equivalent)	**1,807.65**	**1,451.54**	**849.56**	**707.47**	**476.84**	**490.80**	**243.39**	**252.08**	**270.43**	**258.00**	**345.85**	**451.24**	**423.74**	**497.63**	**350.00**	**361.23**
CF4	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	0.04
C2F6	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	0.01
C 3F8	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.00	0.00	0.00	0.00	0.00
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**Base year (1990)**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
	(Gg)															
C4F10	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
c-C4F8	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C5F12	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C6F14	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Unspecified mix of listed PFCs(4) - (Gg CO2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Emissions of SF6(3) - (Gg CO2 equivalent)	**332.92**	**356.39**	**358.26**	**370.40**	**415.66**	**601.45**	**682.56**	**728.64**	**604.81**	**404.51**	**493.43**	**794.96**	**737.65**	**464.69**	**491.57**	**460.17**
SF6	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	0.02	0.02

Table A7.5 Total emission trends, CRF year 2005

TABLE 10 EMISSION TRENDS Italy

(SUMMARY)

(Sheet 5 of 5) 2005

2007

GREENHOUSE GAS EMISSIONS	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	CO2 equivalent (Gg)															
CO2 emissions including net CO2 from LULUCF	354,789.83	332,953.00	336,482.25	345,102.76	322,516.32	342,380.07	332,996.49	344,362.37	358,470.13	355,927.16	366,169.88	359,431.38	357,133.47	374,369.95	386,088.18	383,195.29
CO2 emissions excluding net CO2 from LULUCF	434,781.95	434,226.01	433,892.72	427,710.54	420,709.36	445,712.15	439,194.84	443,434.08	454,391.31	459,386.47	463,607.36	469,298.43	471,144.22	486,618.11	490,932.60	493,371.53
CH4 emissions including CH4 from LULUCF	41,711.64	42,908.99	42,303.53	42,693.06	43,272.45	44,085.64	44,138.57	44,526.07	44,236.46	44,272.01	44,367.40	43,331.00	41,744.14	41,089.10	39,910.98	39,755.62
CH4 emissions excluding CH4 from LULUCF	41,568.75	42,872.46	42,243.14	42,542.23	43,211.61	44,058.27	44,116.39	44,451.99	44,150.23	44,229.55	44,280.40	43,275.81	41,713.21	41,024.13	39,876.37	39,721.46
N2O emissions including N2O from LULUCF	38,039.53	39,001.66	38,442.82	39,009.05	38,167.78	38,813.20	38,546.70	39,823.67	39,969.38	40,740.10	41,111.00	41,233.89	40,700.76	40,407.91	42,563.97	40,498.32
N2O emissions excluding N2O from LULUCF	38,008.60	38,997.95	38,436.69	38,954.09	38,061.37	38,730.01	38,544.45	39,795.91	39,800.37	40,508.37	40,881.17	41,228.29	40,697.62	40,401.32	41,693.71	40,366.05
HFCs	351.00	355.43	358.78	355.42	481.90	671.29	450.33	755.74	1,181.72	1,523.65	1,985.67	2,549.75	3,099.90	3,795.82	4,515.13	5,267.21
PFCs	1,807.65	1,451.54	849.56	707.47	476.84	490.80	243.39	252.08	270.43	258.00	345.85	451.24	423.74	497.63	350.00	361.23
SF6	332.92	356.39	358.26	370.40	415.66	601.45	682.56	728.64	604.81	404.51	493.43	794.96	737.65	464.69	491.57	460.17
Total (including LULUCF)	**437,032.58**	**417,027.01**	**418,795.20**	**428,238.15**	**405,330.95**	**427,042.46**	**417,058.03**	**430,448.57**	**444,732.93**	**443,125.42**	**454,473.22**	**447,792.21**	**443,839.66**	**460,625.11**	**473,919.84**	**469,537.86**
Total (excluding LULUCF)	**516,850.89**	**518,259.78**	**516,139.14**	**510,640.15**	**503,356.73**	**530,263.99**	**523,231.95**	**529,418.43**	**540,398.87**	**546,310.56**	**551,593.87**	**557,598.47**	**557,816.34**	**572,801.70**	**577,859.38**	**579,547.66**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	CO2 equivalent (Gg)															
1. Energy	419,419.26	419,276.19	418,589.52	415,280.07	409,178.01	432,499.67	428,441.97	432,728.20	444,090.83	449,172.27	452,771.94	457,442.05	459,394.07	474,122.05	477,768.73	480,113.79
2. Industrial Processes	36,544.50	36,164.73	35,572.01	32,735.90	31,399.43	34,589.69	31,555.69	32,031.99	32,489.50	32,888.85	34,959.49	36,993.23	37,001.79	38,153.57	40,630.85	40,792.17
3. Solvent and Other Product Use	2,394.46	2,334.44	2,334.44	2,293.12	2,216.35	2,179.77	2,279.45	2,279.79	2,367.00	2,348.44	2,284.53	2,210.51	2,219.20	2,166.67	2,114.18	2,097.80
4. Agriculture	40,577.10	41,372.10	40,863.01	41,163.32	40,641.17	40,349.16	40,096.97	41,150.09	40,418.20	40,794.77	39,939.48	39,428.43	38,249.50	38,098.97	37,892.35	37,214.06
5. Land Use, Land-Use Change and Forestry	-79,818.31	-101,232.78	-97,343.94	-82,402.00	-98,025.78	-103,221.53	-106,173.92	-98,969.87	-95,665.94	-103,185.13	-97,120.65	-109,806.26	-113,976.68	-112,176.59	-103,939.54	-110,009.81
6. Waste	17,915.56	19,112.33	18,780.16	19,167.74	19,921.76	20,645.71	20,857.87	21,228.37	21,033.33	21,106.22	21,638.43	21,524.26	20,951.77	20,260.43	19,453.27	19,329.84
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)	**437,032.58**	**417,027.01**	**418,795.20**	**428,238.15**	**405,330.95**	**427,042.46**	**417,058.03**	**430,448.57**	**444,732.93**	**443,125.42**	**454,473.22**	**447,792.21**	**443,839.66**	**460,625.11**	**473,919.84**	**469,537.86**

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	C, D
Liquid fuels	Yes	T3	NS, PS	CS	No				No			
Solid fuels	Yes	T3	NS, PS	CS	No				Yes	T3	NS, PS	C, 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			
Solid fuels	Yes	NA	NA	NA	No				No			
Gaseous 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	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. Non-Ferrous Metals	Yes	T2	NS	CS	No				No			
Solid fuels	Yes	T2	NS	CS	No				No			
Gaseous fuels	Yes	T2	NS	CS	No				No			
c. Chemicals	Yes	T2	NS	CS	No				No			
Liquid fuels	Yes	T2	NS	CS	No				No			

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]
Solid fuels	Yes	T2	NS	CS	No				No			
Gaseous fuels	Yes	T2	NS	CS	No				No			
Other fuels	Yes	T2	NS	CS	No				No			
d. Pulp, Paper and Print	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			
e. Food Processing, Beverages and Tobacco	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			
f. Other *(as specified in table1.A(a)s2)*	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			
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			
Residual 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	Yes	T2	NS	C	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			
Biomass	No				Yes	T2	NS	C	No			
c. Agriculture/Forestry/Fisheries	Yes				No				No			
Liquid fuels	Yes	T2	NS	CS	No				No			
Solid fuels	Yes	T2	NS	CS	No				No			

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)]
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	Yes	NA	NA	NA	No				No			
Solid fuels	Yes	NA	NA	NA	No				No			
b. Mobile	Yes	T2	NS	CS	No				No			
Liquid fuels	Yes	T2	NS	CS	No				No			
B. Fugitive Emissions from Fuels	No				Yes	T1	NS	D,CS	No			
1. Solid Fuels	No				Yes	T1	NS	D,CS	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	T2	NS	CS	Yes	T2	NS	CS	No			
a. Oil	Yes	T2	NS	CS	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 Magnesium Foundries	No				No				No								No				No			
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																							

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)
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	T1, T2	NS	D, CS				
1. Cattle					Yes	T2	NS	CS				
2. Buffalo					No							
3. Sheep					Yes	T1	NS	D, CS				
4. Other					No							
B. Manure Management					Yes				Yes	T2	NS	D, CS
1. Cattle					Yes	T2	NS	CS	No			
2. Buffalo					No				No			
3. Sheep					No				No			
4. Other					No				No			
8. Swine					Yes	T2	NS	CS	No			
12. Solid Storage and Dry Lot					No				Yes	T2	NS	D, CS
13. Other					No				No			
C. Rice Cultivation					No							
D. Agricultural Soils	No				No				Yes	D	NS	D, CS
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	CS				
2. Unmanaged Waste Disposal Sites	No				Yes	T2	NS	CS				
3. Other *(as specified in table 6.A)*	No				No							
B. Wastewater Handling					Yes				Yes			
1. Industrial Wastewater					No				No			

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]
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).