

ITALIAN GREENHOUSE GAS INVENTORY 1990-2011

NATIONAL INVENTORY REPORT 2013

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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'ISPRA (ex APAT) su incarico del Ministero dell'Ambiente e della Tutela del Territorio e del Mare, attraverso le indicazioni del Decreto Legislativo n. 51 del 7 marzo 2008 e, più di recente, del Decreto Legislativo n. 30 del 13 marzo 2013, che prevedono l'istituzione di un Sistema Nazionale, *National System*, relativo all'inventario delle emissioni dei gas-serra.

L'ISPRA, 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 più, 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 utilizzate 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 sottoposto ogni anno ad un esame (*review*) 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, l'implementazione di progetti con i Paesi in via di sviluppo (CDM) e l'implementazione di progetti congiunti con i Paesi ad economia in transizione (JI).

Questo processo di *review* diviene tanto più importante a mano a mano che i dati prendono in considerazione la fase conclusiva del primo periodo di impegno (2008-2012) del Protocollo di Kyoto, alla fine del quale sarà accertata la rispondenza tra gli impegni di riduzione assunti dai Paesi industrializzati e le rispettive emissioni di gas-serra.

Il rapporto "Italian Greenhouse Gas Inventory 1990-2011. National Inventory Report 2013" descrive la comunicazione annuale italiana dell'inventario delle emissioni dei gas serra dal 1990 al 2011.

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. Le stime che esso contiene e le metodologie utilizzate dovrebbero essere considerate come riferimento per tutte le valutazioni relative agli obiettivi di riduzione delle emissioni, sia quelle a livello nazionale, sia quelle predisposte a livello regionale e locale, come quelle contenute nei Piani di azione per l'energia sostenibile previsti dal "Patto dei Sindaci".

Domenico Gaudioso

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EXECUTIVE SUMMARY

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

The United Nations Framework Convention on Climate Change (FCCC) was ratified by Italy in the year 1994 through law no.65 of 15/01/1994.

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 Institute for Environmental Protection and Research (ISPRA) 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 I 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, is 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 2013, including the update for the year 2011 and the revision of the entire time series 1990-2010.

The assigned amount for Italy, pursuant to Article 3, paragraphs 7 and 8 and calculated in accordance with the annex to decision 13/CMP.1, has been established together with the commitment period reserve (CPR), required in accordance with paragraph 18 of decision 15 CMP.1, during the last in country review in 2007. The calculated figures are reported in the document FCCC/IRR/2007/ITA and amount to 2,416,277,898 tonnes CO₂ eq. for the assigned amount and 2,174,650,108 tonnes of CO₂ eq. for the CPR. The CPR is calculated on the basis of the assigned amount and it has not changed from the previous submission.

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.isprambiente.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/7383.php.

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

Total greenhouse gas emissions, in CO₂ equivalent, excluding emissions and removals of CO₂ from land use, land use change and forestry, decreased by 5.8% between 1990 and 2011 (from 519 to 489 millions of CO₂ equivalent tons), whereas the national Kyoto target is a reduction of 6.5%, as compared to the base year levels, by the period 2008-2012.

The most important greenhouse gas, CO₂, which accounted for 84.7% of total emissions in CO₂ equivalent in 2011, showed a decrease by 4.7% between 1990 and 2011. In the energy sector, specifically, CO₂ emissions in 2011 reduced of 2.8% as compared those in 1990.

CH₄ and N₂O emissions were equal to 7.5% and 5.5%, respectively, of the total CO₂ equivalent greenhouse gas emissions in 2011. Both gases showed a decrease from 1990 to 2011, equal to 16.4% and 28.1% for CH₄ and N₂O, respectively.

Other greenhouse gases, HFCs, PFCs and SF₆, ranged from 0.1% to 1.9% of total emissions.

Table ES.1 illustrates the national trend of greenhouse gases for 1990-2011, expressed in CO₂ equivalent terms, by substance and category.

Table ES.1. Total greenhouse gas emissions and removals in CO₂ equivalent [Gg CO₂ eq]

GHG emissions	1990 <i>base year</i>	1995	2000	2005	2010	2011
<i>Gg CO₂ equivalent</i>						
CO ₂ including net CO ₂ from LULUCF	421,621	414,255	435,952	449,563	381,940	383,394
CO ₂ excluding net CO ₂ from LULUCF	434,656	444,944	462,278	488,078	425,499	414,239
CH ₄ including CH ₄ from LULUCF	44,359	44,495	46,191	41,267	37,453	36,756
CH ₄ excluding CH ₄ from LULUCF	43,761	44,336	45,844	41,107	37,290	36,568
N ₂ O including N ₂ O from LULUCF	37,680	38,569	39,627	37,751	27,132	26,939
N ₂ O excluding N ₂ O from LULUCF	37,396	38,422	39,483	37,668	27,076	26,873
HFCs	351	671	1,986	5,401	8,745	9,306
PFCs	2,487	1,266	1,217	1,715	1,331	1,455
SF ₆	333	601	493	465	373	351
Total (including LULUCF)	506,830	499,858	525,467	536,162	456,973	458,202
Total (excluding LULUCF)	518,984	530,241	551,301	574,433	500,314	488,792

Greenhouse gas source and sink categories	1990 <i>base year</i>	1995	2000	2005	2010	2011
<i>Gg CO₂ equivalent</i>						
1. Energy	417,736	431,111	449,687	471,902	415,299	404,444
2. Industrial Processes	38,390	35,929	36,249	42,592	31,830	31,641
3. Solvent and Other Product Use	2,455	2,235	2,301	2,123	1,677	1,656
4. Agriculture	40,739	40,520	40,135	37,363	33,723	33,530
5. Land Use, Land-Use Change and Forestry	-12,154	-30,383	-25,835	-38,271	-43,341	-30,590
6. Waste	19,665	20,445	22,929	20,454	17,785	17,521
7. Other	NA	NA	NA	NA	NA	NA

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 2011, of 82.7%. Emissions from this sector decreased by about 3.2% from 1990 to 2011. Substances with decrease rates were CO₂, whose levels reduced by 2.8% from 1990 to 2011 and accounts for 97.1% of the total in the energy sector, and CH₄ which showed a reduction of 25.3% but its share out of the sectoral total is only 1.7%; N₂O, on the other hand, showed an increase of 6.8% from 1990 to 2011 but it is not relevant on total emissions, accounting for 1.2%. Specifically, in terms of total CO₂ equivalent, an increase in emissions was observed in the transport sector, and in the other sectors, about 14.3% and 9.7%, from 1990 to 2011, respectively; in 2011 these sectors, altogether, account for 50.4% of total emissions.

For the industrial processes sector, emissions showed a decrease of 17.6% from the base year to 2011. Specifically, by substance, CO₂ emissions account for 63.8% and showed a decrease by about 29.0%, CH₄ decreased by 46.4%, but it accounts only for 0.2%, while N₂O, whose levels share 0.9% of total industrial emissions, decreased by 95.6%. The decrease in emissions is mostly due to a decrease in chemical industry (due to the fully operational abatement technology in the adipic acid industry) and metal production emissions. A considerable increase was observed in F-gases emissions (about 250.5%), whose level on total sectoral emissions is 35.1%. It should be noted that, except for the motivations explained, the economic recession has had a remarkable influence on the production levels of most the industries and consequent emissions in the last two years.

Emissions from the solvent and other product use sector, which refer to CO₂ and N₂O emissions except for pollutants other than greenhouse gases, decreased by 32.5% from 1990 to 2011. The reduction is mainly to be attributed to a decrease by 34.3% in CO₂ emissions, which account for 65.2% of the sector. As regards CO₂, emission levels from paint application sector, which accounts for 50.4% of total CO₂ emissions from this sector, decreased by 35.6%; emissions from other use of solvents in related activities, such as domestic solvent use other than painting, application of glues and adhesives, printing industries, fat edible and non edible oil extraction, vehicle dewaxing, glass wool enduction, which account for 43.9% of the total, show a decrease of 23.8%. Finally, CO₂ emissions from metal degreasing and dry cleaning activities, decreased by 65.1% but they account for only 5.7% of the total.

The level of N₂O emissions shows a decrease of 29.0%, accounting for 34.8% of total emissions in the sector in 2011.

For agriculture, emissions refer to CH₄ and N₂O levels, which account for 43.1% and 56.9% of the sectoral total, respectively. The decrease observed in the total emissions (-17.7%) was mostly due to the decrease of CH₄ emissions from enteric fermentation (-12.4%), which account for 32.1% of sectoral emissions and to the decrease of N₂O from agricultural soils (-21.1%), which accounts for 45.8% of sectoral emissions.

As regards land use, land-use change and forestry, from 1990 to 2011 total removals in CO₂ equivalent increase by 151.7%; CO₂ accounts for almost the total emissions and removals of the sector.

Finally, emissions from the waste sector decreased by 10.9% from 1990 to 2011, mainly due to a decrease in the emissions from solid waste disposal on land (-17.8%), which account for 71.5% of waste emissions. The most important greenhouse gas in this sector is CH₄ which accounts for 87.5% of the sectoral emissions and shows a decrease of 11.4% from 1990 to 2011. N₂O emission levels increased by 5.0%, whereas CO₂ decreased by 53.8%; these gases account for 11.2% and 1.3%, respectively.

Table ES.2 provides an overview of the CO₂ equivalent emission trends by IPCC source category.

Table ES.2. Summary of emission trends by source category and gas in CO₂ equivalent [Gg CO₂ eq]

Category	1990 base year	1995	2000	2005	2006	2007	2008	2009	2010	2011
	<i>Gg CO₂ equivalent</i>									
1A. Energy: fuel combustion	406,956	421,039	440,663	464,076	459,446	450,956	441,858	398,055	407,781	397,038
CO ₂ : 1. Energy Industries	136,503	139,841	151,894	159,829	160,984	160,769	156,106	131,167	132,557	130,565
CO ₂ : 2. Manufacturing Industries and Construction	85,276	85,037	82,245	78,551	77,490	74,222	70,905	54,580	60,015	59,854
CO ₂ : 3. Transport	101,269	111,445	120,101	125,825	127,145	127,209	122,273	117,897	117,481	116,428
CO ₂ : 4. Other Sectors	76,634	76,047	78,596	91,847	85,986	80,959	85,117	87,092	90,543	83,093
CO ₂ : 5. Other	1,046	1,440	806	1,198	982	896	738	844	627	495
CH ₄	1,610	1,845	1,653	1,503	1,490	1,555	1,562	1,550	1,612	1,668
N ₂ O	4,617	5,382	5,367	5,323	5,369	5,345	5,158	4,925	4,945	4,935
1B2. Energy: fugitives from oil & gas	10,781	10,072	9,024	7,825	7,367	7,208	7,344	7,137	7,518	7,406
CO ₂	3,344	3,178	2,588	2,117	2,194	2,181	2,264	2,170	2,322	2,315
CH ₄	7,425	6,883	6,423	5,695	5,160	5,014	5,067	4,955	5,184	5,079
N ₂ O	12	12	13	14	13	13	13	12	12	11
2. Industrial processes	38,390	35,929	36,249	42,592	38,143	38,601	35,668	30,743	31,830	31,641
CO ₂	28,434	26,038	24,571	27,186	27,205	27,711	25,093	19,951	20,682	20,176
CH ₄	108	113	63	64	66	65	61	38	53	58
N ₂ O	6,676	7,239	7,918	7,760	2,647	1,891	1,066	1,130	647	295
HFCs	351	671	1,986	5,401	6,106	6,855	7,513	8,164	8,745	9,306
PFCs	2,487	1,266	1,217	1,715	1,714	1,652	1,501	1,063	1,331	1,455
SF ₆	333	601	493	465	406	428	436	398	373	351
3. Solvent and other product use	2,455	2,235	2,301	2,123	2,126	2,075	1,954	1,829	1,677	1,656
CO ₂	1,642	1,463	1,275	1,299	1,317	1,287	1,226	1,146	1,050	1,080
N ₂ O	812	772	1,027	823	808	788	727	684	626	577
4. Agriculture	40,739	40,520	40,135	37,363	36,767	37,380	36,015	34,777	33,723	33,530
CH ₄ : Enteric fermentation	12,278	12,348	12,246	10,914	10,699	11,099	10,996	11,007	10,732	10,761
CH ₄ : Manure management	3,462	3,286	3,278	3,149	3,028	3,054	2,961	2,873	2,567	2,114
CH ₄ : Rice Cultivation	1,576	1,671	1,391	1,472	1,475	1,516	1,386	1,565	1,565	1,550

Category	1990 base year	1995	2000	2005	2006	2007	2008	2009	2010	2011
	<i>Gg CO₂ equivalent</i>									
CH ₄ : Field of Burning of Agricultural Residues	13	13	13	14	14	14	15	14	14	13
N ₂ O: Manure management	3,921	3,782	3,862	3,709	3,601	3,779	3,775	3,812	3,701	3,716
N ₂ O: Agriculture soils	19,484	19,417	19,341	18,100	17,947	17,914	16,879	15,502	15,139	15,372
N ₂ O: Field of Burning of Agricultural Residues	4	4	4	4	4	4	5	4	4	4
5A. Land-use change and forestry	-12,154	-30,383	-25,835	-38,271	-39,167	-17,602	-36,670	-39,920	-43,341	-30,590
CO ₂	-13,035	-30,688	-26,326	-38,515	-39,379	-18,565	-36,968	-40,290	-43,560	-30,845
CH ₄	598	159	347	160	139	722	212	269	162	189
N ₂ O	283	147	144	83	72	241	85	101	57	66
6. Waste	19,665	20,445	22,929	20,454	19,818	19,147	18,338	18,238	17,785	17,521
CO ₂	507	454	202	226	239	207	200	242	222	235
CH ₄	17,288	18,178	20,775	18,295	17,646	16,996	16,145	16,012	15,564	15,323
N ₂ O	1,870	1,814	1,952	1,933	1,933	1,943	1,993	1,984	2,000	1,963
TOTAL EMISSIONS (with LULUCF)	506,830	499,858	525,467	536,162	524,501	537,766	504,507	450,860	456,973	458,202
TOTAL EMISSIONS (without LULUCF)	518,984	530,241	551,301	574,433	563,668	555,367	541,177	490,780	500,314	488,792

ES.4. Other information

In Table ES.3 NO_x, CO, NMVOC and SO₂ emission trends from 1990 to 2011 are summarised.

All gases showed a significant reduction in 2011 as compared to 1990 levels. The highest reduction is observed for SO₂ (-89.1%), while CO and NO_x emissions reduced by about 65.0% and 54.0% respectively; NMVOC levels showed a decrease by 49.0%.

Table ES.3. Total emissions of indirect greenhouse gases and SO₂ (1990-2011) [Gg]

Indirect greenhouse gases and SO ₂	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	Gg									
NO _x	2,052	1,908	1,446	1,226	1,170	1,153	1,067	1,000	963	943
CO	7,734	7,172	5,098	3,472	3,214	3,759	2,990	2,819	2,722	2,703
NMVOC	1,955	1,966	1,531	1,260	1,231	1,209	1,125	1,070	1,010	998
SO ₂	1,800	1,326	753	406	383	341	285	233	215	196

Sommario (Italian)

Nel documento “Italian Greenhouse Gas Inventory 1990-2011. National Inventory Report 2013” 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. Tale comunicazione è anche trasmessa all’Unione Europea nell’ambito del Meccanismo di Monitoraggio dei Gas Serra.

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

http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5270.php

La serie storica nazionale delle emissioni è anche disponibile sul sito web all’indirizzo:

http://www.sinanet.isprambiente.it/it/sinanet/serie_storiche_emissioni.

Da un’analisi di sintesi della serie storica dei dati di emissione dal 1990 al 2011, si evidenzia che le emissioni nazionali totali dei sei gas serra, espresse in CO₂ equivalente, sono diminuite del 5.8% nel 2011 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 CO₂ sono pari all’85% del totale e risultano nel 2011 inferiori del 4.7% rispetto al 1990. Le emissioni di metano e di protossido di azoto sono pari a circa il 7.5 % e 5.5% del totale, rispettivamente, e presentano andamenti in diminuzione sia per il metano (-16.4%) che per il protossido di azoto (-28.1%). Gli altri gas serra, HFC, PFC e SF₆, hanno un peso complessivo sul totale delle emissioni che varia tra lo 0.1% e l’1.9%; le emissioni degli HFC evidenziano una forte crescita, mentre le emissioni di PFC decrescono e quelle di SF₆ 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.

PART I: ANNUAL INVENTORY SUBMISSION

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 (UNFCCC) which was approved in New York on 9th May 1992 and signed during the summit of the Earth in Rio de 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; IPCC, 2006; EMEP/CORINAIR, 2007; EMEP/EEA, 2009).

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 account for any difference in previously published data.

The submission also provides for detailed information on emission figures and estimation methodologies in the annual National Inventory Report.

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 2011 Italian GHG emission inventory, and a revision

of the entire time series 1990-2010, communicated in the framework of the annual submission under the Climate Change Convention and the Kyoto Protocol. It is also the annual submission to the European Commission in the framework of the Greenhouse Gas Monitoring Mechanism.

The assigned amount for Italy, pursuant to Article 3, paragraphs 7 and 8, of the Kyoto Protocol, and calculated in accordance with the annex to decision 13/CMP.1, has been established during the last in country review in 2007 (UNFCCC, 2007 [a]). The commitment period reserve (CPR), required in accordance with paragraph 18 of decision 15/CMP.1, has also been calculated and confirmed during the review. The determined figures are reported in the document FCCC/IRR/2007/ITA and amount to 2,416,277,898 tonnes CO₂ eq., for the assigned amount, and 2,174,650,108 tonnes of CO₂ eq., for the CPR. The CRP is calculated on the basis of the assigned amount and it has not changed from the previous submissions.

Regarding the selection of LULUCF activities under Article 3, paragraph 4, of the Kyoto Protocol for the commitment period 2008-2012, Italy has elected forest management and intends to account for Article 3.3 and 3.4 elected activities for the entire period.

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.isprambiente.it/it/sinanet/serie_storiche_emissioni. Information on accounts, legal entities, Art.6 projects, holdings and transactions is publicly available at <http://www.info-ets.isprambiente.it>. The new internet address of the Italian registry is: <https://ets-registry.webgate.ec.europa.eu/euregistry/IT/index.xhtml>.

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/4303.php.

1.2 Description of the institutional arrangement for inventory preparation

1.2.1 National Inventory System

The Legislative Decree 51 of March 7th 2008 instituted the National System for the Italian Greenhouse Gas Inventory.

Article 5.1 of the Kyoto Protocol established that Annex I Parties should have in place a National System since the end of 2006 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 UNFCCC 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 (EC, 2005) required that Member States established a national greenhouse gas inventory system since the end of 2005 at the latest and that the Commission adopts the EC's inventory system since 30 June 2006.

The 'National Registry for Carbon sinks', instituted by a Ministerial Decree on 1st April 2008, is part of the Italian National System and includes information on units of lands subject of activities under Article 3.3 and activities elected under Article 3.4 and related carbon stock changes. In agreement with the Ministerial decree art.4, the Ministry for the Environment, Land and Sea is responsible for the management of the National Registry for Carbon sinks. The Decree also provides that ISPRA and the State Forestry Corps are involved by the Ministry as technical scientific support for specific activities as defined in the relevant protocol. ISPRA is responsible for the preparation of emission and removals estimates for the LULUCF sector and for KP LULUCF supplementary information under art.7.1 of the Kyoto Protocol.

The National Registry for Carbon sinks is the instrument to estimate, in accordance with the COP/MOP decisions, the IPCC Good Practice Guidance on LULUCF and every relevant IPCC guidelines, greenhouse gases emissions by sources and removals by sinks in forest land and related land-use changes and to account for the net removals in order to allow the Italian Registry to issue the relevant amount of removal units

(RMUs). Detailed information on the Registry is included in Annex 10, whereas additional information on activities under Article 3.3 and Article 3.4 is reported in paragraph 1.2.2.

The Italian National System, currently in place, is fully described in the document ‘National Greenhouse Gas Inventory System in Italy’ (ISPRA, 2013 [a]). No changes with respect to the last year submission occurred in the National System.

A summary picture is reported herebelow.

As indicated by art. 14 bis of the Legislative Decree, the Institute for Environmental Protection and Research (ISPRA), former Agency for Environmental Protection and Technical Services (APAT), is the single entity in charge of the preparation and compilation of the national greenhouse gas emission inventory. The Ministry for the Environment, Land and Sea is responsible for the endorsement of the inventory and for the communication to the Secretariat of the Framework Convention on Climate Change and the Kyoto Protocol. The inventory is also submitted to the European Commission in the framework of the Greenhouse Gas Monitoring Mechanism.

The Institute prepares annually a document which describes the national system including all updated information on institutional, legal and procedural arrangements for estimating emissions and removals of greenhouse gases and for reporting and archiving inventory information. The reports are publicly available at http://www.sinanet.isprambiente.it/it/sinanet/serie_storiche_emissioni.

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

ISPRA is responsible for the general administration of the inventory and all aspects related to its 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 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, primary to ISPRA for carrying out emission estimates. These institutions are part of the National Statistical System (Sistan), which provides national official statistics, and therefore are required to periodically 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); 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, establishing 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 was established to be drawn up and updated annually. 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 were 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 2011-2013, updated for 2012-2013, was issued on 20th April 2012. 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.

Sistan activity is supervised by the Commission for Guaranteeing Statistical Information (CGIS) which is an external and independent body. In particular, the Commission supervises: the impartiality and completeness of statistical information, the quality of methodologies, the compliance of surveys with EU and international directives. The Commission, established within the Presidency of the Council of Ministers, is composed of high-profile university professors, directors of statistical or research institutes and managers of public administrations and bodies, which do not participate at Sistan.

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 MIT (Ministry of Transportation);
- Annual Statistics on Electrical Energy in Italy, by Terna (National Independent System Operator);
- Annual Report on Waste, by ISPRA;
- National Forestry Inventory, by MIPAAF (Ministry of Agriculture, Food and Forest Policies).

The national emission inventory is also a Sistan product.

Other information and data sources are used to carry out emission estimates, which are generally referred to in Table 1.1 of the following section 1.4

1.2.2 Institutional arrangement for reporting under Article 3, paragraphs 3 and 4 of Kyoto Protocol

The ‘National Registry for Carbon sinks’ was instituted by a Ministerial Decree on 1st April 2008 and is part of the National Greenhouse Gas Inventory System in Italy (ISPRA, 2013 [a]). In 2009, a technical group, formed by experts from different institutions (ISPRA, Ministry of the Environment, Land and Sea, Ministry of Agriculture, Food and Forest Policies and University of Tuscia), set up the methodological plan of the activities necessary to implement the registry and defined the relative funding. Some of these activities (in particular IUTI, inventory of land use, see Annex 10) have been completed, resulting in land use classification, for all national territory, for the years 1990, 2000 and 2008. A process of validation and verification of IUTI data is currently on going and will supply data useful to update and improve the estimations. For this year submission, emissions and removals from 3.3 and 3.4 activities have been estimated on the basis of data and methodologies used for the inventory under the Convention.

Italy has chosen to elect Forest Management (FM) as an activity under Article 3.4. In accordance with the Annex to Decision 16/CMP.1, credits from Forest Management are capped in the first commitment period. Following the Decision 8/CMP.2, the cap is equal to 2.78 Mt C (10.19 MtCO₂) per year, or 13.90 Mt C (50.97 MtCO₂) for the whole commitment period.

The description of the main elements of the institutional arrangement under Article 3.3 and activities elected under Article 3.4 is detailed in Annex 10.

Italy has decided to account for Article 3.3 and 3.4 elected activities at the end of the commitment period; information on accounting for activities under art. 3.3 and 3.4 of the Kyoto Protocol, for the years 2008-2011, is reported in Table 11.1 (par. 11.6), while detailed information on supplementary information under art. 3.3 and 3.4 of the Kyoto Protocol is reported in Chapter 10 KP-LULUCF.

1.2.3 National Registry System

Between March 2006 and June 2012 Italy has been operating a national registry under Article 19 of Directive 2003/87/CE establishing the European Emission Trading Scheme (EU ETS) and according to Regulation No. 2216/2004 of the European Commission. Italy has had such registry system tested successfully with the EU Commission on February the 6th 2006; the connection between the registry's production environment and the Community Independent Transaction Log (CITL) has been established on March the 13th 2006 and the Registry went live on 28 March 2006.

This registry was conceived for the administration of emissions allowances allocated to operators participating to the EU ETS and it was developed according to the UN Data Exchange Standards document. As a consequence, the registry established under Directive 2003/87/CE could also be used as a registry for the administration of Kyoto Protocol units.

Consequently, the Italian registry for the EU ETS could go through an initialization process and a go-live phase with the UNFCCC in order to become part of the Kyoto system of registries. In particular, Italy successfully performed and passed the SSL connectivity testing (Oct. 26th 2007), the VPN connectivity testing (Oct. 15th 2007), the Interoperability test according to Annex H of the UN DES (Nov. the 9th 2007), and submitted all required information through a complete Readiness Questionnaire.

Following this process, the Italian registry fulfilled all of its obligations regarding conformity with the UN Data Exchange Standards and has been deemed fully compliant with the registry requirements defined in decisions 13/CMP.1 and 5/CMP.1.

After successful completion of the go-live process on 16th October 2008, the Italian registry commenced live operations with the International Transaction Log (ITL) and it's been operational ever since, ensuring the precise tracking of holdings, issuances, transfers, cancellations and retirements of allowances and Kyoto units.

Directive 2009/29/EC adopted in 2009, provided for the centralization of the EU ETS operations into a single European Union registry operated by the European Commission as well as for the inclusion of the aviation sector. At the same time, and with a view to increasing efficiency in the operations of their respective national registries, the EU Member States who are also Parties to the Kyoto Protocol (25) plus Iceland, Liechtenstein and Norway decided to operate their registries in a consolidated manner in accordance with all relevant decisions applicable to the establishment of Party registries - in particular Decision 13/CMP.1 and decision 24/CP.8.

With a view to complying with the new requirements of Commission Regulation 920/2010 and Commission Regulation 1193/2011, in addition to implementing the platform shared by the consolidating Parties, the registry of EU has undergone a major re-development. The consolidated platform which implements the national registries in a consolidated manner (including the registry of EU) is called Consolidated System of EU registries (CSEUR) and was developed together with the new EU registry on the basis the following modalities:

1. Each Party retains its organization designated as its registry administrator to maintain the national registry of that Party and remains responsible for all the obligations of Parties that are to be fulfilled through registries;
2. Each Kyoto unit issued by the Parties in such a consolidated system is issued by one of the constituent Parties and continues to carry the Party of origin identifier in its unique serial number;
3. Each Party retains its own set of national accounts as required by paragraph 21 of the Annex to Decision 15/CMP.1. Each account within a national registry keeps a unique account number comprising the identifier of the Party and a unique number within the Party where the account is maintained;
4. Kyoto transactions continue to be forwarded to and checked by the UNFCCC Independent Transaction Log (ITL), which remains responsible for verifying the accuracy and validity of those transactions;
5. The transaction log and registries continue to reconcile their data with each other in order to ensure data consistency and facilitate the automated checks of the ITL;
6. The requirements of paragraphs 44 to 48 of the Annex to Decision 13/CMP.1 concerning making non-confidential information accessible to the public would be fulfilled by each Party individually;
7. All registries reside on a consolidated IT platform sharing the same infrastructure technologies. The chosen architecture implements modalities to ensure that the consolidated national registries are uniquely identifiable, protected and distinguishable from each other, notably:

With regards to the data exchange, each national registry connects to the ITL directly and establishes a distinct and secure communication link through a consolidated communication channel (VPN tunnel);

The ITL remains responsible for authenticating the national registries and takes the full and final record of all transactions involving Kyoto units and other administrative processes such that those actions cannot be disputed or repudiated;

With regards to the data storage, the consolidated platform continues to guarantee that data is kept confidential and protected against unauthorized manipulation;

The data storage architecture also ensures that the data pertaining to a national registry are distinguishable and uniquely identifiable from the data pertaining to other consolidated national registries;

In addition, each consolidated national registry keeps a distinct user access entry point (URL) and a distinct set of authorisation and configuration rules.

Following the successful implementation of the CSEUR platform, the 28 national registries concerned were re-certified in June 2012 and switched over to their new national registry on 20 June 2012. During the go-live process, all relevant transaction and holdings data were migrated to the CSEUR platform and the individual connections to and from the ITL were re-established for each Party.

With regards to the administration of the Registry, the Italian Government modified the previous Legislative Decree 216/2006 which enforced European Directive 87/2003/CE, by the new Legislative Decree 51 of March 7th 2008. Due to this new Decree, ISPRA, as Registry Administrator, is responsible for developing, operating and maintaining the national registry under the Directive; the Institute performs these tasks under the supervision of the national Competent Authority for the implementation of Directive 2003/87/CE, jointly established by the Ministry for Environment, Land and Sea and the Ministry for Economic Development.

The Decree 51/2008 also establishes that the economic resources for the technical and administrative support of the Registry will be supplied to ISPRA by operators paying a fee for the use of the Registry. The amount of such a fee still has to be regulated by a future Decree.

ISPRA set up an operational unit (“Settore del Registro nazionale dei crediti di emissione”) for the administration of the National Registry. In the reporting period, three persons have been working for this unit in order to maintain the Registry:

- the Registry Administrator (chief of the unit)
- two Registry Managers in charge of Registry functions and operations, resolution of problems, manual intervention, coordination with the “Competent Authority”, helpdesk and administrative tasks (e.g. documentation archiving).

A description of the Italian registry system is presented in Annex 11.

Information on accounting of Kyoto Protocol units, including a summary of information reported in the standard electronic format (SEF) tables is provided in Chapter 11, while information on changes in the National Registry is reported in Chapter 13.

SEF tables including all data referring to units holdings and transactions during the year 2012 can be found in Annex 8.

1.3 Brief description of the process of inventory preparation

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

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

The main basic data needed for the preparation of the 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 (MIT), and data supplied directly by the relevant professional associations.

Emission factors and methodologies used in the estimation process are consistent with the IPCC Guidelines and 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 energy and industrial sectors, emissions and background data collected in the framework of the European Emissions Trading Scheme, the National Pollutant Release and Transfer Register (Italian PRTR) and the Large Combustion Plant (LCP) Directive have yielded considerable developments in the relevant sectors of the inventory. In fact, these figures are used either directly in the estimation process or as verification of emission estimates, improving national emissions factors as well as activity data. Other small plants voluntarily communicate their emissions which are also considered individually.

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

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

The process of the inventory preparation takes place 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.

In Figure 1.1 the most important steps to guarantee the continuous improvement of the national GHG emission inventory are outlined.

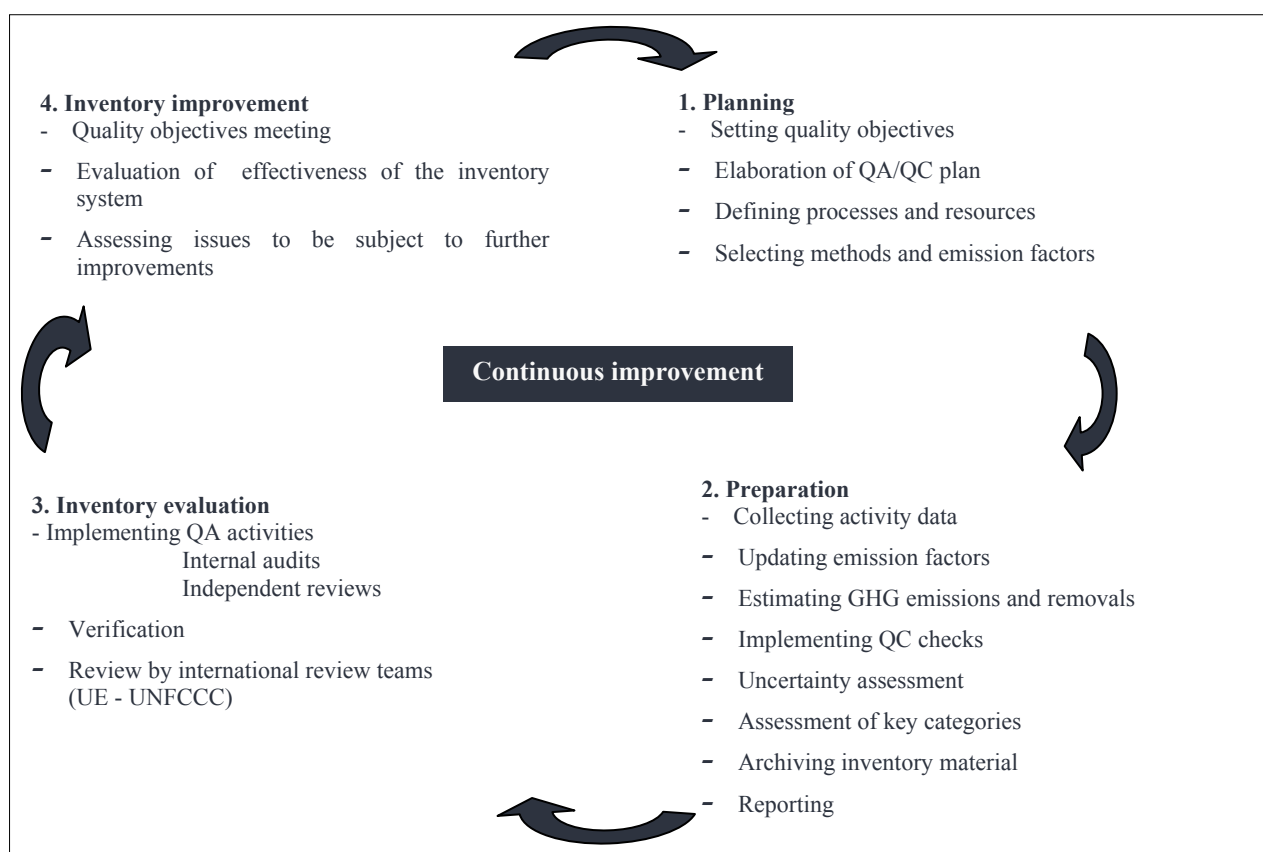


Figure 1.1 National Greenhouse Gas Inventory: annual inventory process

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

Technical reports and emission figures are publicly accessible by website at the address http://www.sinanet.isprambiente.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 IPCC Guidelines, IPCC Good Practice Guidance and EMEP/EEA Guidebooks (IPCC, 1997; IPCC, 2006; IPCC, 2000; IPCC, 2003; EMEP/CORINAIR, 2007; EMEP/EEA, 2009); 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.

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

SECTOR	ACTIVITY DATA	SOURCE
1 Energy		
1A1 Energy Industries	Fuel use	Energy Balance - Ministry of Economic Development Major national electricity producers European Emissions Trading Scheme
1A2 Manufacturing Industries and Construction	Fuel use	Energy Balance - Ministry of Economic Development Major National Industry Corporation European Emissions Trading Scheme
1A3 Transport	Fuel use Number of vehicles Aircraft landing and take-off cycles and maritime activities	Energy Balance - Ministry of Economic Development Statistical Yearbooks - National Statistical System Statistical Yearbooks - Ministry of Transportation Statistical Yearbooks - Italian Civil Aviation Authority (ENAC) Maritime and Airport local authorities
1A4 Residential-public-commercial sector	Fuel use	Energy Balance - Ministry of Economic Development
1B Fugitive Emissions from Fuel	Amount of fuel treated, stored, distributed	Energy Balance - Ministry of Economic Development Statistical Yearbooks - Ministry of Transportation Major National Industry Corporation
2 Industrial Processes	Production data	National Statistical Yearbooks- National Institute of Statistics International Statistical Yearbooks-UN European Emissions Trading Scheme European Pollutant Release and Transfer Register 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 area, biomass increment and stock Biomass burnt	National Forestry Service (CFS) - National and Regional Forestry Inventory Statistical Yearbooks - National Institute of Statistics Universities and Research Institutes
6 Waste	Amount of waste	National Waste Cadastre - Institute for Environmental Protection and Research , National Waste Observatory

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, describing methods and emission factors for the key categories of the national inventory for 2011, is included in Annex 9.

Table 1.2 Methods and emission factors used in the inventory preparation

SUMMARY 3 SUMMARY REPORT FOR METHODS AND EMISSION FACTORS USED												
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO ₂		CH ₄		N ₂ O		HFCs		PFCs		SF ₆	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1. Energy	D,M,T1,T2,T3	CS,D,OTH	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,OTH	T1,T2	CR,CS,D	T1	D						
1. Solid Fuels	T1	OTH	T1	CR,CS,D	NA	NA						
2. Oil and Natural Gas	T1,T2	CS,D	T1,T2	CS,D	T1	D						
2. Industrial Processes	D,T2	CR,CS,D,PS	D,T2	CR,CS,PS	T2	D,PS	CS,D,T2	CS,D,PS	CS,T2	PS	CS,T3	CS,PS
A. Mineral Products	T2	CS,D,PS	NA	NA	NA	NA						
B. Chemical Industry	D,T2	PS	D,T2	CR,CS,PS	T2	D,PS	NA	NA	NA	NA	NA	NA
C. Metal Production	D,T2	CR,CS,PS	D	CR,CS,PS	NA	NA	NA	NA	T2	PS	NA	NA
D. Other Production	NA	NA										
E. Production of Halocarbons and SF ₆							NA	NA	CS	PS	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	D	PS	NA	NA	NA	NA
3. Solvent and Other Product Use	CR,CS	CR,CS			CS	CS						
4. Agriculture			CS,T1,T2	CS,D	CS,T1,T2	CS,D						
A. Enteric Fermentation			T1,T2	CS,D								
B. Manure Management			T1,T2	CS,D	T2	CS,D						
C. Rice Cultivation			T2	CS								
D. Agricultural Soils			NA	NA	CS,T1	CS,D						
E. Prescribed Burning of Savannas			NA	NA	NA	NA						
F. Field Burning of Agricultural Residues			CS	CS,D	CS	CS,D						
G. Other			NA	NA	NA	NA						
5. Land Use, Land-Use Change and Forestry	T1,T2,T3	CS,D	T1	CS,D	T1	CS,D						
A. Forest Land	T1,T2,T3	CS,D	T1	D	T1	D						
B. Cropland	T1,T2,T3	CS,D	T1	D	T1	D						
C. Grassland	T1,T2,T3	CS,D	T1	CS	T1	CS						
D. Wetlands	NA	NA	NA	NA	NA	NA						
E. Settlements	T1	CS,D	NA	NA	NA	NA						
F. Other Land	NA	NA	NA	NA	NA	NA						
G. Other	NA	NA	NA	NA	NA	NA						
6. Waste	D	CS	CS,D,T2	CR,CS,D	CS,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	CS,D	CR,CS,D	CS,D	CS,D						
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
<p>Use the following notation keys to specify the method applied:</p> <p>D (IPCC default) T1a, T1b, T1c (IPCC Tier 1a, Tier 1b and Tier 1c, respectively) CR (CORINAIR)</p> <p>RA (Reference Approach) T2 (IPCC Tier 2) CS (Country Specific)</p> <p>T1 (IPCC Tier 1) T3 (IPCC Tier 3) OTH (Other)</p> <p>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 regarding the use of different methods per source category where more than one method is indicated, should be provided in the documentation box. Also use the documentation box to explain the use of notation OTH.</p> <p>Use the following notation keys to specify the emission factor used:</p> <p>D (IPCC default) CS (Country Specific) OTH (Other)</p> <p>CR (CORINAIR) PS (Plant Specific)</p> <p>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.</p>												

Activity data used in emission calculations and their sources are briefly described here below.

In general, for the energy sector, basic statistics for estimating emissions are fuel consumptions provided in the Energy Balance by the Ministry of Economic Development. Additional information for electricity production is supplied 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 published by the National Institute of Statistics and the Ministry of Transportation in the relevant statistical yearbooks. Other data are communicated by different category associations.

In the last years, a lot of information on productions, fuel consumptions, emission factors and emissions in specific energy and industrial sub sectors is obtained from data collected by operators under the European Emissions Trading Scheme (ETS).

To implement the European Directive 2003/87 (EU, 2003), amended by Directive 2009/29/EC (EU, 2009) establishing the EU ETS, Italy, according to Legislative Decree n. 216/2006 (Legislative Decree, 2006) and Legislative Decree n. 51/2008 (MATTM, 2008), established the national registry and the national ETS committee. The criteria of data reporting are defined by Decision 2007/589/EC (EC, 2007), Monitoring and

Reporting Guidelines for GHG emissions under ETS, and adopted at national level by Deliberation of the national ETS Committee n. 14/2010 (MATTM, 2010).

In compliance with the above mentioned legislations, independent certifications and verifications of activity data, emission data and emission factors are required. At national level, data verification has to be carried out by verifiers accredited by the national ETS Committee according to the ministerial decree DEC/RAS/115/2006. The verification of data submissions ensures reliability, credibility, and precision/accuracy of monitoring systems for data and any information relating emissions by plant.

Data from the Italian Emissions Trading Scheme database are incorporated into the national inventory whenever the sectoral coverage is complete; in fact, ETS data not always entirely cover energy categories whereas national statistics, such as the national energy balance and the energy production and consumption statistics, provide the complete basic data needed for the Italian emission inventory. Nevertheless, ETS data are entirely 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 Release and Transfer Register are also used in the development of emission estimates or taken into account as a verification of emission estimates for some specific categories. According to the Italian Decree of 23 November 2001, data (reporting period 2002-2006) included in the Italian pollutant emissions register were validated by competent authorities within 30 June each year and communicated by ISPRA to the Ministry for the Environment, Land and Sea every year and to the European Commission every three years according to EC Decision 2000/479 (two reporting cycles: data related to 2002 and 2004 were reported respectively in 2003 and in 2006). Since 2008 the national pollutant emissions register has been replaced by the national pollutant release and transfer register (the Italian PRTR) to comply with Regulation EC n.166/2006; data are collected annually at facility level and sent, after validation, by competent authorities to European Commission within 31 March every year for data referring to the previous year. These data are used for the compilation of the inventory whenever they are complete in terms of sectoral information; in fact, industries communicate figures only if they exceed specific thresholds; furthermore, basic data such as fuel consumption are not supplied and production data are not always split by product but reported as an overall figure. Anyway, the Italian PRTR 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 voluntarily communicate their emissions which are also considered individually.

ISPRA directly collects data from the industrial associations under the ETS and other European directives, Large Combustion Plant and INES/PRTR, and makes use of these data in the preparation of the national inventory ensuring the consistency of time series.

For the other sectors, i.e. for solvents, the amount of solvent use is provided by environmental publications of sectoral 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 areas are derived from national forest inventories provided by the Ministry of Agriculture, Food and Forest Policies (National Forest Service); the National Forest Service is also the provider of official statistics related to the areas subject to fires.

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

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

All the material and documents used for the inventory estimation process are stored at the Institute for Environmental Protection and Research. 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 Approach 1 and Approach 2 described in the 2006 IPCC Guidelines (IPCC, 2006). These guidelines provide a harmonized method to deal with both sources and removals and correct some inconsistencies between the previous IPCC Good Practice Guidance and Guidelines, which dealt with and without the LULUCF separately (IPCC, 2000; IPCC, 2003). According to the IPCC 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 or 90% of total uncertainty.

National emissions have been disaggregated into the categories proposed in the IPCC guidelines; other categories have been added to reflect specific national circumstances. Both level and trend analysis have 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, 20 sources were individuated implementing Approach 1, whereas 17 sources were carried out by Approach 2. Including the LULUCF in the analysis, 25 categories were selected by Approach 1 and 22 by Approach 2. The description of these categories is shown in Table 1.3 and Table 1.4.

Table 1.3 Key categories (excluding LULUCF) by the IPCC Approach 1 and Approach 2. Base year

<i>Key categories (excluding the LULUCF sector)</i>	
CO ₂ stationary combustion liquid fuels	L
CO ₂ stationary combustion solid fuels	L
CO ₂ stationary combustion gaseous fuels	L
N ₂ O stationary combustion	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 ₂ O Adipic Acid	L1
N ₂ O Nitric Acid	L1
CH ₄ Enteric Fermentation in Domestic Livestock	L
N ₂ O Manure Management	L
CH ₄ Manure Management	L
Direct N ₂ O Agricultural Soils	L
Indirect N ₂ O from Nitrogen used in agriculture	L
CH ₄ from Solid waste Disposal Sites	L
CO ₂ Iron and steel production	L1
CO ₂ Mobile combustion: Waterborne Navigation	L1
CO ₂ Limestone and dolomite use	L1
CO ₂ Ammonia production	L1
CO ₂ Emissions from solvent use	L2
N ₂ O from animal production	L2
CH ₄ Emissions from Wastewater Handling	L2

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

Table 1.4 Key categories (including LULUCF) by the IPCC Approach 1 and Approach 2. Base year

<i>Key categories (including the LULUCF sector)</i>	
CO ₂ stationary combustion liquid fuels	L
CO ₂ stationary combustion solid fuels	L
CO ₂ stationary combustion gaseous fuels	L
N ₂ O stationary combustion	L
CO ₂ Mobile combustion: Road Vehicles	L
CH ₄ Fugitive emissions from Oil and Gas Operations	L
CO ₂ Cement production	L1
CH ₄ Enteric Fermentation in Domestic Livestock	L
CH ₄ Manure Management	L
N ₂ O Manure Management	L
Direct N ₂ O Agricultural Soils	L
Indirect N ₂ O from Nitrogen used in agriculture	L
CH ₄ from Solid waste Disposal Sites	L
CO ₂ Forest land remaining Forest land	L
CO ₂ Cropland remaining Cropland	L2
CO ₂ Land converted to settlements	L
CO ₂ Fugitive emissions from Oil and Gas Operations	L1
CO ₂ Mobile combustion: Waterborne Navigation	L1
CO ₂ Iron and steel production	L1
N ₂ O Adipic Acid	L1
N ₂ O Nitric Acid	L1
CO ₂ Limestone and Dolomite Use	L1
CO ₂ Ammonia production	L1
N ₂ O from animal production	L2
CH ₄ Emissions from Wastewater Handling	L
CO ₂ Emissions from solvent use	L2
CO ₂ Grassland remaining Grassland	L
CO ₂ Lime production	L1
CO ₂ Land converted to Grassland	L2

Applying the analysis to the 2011 inventory, without the LULUCF sector, 27 key categories were totally individuated, both at level and trend. Results are reported in Table 1.5.

Table 1.5 Key categories (excluding LULUCF) by the IPCC Approach 1 and Approach 2. Year 2011

<i>Key categories (excluding the LULUCF sector)</i>	
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
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,T2
Direct N ₂ O Agricultural Soils	L,T
Indirect N ₂ O from Nitrogen used in agriculture	L,T
CO ₂ Cement production	L,T
N ₂ O Manure Management	L
CH ₄ Manure Management	L2,T2
CH ₄ from Solid waste Disposal Sites	L,T
CO ₂ Fugitive emissions from Oil and Gas Operations	L1, T2
N ₂ O stationary combustion	L,T2
N ₂ O Adipic Acid	T
CO ₂ stationary combustion other fuels	L1,T1

Key categories (excluding the LULUCF sector)	
CO ₂ Emissions from solvent use	T2
N ₂ O from animal production	L2
CH ₄ Emissions from Wastewater Handling	L,T2
CO ₂ Mobile combustion: Waterborne Navigation	L1
CO ₂ Iron and steel production	T1
CO ₂ Ammonia production	T1
N ₂ O Nitric Acid	T1
PFC Aluminium production	T1
CH ₄ stationary combustion	T2
CO ₂ mobile combustion aircraft	L1

If considering emissions and removals from the LULUCF sector, 32 key categories were individuated as reported in Table 1.6.

Table 1.6 Key categories (including LULUCF) by the IPCC Approach 1 and Approach 2. Year 2011

Key categories (including the LULUCF sector)	
CO ₂ stationary combustion liquid fuels	L,T
CO ₂ stationary combustion solid fuels	L,T1
CO ₂ stationary combustion gaseous fuels	L,T
CO ₂ Mobile combustion: Road Vehicles	L,T
CH ₄ Fugitive emissions from Oil and Gas Operations	L1, T
HFC, PFC substitutes for ODS	L,T
CH ₄ Enteric Fermentation in Domestic Livestock	L
Direct N ₂ O Agricultural Soils	L,T
CO ₂ Forest land remaining Forest land	L,T
CO ₂ Cropland remaining Cropland	L,T
CO ₂ Grassland remaining Grassland	T
CO ₂ Land converted to Grassland	L,T
Indirect N ₂ O from Nitrogen used in agriculture	L,T2
N ₂ O Manure Management	L
CH ₄ from Solid waste Disposal Sites	L, T
CO ₂ Cement production	L1, T1
CO ₂ Land converted to Settlements	L,T
CH ₄ Manure Management	L2, T2
CO ₂ stationary combustion other fuels	L1,T1
CH ₄ Emissions from Wastewater Handling	L, T2
N ₂ O stationary combustion	L
CO ₂ Mobile combustion: Waterborne Navigation	L1
N ₂ O Adipic Acid	T
CO ₂ Iron and steel production	T1
CO ₂ Ammonia production	T1
N ₂ O Nitric Acid	T1
CO ₂ Land converted to Cropland	T2
N ₂ O from animal production	L2
CO ₂ Land converted to Forest land	T2
PFC Aluminium production	T1
CO ₂ Fugitive emissions from Oil and Gas Operations	L1
CO ₂ Land converted to Forest land	L, T1

Key category analysis for KP-LULUCF was performed according to section 5.4 of the IPCC GPG for LULUCF (IPCC, 2003).

CO₂ emissions and removals from *Afforestation/Reforestation* activities (art. 3.3) and from *Forest management* (art. 3.4) have been assessed as key categories. Their figures have been compared with Table

1.6, key categories for the latest reported year (2011) based on the level of emissions including LULUCF. The respective associated UNFCCC subcategories are *Land converting to forest land*, which has been identified as key category, at level and trend assessment, and *Forest land remaining Forest land*, which is a key category at level and trend assessment.

The analysis of key categories is used to prioritize improvements that should be taken into account for the next inventory submissions. First of all, it is important that emissions of key categories, being the most significant in terms of absolute weight and/or combined uncertainty, are estimated with a high level of accuracy. For the Italian inventory, higher tiers are mostly used for calculating emissions from these categories as requested by the Good Practice Guidance (IPCC, 2000) and the use of country specific emission factors is extensive. As reported in Table A9.1, in the Annex, there are only a few key categories which estimates do not meet these quality objectives, in terms of the methodology and the application of default emission factors. Among these categories, prioritization is made on account of the actual absolute weight, the expected future relevance, the level of uncertainty and a cost-effectiveness analysis. Therefore improvements are planned for the LULUCF sector. In addition to this evaluation, also categories estimated with higher tiers but affected by a high level of uncertainty are considered in the prioritization plan. For instance, this year, activities are planned for HFC, PFC substitutes for ODS in order to improve the accuracy of the Italian inventory and reduce the overall uncertainty.

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

ISPRA 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) 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 (ISPRA, 2013 [b]). These documents are publicly available at ISPRA website http://www.sinanet.isprambiente.it/it/sinanet/serie_storiche_emissioni.

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 the UNFCCC inventory reviews and taking into account the result of the key category assessment.

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 CO₂ equivalent emissions and with a high uncertainty.

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

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

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

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 results in a pre-check of the GHG values before the submission to the UNFCCC and relevant inconsistencies may be highlighted.

Every year, emission figures are also subjected to a process of re-examination once the inventory, the inventory related publications and the national inventory reports are posted on website, specifically www.isprambiente.it, and from the communication of data to different institutions and/or at local level. In some cases, sectoral major recalculations are presented and shared with the relevant stakeholders prior to the official submission.

For the energy and industrial sectors, different meetings have been held in the last years jointly with the industrial associations, the Ministries of the Environment and Economic Development and ISPRA in the framework of the European Emissions Trading Scheme, specifically for assessing carbon leakage in EU energy intensive industries and the definition of GHG emission benchmarks; also in this context, estimations of the emission inventory for different sectors have been presented.

Generally, in the last years ISPRA has held different meetings with the industrial associations in the context of different European legislation. ISPRA collects data from the industrial associations and industrial facilities under the ETS and other European legislation such as Large Combustion Plant Directive and E-PRTR Regulation. The inventory team manages all these data and makes use of them in the preparation of the national inventory ensuring the consistency of time series among data by the comparison of the information collected under the directives with other sources available before the first available years of data collected (2000 and 2002, reporting years for data collected under ETS and INES/ PRTR facilities, respectively). Emissions and activity data submitted under the ETS are mandatorily subject to verification procedures, as requested and specified by the European Directive 2003/87/EC (art. 15 and Annex V). Also the quality of the Italian PRTR data is guaranteed by art.9 of the Regulation 2006/166/EC and by art.3(3) of the Presidential Decree n.157/2011.

In addition, ISPRA manages all this information in an informative system to help in highlighting the main discrepancies among data, and improving the management of the time series consistency. The informative system is based on identification codes to trace back individual point sources in different databases.

Other specific activities relating to improvements of the inventory and QA/QC practises in the last year regarded the progress on the building of a unique database where information collected in the framework of different European legislation, Large Combustion Plant, INES/PRTR and Emissions Trading, are gathered together thus highlighting the main discrepancies in information and detecting potential errors. The actual figures are considered in an overall approach and used in the compilation of the inventory.

In the current year, ISPRA finalised the provincial inventory at local scale for the year 2010 and updated the previously published figures 1990, 1995, 2000 and 2005; in fact, every 5 years, in the framework of the Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) under the Convention on Long-range Transboundary Air Pollution (CLTRAP), Parties has to report their national air emissions disaggregated on a 50*50 km grid. Specifically, ISPRA has applied a top-down approach to estimate emissions at provincial areas based on proxy variables. The results were checked out by regional and local environmental agencies and authorities; data are available at ISPRA web address <http://www.sinanet.isprambiente.it/it/inventaria> and a report which describes detailed methodologies to carry out estimates is published (Liburdi et al., 2004; ISPRA, 2009). Comparisons between top-down and local inventories have been carried out during the last year and will continue in the next years; results are shared among the 'local inventories' expert group leading to an improvement in methodologies for both the inventories.

The inventory is also 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. Especially in the last years, there has been an intensification of these activities in order to establish national policies and measures to meet the

2020 EU target and implement national programmes for the post Kyoto period. In this regard, and as a basis for emission scenarios, the importance of the emission inventory is primary.

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, in June 2007, Italy was subjected by the UNFCCC Secretariat to the in-country review of the national initial report and the GHG inventory submitted in 2006, which results and recommendations can be found on website at the addresses <http://unfccc.int/resource/docs/2007/arr/ita.pdf>, <http://unfccc.int/resource/docs/2007/irr/ita.pdf>, (UNFCCC, 2007 [a]; UNFCCC, 2007 [b]). The results of the last centralised review are reported in UNFCCC (2013). The issues raised during the process were addressed and implemented; details are reported in Annex 12 and in relevant sections.

At European level, reviews of the European inventory are undertaken by experts from different Member States for critical sectoral categories in the context of the European GHG Monitoring Mechanism. Moreover, in the context of the European Effort Sharing Decision (EC, 2009) defining the 2020 emission limit of a Member State in relation to its 2005 emissions, a technical review will be carried out to review and verify emission data of each Member State, for the reference years 2005, 2008 and 2009, prior to determining their annual emission allocations. The review process will take place from June to August this year.

An 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).

More recently, VITO, Öko-Institut and the Institute for European Environmental Policy, for DG Environment, undertook a review on the methodologies and EU Member States best practices used for GHG projections to identify possible ways to improve GHG projections and ensure consistency across the EU. The results were presented at the Workshop ‘Assessing and improving methodologies for GHG projections’ in 2008. Further analyses were presented during the Workshop on ‘Quantification of the effects on greenhouse gas emissions of policies and measures’.

An agreement to conduct a bilateral independent review between Italy and Spain was established last year, with a focus on the revision of the GHG inventories of both the Parties. Two in-country visits were already held, in September and October 2012; the Italian team revised part of the energy sector of Spain, specifically the categories public power plants, petroleum refining plants, road transport and off-road, whereas the Spanish team revised the Industrial processes and solvent and other product use, and the LULUCF sectors of Italy. Results of these analyses are not finalized yet but a report will be published as soon as possible. Aim of the review was to carry out a general quality assurance analysis of the inventories in terms of the methodologies, the EFs and the references used, as well as analysing critical cross cutting issues such as the details of the national energy balances and comparison with international data (Eurostat and IEA), use of plant specific information. Revisions of the other inventory sectors are planned during the year 2013.

In addition, a call for tender to carry out an official independent technical review of the entire Italian national greenhouse gas inventory has been launched this year and will be finalized in the next few months.

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 ISPRA. 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, ISPRA 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 from 1990 to the last submitted year and forecasts for some specified years. National trends of these indicators are reported in the document ‘Carbon Dioxide Intensity Indicators’ (ISPRA, 2013 [c]).

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 (ENEA/MAP/APAT, 2004). Emission intensity indicators among countries (e.g. emissions per capita, industrial emissions per unit of value added, road transport emissions per passenger car, emissions from power generation per kWh of electricity produced, emissions from dairy cows per tonne of milk produced) can also be useful to provide a preliminary check and verification of the order of magnitude of the emissions. 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 their 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 addresses to the improvement of different inventory sectors. Specifically in the last years, 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 ISPRA 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 meeting.

In 2007, in the context of the national conference on climate change a specific session was dedicated to the national emission inventory. In addition, a specific event was held on the results of the 2005 national GHG inventory. In 2010, the time series of emission figures 1990-2008 were presented in a specific national Kyoto Protocol event.

A specific procedure undertaken for improving the inventory regards the establishment of national expert panels (in particular, in road transport, land use change and forestry and energy sectors) which involve, on a voluntary basis, different institutions, local agencies and industrial associations cooperating for improving activity data and emission factors accuracy. Specifically, for the LULUCF sector, following the election of the 3.3 and 3.4 activities and on account of an in-depth analysis on the information needed to report LULUCF under the Kyoto Protocol, a Scientific Committee, *Comitato di Consultazione Scientifica del Registro dei Serbatoi di Carbonio Forestali*, constituted by the relevant national experts has been established by the Ministry for the Environment, Land and Sea in cooperation with the Ministry of Agriculture, Food and Forest Policies.

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

A summary of all the main QA/QC activities over the past years which ensure the continuous improvement of the inventory is presented in the document 'Quality Assurance/Quality Control plan for the Italian Emission Inventory. Year 2013' (ISPRA, 2013 [b]).

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 ISPRA.

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 2006 IPCC Guidelines (IPCC, 2006) define two approaches to estimating uncertainties in national greenhouse gas inventories: Approach 1, based on the error propagation equations, and Approach 2, corresponding to the application of Monte Carlo analysis.

For the Italian inventory, quantitative estimates of the uncertainties are calculated using Approach 1 which application is described in Annex 1, with or without emissions and removals from the LULUCF sector. Emission categories are disaggregated into a detailed level and uncertainties are therefore estimated for these categories.

For the 2011 total emission figures without LULUCF, an uncertainty of 3.4% in the combined global warming potential (GWP) total emissions is estimated, whereas for the trend between 1990 and 2011 the analysis assesses an uncertainty by 2.6%.

Including the LULUCF sector into national figures, the uncertainty according to Approach 1 is equal to 5.1% for the year 2011, whereas the uncertainty for the trend is estimated to be 4.2%.

The reduction in the uncertainty levels, including the LULUCF sector, as compared the 2012 submission, are due to the improvements and recalculation in the LULUCF sector and consequent different weights of the categories and their uncertainties.

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 4.1 % including the LULUCF sector.

Following the recommendations of UNFCCC reviews, Approach 2 was implemented in the previous two years to estimate uncertainty of some key categories, for 2009 emission levels. The results show that uncertainty values are lower than those derived from the application of Approach 1. Details on the categories for which the analysis has been implemented are reported in Annex 1. The study will be progressively extended to other inventory categories.

Monte Carlo analysis had also been applied some years ago, following the IPCC Good Practice Guidance (IPCC, 2000), to specific categories of the inventory. Also in that case, the results show that, applying methods higher than the Tier 1 does not make a significant difference in figures if information on uncertainty levels is not sufficiently detailed. Tier 2 was applied to CO₂ emissions from road transport and N₂O emissions from agricultural soils; in the first case measurements were available for emission factors so a low uncertainty was expected, in the other no information on EFs was available and a high uncertainty was supposed. A combination of Montecarlo and Bootstrap simulation was applied to CO₂ emissions, in consideration of the specific data availability assuming a normal distribution for activity data and for the emission factor of natural gas. The overall uncertainty of CO₂ emissions for road transport resulted in 2.1%, lower than that resulting from Approach 1 which estimated a figure of 4.2%; the reason of the difference is in the lower uncertainty resulting from the application of bootstrap analysis to the emission factor of diesel oil, all the other figures are very similar. For N₂O emissions from agricultural soils, a Montecarlo analysis was applied assuming a normal distribution for activity data and two tests one with a lognormal and the other with a normal for emission factors; the results with the normal distribution calculated an uncertainty figure equal to 32.4%, lower than the uncertainty by Approach 1 which was 102%; in the case of the lognormal

distribution there were problems caused by the formula specified in the IPCC guidelines which is affected by the unit and needs further study before a throughout application. The importance of these results is that in neither of the cases does the uncertainty estimation of the national sectors result in an underestimation.

Results and details 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, had also been carried out in the past (Romano et al., 2004).

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 uncertainty estimations are based on 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 and Guidelines (IPCC, 2000; IPCC, 2003; IPCC, 2006).

More in details, facility level data are used to check and verify information from the industrial sector; these data also include information from the European Emissions Trading Scheme, the Italian PRTR register which is also collected and elaborated by the inventory team. Most of the times there is a correspondence among activity data from different databases so that the level of uncertainty could be assumed lower than the one fixed at 3%; the same occurs for emission factors coming from measurements at plant level, and even in this case the uncertainty may be assumed lower than the predetermined level. Since the overall uncertainty of the Italian inventory is relatively low due to the prevalence of the energy sector sources, which estimates derive from accurate parameters, out of the total, it has been decided to use conservative figures; this occurs especially for energy and industrial sectors.

The results of the uncertainty analysis, generally associated with a key category assessment by Approach 2, are used to prioritize improvements for the next inventory submissions.

Emissions of key categories are usually estimated with a high level of accuracy in terms of the methodology used and characterised by a low uncertainty; some exceptions may occur and categories estimated with higher tiers may be affected by a high level of uncertainty. For instance, in the agriculture sector, direct N₂O emissions from agricultural soils and indirect N₂O from nitrogen used in agriculture are affected by a high level of uncertainty especially in the emission factors notwithstanding the advanced tiers used.

For the categories with a high uncertainty, generally, further improvements are planned whenever sectoral studies can be carried out.

For example, last year, the prioritization of improvements related to the results of uncertainty analysis led to a revision of the net carbon stock changes and further activities are planned for the LULUCF sector to improve the accuracy and reduce the overall uncertainty.

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.

Details are reported in Table 1.7 and Table 1.8. Sectoral and background tables of CRF sheets are complete as far as details of basic information are available. For instance, multilateral operations emissions are not estimated because no activity data are available.

Allocation of emissions is not consistent with the IPCC Guidelines only where there is no data available to split the information. For instance, for fugitive emissions, CO₂ and CH₄ emissions from oil and natural gas exploration and venting are included in those from oil production because no detailed information is available. CH₄ emissions from other leakage emissions are included in distribution emission estimates. N₂O emissions from oil and natural gas exploration and refining and storage activities are reported under category 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 production emissions because the use of soda is part of that specific production process.

Table 1.7 Source and sinks not estimated in the 2011 inventory

Sources and sinks not estimated (NE) ⁽¹⁾			
GHG	Sector ⁽²⁾	Source/sink category ⁽²⁾	Explanation
Carbon	5 LULUCF	5.D.1 5.D.1 Wetlands remaining Wetlands	Up to now, no information is available in order to estimate GHG emissions from wetlands
Carbon	5 LULUCF	5.E.1 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.D.1 5.D.1 Wetlands remaining Wetlands	Up to now, no information is available in order to estimate GHG emissions from wetlands
Carbon	5 LULUCF	5.E.1 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.D.1 5.D.1 Wetlands remaining Wetlands	Up to now, no information is available in order to estimate GHG emissions from wetlands
Carbon	5 LULUCF	5.E.1 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.D.1 5.D.1 Wetlands remaining Wetlands	Up to now, no information is available in order to estimate GHG emissions from wetlands
Carbon	5 LULUCF	5.E.1 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
Carbon	5 LULUCF	5.B.1 perennial - woody crops	Tier 1 approach has been used, on the basis of data and documentation demonstrating that this pool is not a source.
Carbon	5 LULUCF	5.C.1 other wooded lands	Tier 1 approach has been used, on the basis of data and documentation demonstrating that this pool is not a source.
Carbon	5 LULUCF	5.B.1 perennial - plantations	Tier 1 approach has been used, on the basis of data and documentation demonstrating that this pool is not a source.
Carbon	5 LULUCF	5.A.1 stands	Tier 1 approach has been used, on the basis of data and documentation demonstrating that this pool is not a source.
Carbon	5 LULUCF	5.A.1 rupicolous and riparian forests	Tier 1 approach has been used, on the basis of data and documentation demonstrating that this pool is not a source.
Carbon	5 LULUCF	5.A.1 coppices	Tier 1 approach has been used, on the basis of data and documentation demonstrating that this pool is not a source.
CH ₄	1 Energy	1.C2 Multilateral Operations	information and statistical data are not available
CO ₂	1 Energy	1.C2 Multilateral Operations	information and statistical data are not available
N ₂ O	1 Energy	1.C2 Multilateral Operations	information and statistical data are not available

Table 1.8 Source and sinks reported elsewhere in the 2011 inventory

Sources and sinks reported elsewhere (IE)				
GHG	Source/sink category	Allocation as per IPCC Guidelines	Allocation used by the Party	Explanation
CH4	1.B.2.B.5.1 at industrial plants and power sta	1.B.2.B.5.1	1.A.1 /1.A.2	Emissions are reported under the respective sectors where they occur
CH4	1.B.2.B.5.2 in residential and commercial secto	1.B.2.B.5.2	1.A.4	Emissions are reported under the respective sectors where they occur
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	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	6.B.1 Industrial Wastewater/Sludge	6.B.1 Industrial Wastewater/Wastewater	Emissions are reported under 6.B.1 Industrial Wastewater/Wastewater
CH4	1.AA.3.B Road Transportation	1.AA.3B biomass	1.AA.3B liquid fuel	Emissions are included in liquid fuel - gasoil/diesel category
CO2	1.B.2.B.5.1 at industrial plants and power sta	1.B.2.B.5.1	1.A.1 /1.A.2	Emissions are reported under the respective sectors where they occur
CO2	1.B.2.B.5.2 in residential and commercial secto	1.B.2.B.5.2	1.A.4	Emissions are reported under the respective sectors where they occur
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	2.A.4.2 Soda Ash Use	2.A.4.2	2.A.7	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
CO2	5.A.2 Land converted to 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
CO2	5.B.1 Cropland remaining Cropland	5 (IV) CO2 emissions from agricultural lime application - Dolomite CaMg (CO3)2	IE in 5 (IV) CO2 emissions from agricultural lime application - Limestone Ca CO3	CO2 emissions from agricultural dolomite CaMg(CO3)2 application have been included in CO2 emissions from Limestone application, as national statistics on amount of lime applied don't allow to disaggregate the two component (limestone and dolomite)
N2O	1.B.2.A.4 Refining / Storage	1.B.2.A.4	1.B.2.D	Emission are included in 1.B.2.D flaring in refineries
N2O	6.B.1 Industrial Wastewater	6.B.1 Industrial Wastewater/Sludge	6.B.1 Industrial Wastewater/Wastewater	Emissions are reported under 6.B.1 Industrial Wastewater/Wastewater
N2O	6.B.2.1 Domestic and Commercial (w/o human)	6.B.2.1 Domestic and commercial/Wastewater	6.B.2.2 Human sewage	Emissions are reported under 6.B.2.2 Human sewage
N2O	6.B.2.1 Domestic and Commercial (w/o human)	6.B.2.1 Domestic and commercial/Sludge	6.B.2.2 Human sewage	Emissions are reported under 6.B.2.2 Human sewage
N2O	1.AA.3.B Road Transportation	1.AA.3B biomass	1.AA.3B liquid fuel	Emissions are included in liquid fuel - gasoil/diesel category
SF6	2.F.7 Semiconductor Manufacture	2.F.7 Semiconductor Manufacture/SF6/Amount of fluid in operating systems	2.F.7 Semiconductor Manufacture/SF6/Amount of fluid in new mmanufactured products	Data are included in new manufactured products
SF6	2.F.7 Semiconductor Manufacture	2.F.7 Semiconductor Manufacture/SF6/Amount of fluid remained in products at decommissioning	2.F.7 Semiconductor Manufacture/SF6/Amount of fluid in new mmanufactured products	Data are included in new manufactured products
SF6	2.F.7 Semiconductor Manufacture	2.F.7 Semiconductor Manufacture/SF6/Actual emissions from stocks	2.F.7 Semiconductor Manufacture/SF6/Actual emissions from manufacturing	Emissions are included in emissions from manufacturing
SF6	2.F.7 Semiconductor Manufacture	2.F.7 Semiconductor Manufacture/SF6/Actual emissions from disposal	2.F.7 Semiconductor Manufacture/SF6/Actual emissions from manufacturing	Emissions are included in emissions from manufacturing

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 1990-2011 are reported in Tables A8.1-A8.5 of Annex 8.

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 CO₂ equivalent, excluding emissions and removals from LULUCF, have decreased by 5.8% between 1990 and 2011, varying from 519 to 489 CO₂ 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. It should be noted that the economic recession has had a remarkable influence on the production levels affecting the energy and industrial process sectors, with a consequent notable reduction of total emissions, especially in the last three years.

The most important greenhouse gas, CO₂, which accounts for 84.7% of total emissions in CO₂ equivalent, shows a decrease by 4.7% between 1990 and 2011. In the energy sector, in particular, CO₂ emissions in 2011 are 2.8% lower than in 1990.

CH₄ and N₂O emissions are equal to 7.5% and 5.5% of the total CO₂ equivalent greenhouse gas emissions, respectively. CH₄ emissions have decreased by 16.4% from 1990 to 2011, while N₂O has decreased by 28.1%.

As for other greenhouse gases, HFCs account for 1.9% of total emissions, PFCs and SF₆ are equal to 0.3% and 0.1% of total emissions, respectively. HFC emissions show a strong increase, while PFC emissions show a decrease and SF₆ emissions show a slight 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 1990-2011, expressed in CO₂ equivalent terms and by substance; total emissions do not include emissions and removals from land use, land use change and forestry.

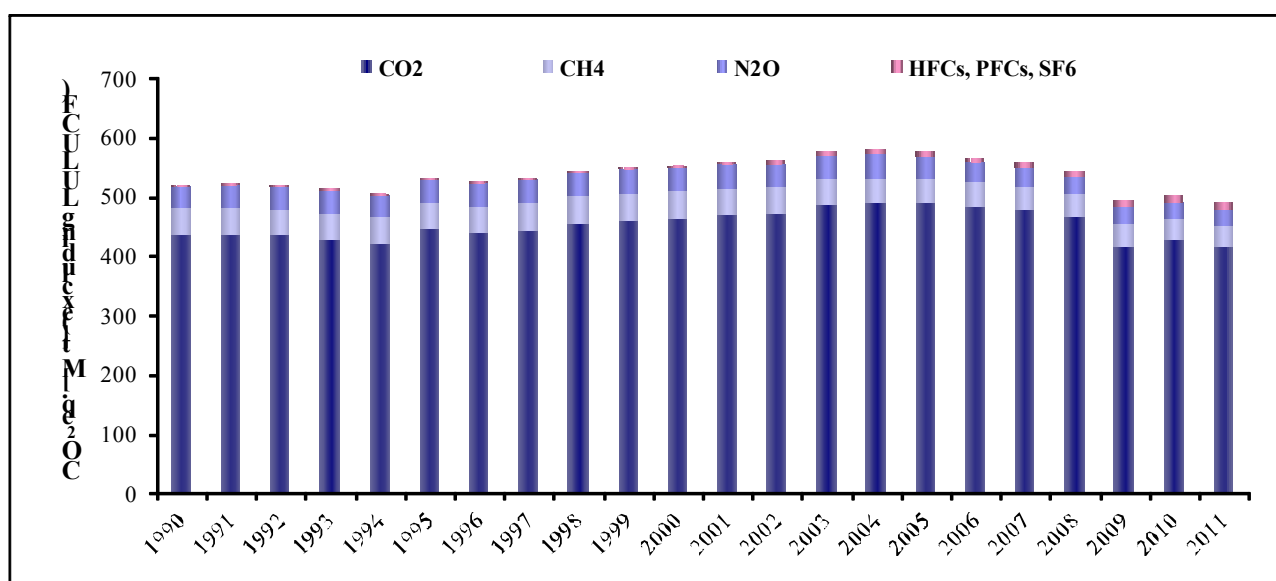


Figure 2.1 National greenhouse gas emissions from 1990 to 2011 (without LULUCF) (Mt CO₂ eq.)

The share of the different sectors, in terms of total emissions, remains nearly unvaried over the period 1990-2011. Specifically for the year 2011, the greatest part of the total greenhouse gas emissions is to be attributed

to the energy sector, with a percentage of 82.7%, followed by agriculture and industrial processes, accounting for 6.9% and 6.5% of total emissions, respectively, waste contributing with 3.6% and use of solvents with 0.3%.

Total greenhouse gas emissions and removals, including LULUCF sector, are shown in Figure 2.2 in subdivided by sector.

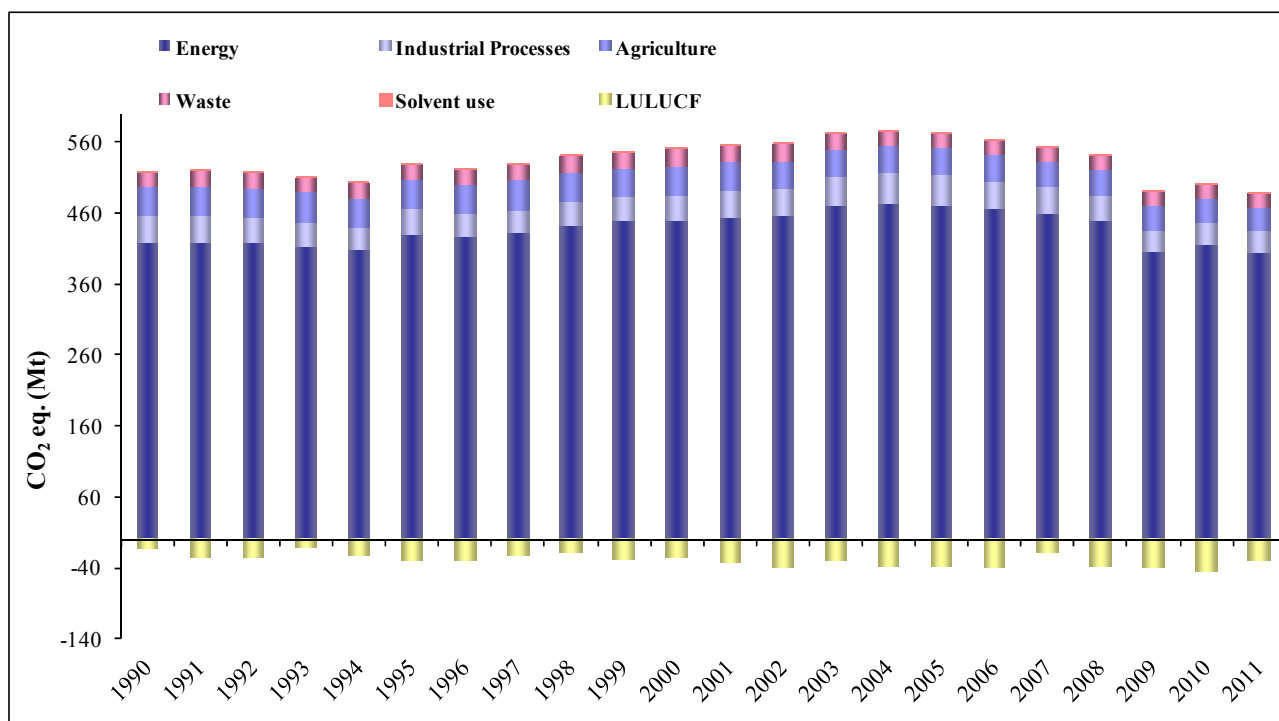


Figure 2.2 Greenhouse gas emissions and removals from 1990 to 2011 by sector (Mt CO₂ eq.)

2.2 Description and interpretation of emission trends by gas

2.2.1 Carbon dioxide emissions

CO₂ emissions, excluding CO₂ emissions and removals from LULUCF, have decreased by 4.7% from 1990 to 2011, ranging from 435 to 414 million tons.

The most relevant emissions derive from the energy industries (31.5%) and transportation (28.1%). Non-industrial combustion accounts for 20.2% and manufacturing and construction industries for 14.4%, while the remaining emissions derive from industrial processes (4.9%) and other sectors (0.9%).

The performance of CO₂ emissions by sector is shown in Figure 2.3.



Figure 2.3 National CO₂ emissions by sector from 1990 to 2011 (Mt)

The main sectors responsible for CO₂ emissions are transport and energy industries; in the period 1990-2011, emissions from transport have increased by 15.0% from 1990 to 2011 while those from energy industries decreased by 4.3%. Non industrial combustion emissions have increased by 7.6% and those from industrial processes decreased by 29.0%; emissions from manufacturing industries and construction show a decrease of 29.8%, emissions in the ‘Other’ sector, fugitive emissions from oil and natural gas, emissions from solvent and other product use and emissions from waste, reduced by 33.9%.

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;
- CO₂ emissions, excluding emissions and removals from land-use change and forests;
- CO₂ intensity, which represents CO₂ emissions per unit of total energy consumption.

The figures of CO₂ emissions per total energy unit show that CO₂ 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. In the last years, the increase in the use of renewable sources has led to a notable reduction of CO₂ intensity.

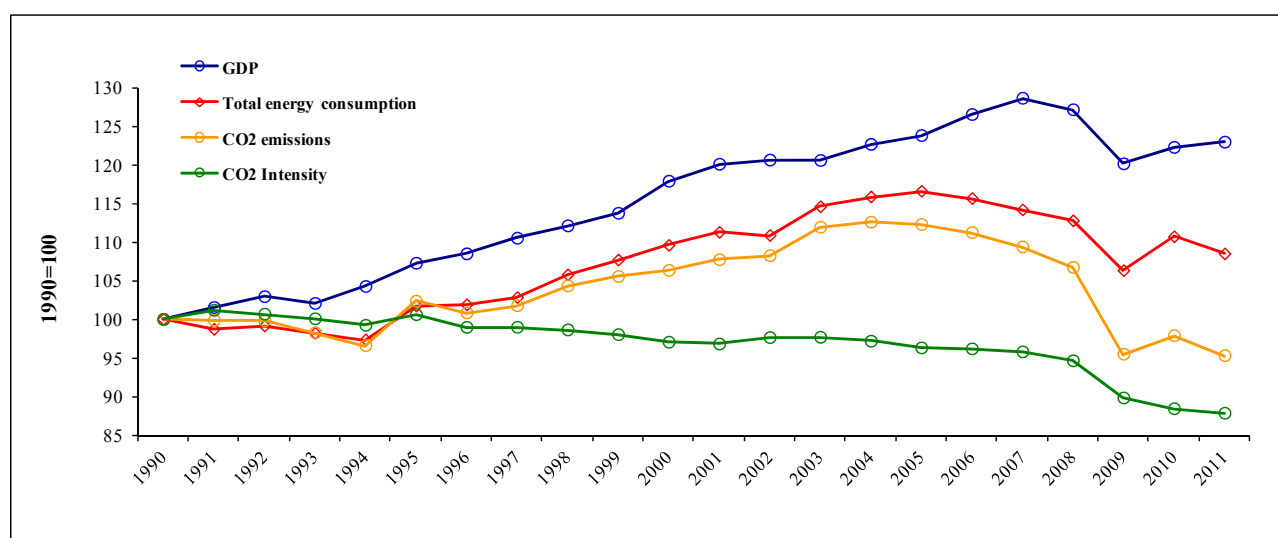


Figure 2.4 Energy-related and economic indicators and CO₂ emissions

2.2.2 Methane emissions

Methane emissions (excluding LULUCF) in 2011 represent 7.5% of total greenhouse gases, equal to 36.6 Mt in CO₂ equivalent, and show a decrease of 7.2 Mt (-16.4%) as compared to 1990 levels.

CH₄ emissions, in 2011, are mainly originated from waste sector which accounts for 41.9 % of total methane emissions, as well as from the agriculture (39.5%) and energy (18.5%) sectors.

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 a decrease in emission levels, 11.4% compared to 1990; the solid waste disposal on land, which represents the largest emission sectoral share (81.8%), decreases of 17.8%, while the highest increases concern waste-water handling (37.4%) and waste incineration (15.8%) and subcategories.

Emissions in the agricultural sector regard mainly the enteric fermentation (74.5%) and manure management (14.6%) categories. The agriculture sector shows a decrease of emissions equal to 16.7% as compared to 1990.

In terms of CH₄ emissions in the energy sector, the reduction (-25.3%) is the result of two contrasting factors: on the one hand there has been a considerable reduction in emissions deriving from energy industries, manufacturing industries and construction, transport, fugitive emissions from fuels (caused by leakage from the extraction and distribution of fossil fuels, due to the gradual replacement of natural-gas distribution networks), on the other hand a strong increase in the civil sector can be observed, as a result of increased use of methane and biomass in heating systems. Figure 2.5 shows the emission figures by sector.

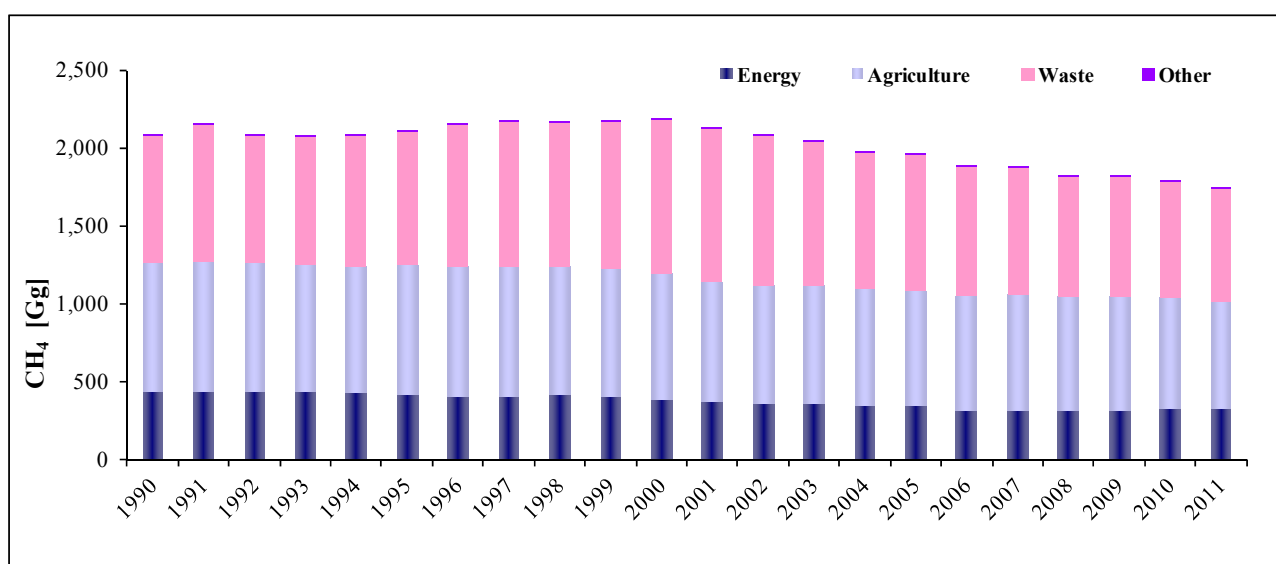


Figure 2.5 National CH₄ emissions by sector from 1990 to 2011 (Gg)

2.2.3 Nitrous oxide emissions

In 2011 nitrous oxide emissions (excluding LULUCF) represent 5.5% of total greenhouse gases, with a decrease of 28.1% between 1990 and 2011, from 37.4 to 26.9 Mt CO₂ equivalent.

The major source of N₂O emissions is the agricultural sector (71.0%), 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 18.4% during the period 1990-2011.

Emissions in the energy-use sector (18.4% of the total) show an increase by 6.8% from 1990 to 2011; 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 N₂O emission factors of catalysed automobiles.

Emissions from production of nitric acid have decreased of 91.5% from 1990 to 2011 with a notable decrease in the last year due to the introduction of the abatement systems in the main production plant; emissions from production of adipic acid show an increase from 1990 to 2005 of 32.6% and a decrease from 2005 to 2011 of 98.1% because of the introduction of an abatement technology, showing a global reduction of 97.5%.

Other emissions in the waste sector primarily regard the processing of industrial and domestic waste-water (7.3% of national N₂O emissions).

Figure 2.6 shows national emission figures by sector.

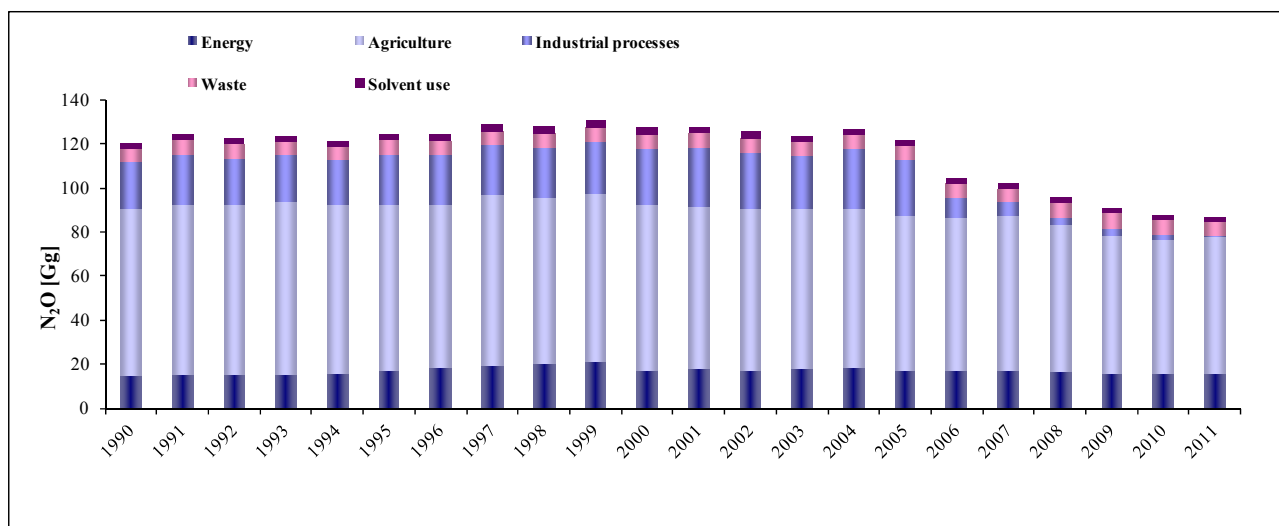


Figure 2.6 National N₂O emissions by sector from 1990 to 2011 (Gg)

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, HFCs, PFCs and SF₆. Taken altogether, the emissions of fluorinated gases represent 2.3% of total greenhouse gases in CO₂ equivalent in 2011 and they show an increase of 250.5% between 1990 and 2011. This increase is the result of different features for the different gases.

HFCs, for instance, have increased considerably from 1990 to 2011, from 0.4 to 9.3 Mt in CO₂ equivalent. 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 substitutes for gases that destroy the ozone layer and to the greater use of air conditioners in automobiles.

Emissions of PFCs show a decrease of 41.5% from 1990 to 2011. The level of PFCs emissions in 2011 is 1.5 Mt in CO₂ equivalent, and it is due to by product emissions in the production of halocarbons (87%), the production of primary aluminium (5.6%) and the use of the gases in the production of semiconductors (7.4%). The production of PFCs is equal to zero in Italy from the year 1999 onwards.

Emissions of SF₆ are equal to 0.35 Mt in CO₂ equivalent in 2011, with an increase of 5.5% as compared to 1990 levels. In 2011, 84.9% of SF₆ emissions derive from the gas contained in electrical equipments and 15.1% from the gas use in the semiconductors manufacture. From 2005 to 2006, emissions of SF₆ have fallen by 12.8%, and between 2006 and 2011 a decrease of 13.4%.

The National Inventory of fluorinated gases has largely improved in terms of sources and 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.

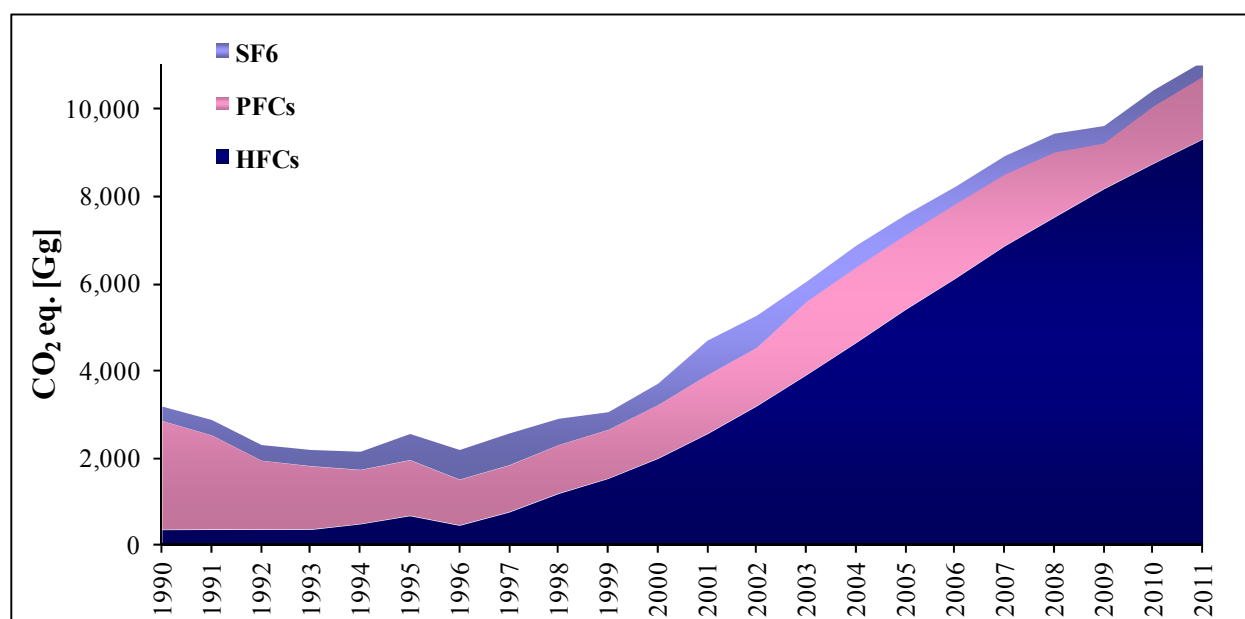


Figure 2.7 National emissions of fluorinated gases by sector from 1990 to 2011 (Gg CO₂ eq.)

2.3 Description and interpretation of emission trends by source

2.3.1 Energy

Emissions from the energy sector account for 82.7% of total national greenhouse gas emissions, excluding LULUCF.

Emissions in CO₂ equivalent from the energy sector are reported in Table 2.1 and Figure 2.8.

Table 2.1 Total emissions from the energy sector by source (1990-2011) (Gg CO₂ eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
<i>Gg CO₂ eq.</i>										
Total emissions	417,736	431,111	449,687	471,902	466,813	458,165	449,202	405,192	415,299	404,444
Fuel Combustion (Sectoral Approach)	406,956	421,039	440,663	464,076	459,446	450,956	441,858	398,055	407,781	397,038
Energy Industries	137,214	140,541	152,556	160,552	161,698	161,469	156,806	131,796	133,182	131,230
Manufacturing Industries and Construction	86,948	86,586	83,811	80,239	79,187	75,903	72,473	55,903	61,374	61,251
Transport	103,106	114,101	122,442	127,461	128,823	128,836	123,776	119,338	118,911	117,851
Other Sectors	78,569	78,300	81,003	94,533	88,680	83,780	88,001	90,098	93,645	86,179
Other	1,120	1,511	851	1,291	1,058	969	801	920	669	527
Fugitive Emissions from Fuels	10,781	10,072	9,024	7,825	7,367	7,208	7,344	7,137	7,518	7,406
Solid Fuels	127	66	75	70	54	86	74	45	66	71
Oil and Natural Gas	10,654	10,007	8,949	7,756	7,313	7,122	7,270	7,092	7,451	7,334

Total greenhouse gas emissions, in CO₂ equivalent, show a decrease of about 3.2% from 1990 to 2011; in particular, an upward trend is noted from 1990 to 2004, with an increase by 13.4%, while between 2004 and 2010 emissions have decreased by 14.6%.

CO₂ emissions, accounting for 97.1% of the total, have decreased by 2.8% from 1990 to 2011; N₂O shows an increase of 6.8% but its share out of the total is only 1.2% whereas CH₄ shows a decrease of 25.3% from 1990 to 2011, accounting for 1.7% of the total emission levels.

It should be noted that from 1990 to 2011 the most significant increase, in terms of total CO₂ equivalent, is observed in transport and in other sectors, about 14.3% and 9.7%, respectively; in 2011 these sectors, altogether, account for 50.4% of total emissions. In the period 1990-2011, energy industries emissions have decreased by 4.4%, accounting for 32.4% of total emissions.

Details on these figures are described in the specific chapter.

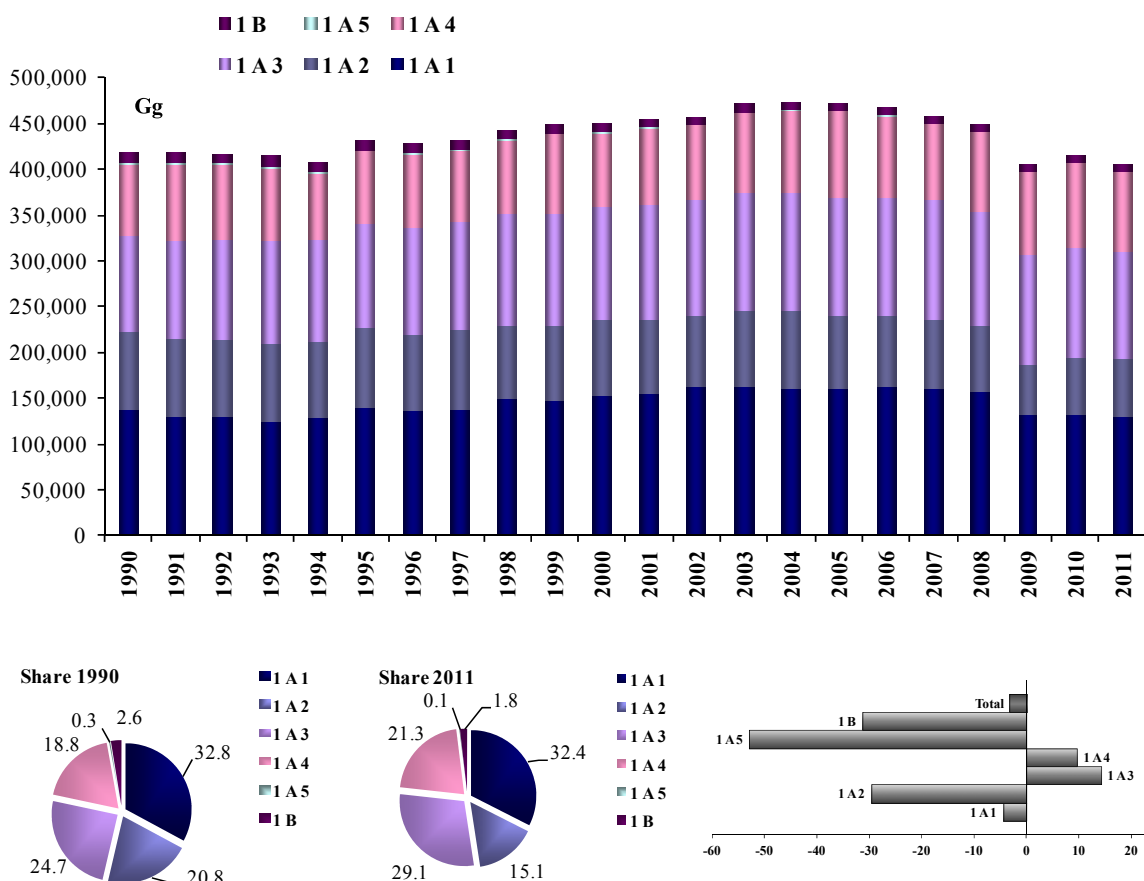


Figure 2.8 Trend of total emissions from the energy sector (1990-2010) (Gg CO₂ eq.)

2.3.2 Industrial processes

Emissions from industrial processes account for 6.5% of total national greenhouse gas emissions, excluding LULUCF.

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

Total emissions, in CO₂ equivalent, show a decrease of 17.6%, from the base year to 2011. Taking into account emissions by substance, CO₂ and N₂O decreased by 29.0% and 95.6%, respectively; these two gases account altogether for about 64.7% of the total emissions from industrial processes (CO₂ for 63.8% and N₂O for 0.9%). CH₄ decreased by 46.4% but it accounts only for 0.2%.

The decrease in emissions is mostly to be attributed to a decrease in chemical industry and metal production emissions. The decrease of GHG emissions in the chemical industry (-81.1%) is due to the decreasing trend of the emissions from nitric acid and adipic acid production (the last production process sharply reduced its emissions, due to a fully operational abatement technology). Emissions from metal production decreased by 57.8% mostly for the different materials used in the pig iron and steel production processes.

On the other hand, a considerable increase is observed in F-gas emissions (250.5%), whose share on total emissions is 35.1%.

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

Table 2.2 Total emissions from the industrial processes sector by gas (1990-2011) (Gg CO₂ eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Gg CO₂ eq										
Total	38,390	35,929	36,249	42,592	38,143	38,601	35,668	30,743	31,830	31,641
CO ₂	28,434	26,038	24,571	27,186	27,205	27,711	25,093	19,951	20,682	20,176
CH ₄	108	113	63	64	66	65	61	38	53	58
N ₂ O	6,676	7,239	7,918	7,760	2,647	1,891	1,066	1,130	647	295
F-gases	3,171	2,539	3,697	7,581	8,226	8,935	9,449	9,625	10,449	11,112
HFCS	351	671	1,986	5,401	6,106	6,855	7,513	8,164	8,745	9,306
PFCS	2,487	1,266	1,217	1,715	1,714	1,652	1,501	1,063	1,331	1,455
SF ₆	333	601	493	465	406	428	436	398	373	351

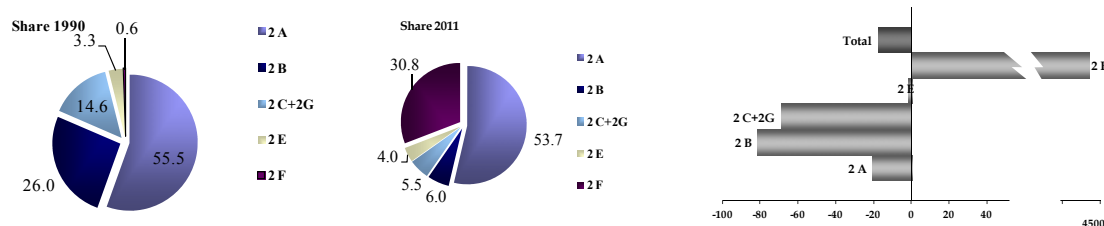
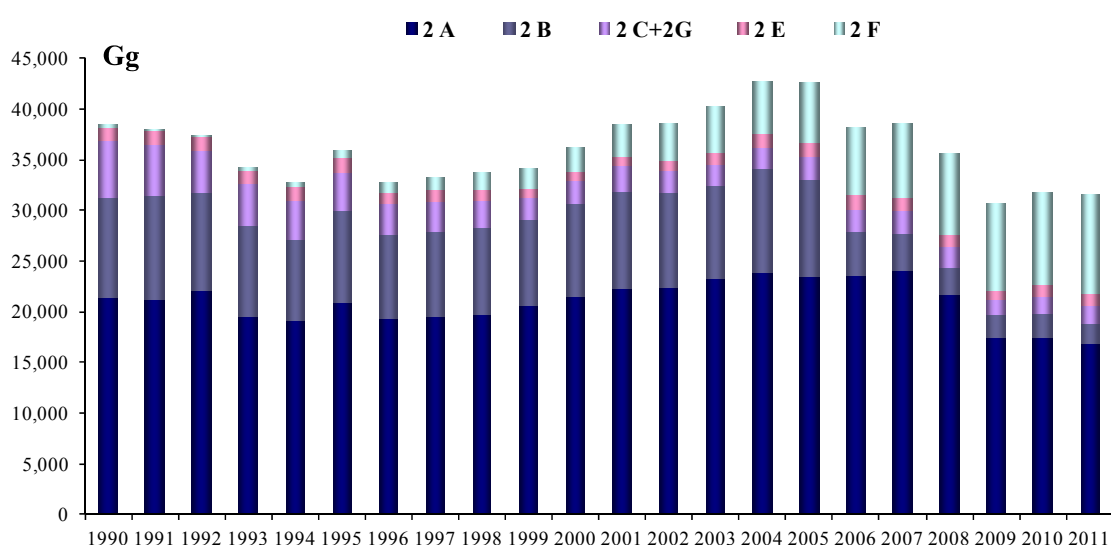


Figure 2.9 Trend of total emissions from the industrial processes sector (1990-2011) (Gg CO₂ eq.)

2.3.3 Solvent and other product use

Emissions from the solvent and other product use sector refer to CO₂ and N₂O, and to other substances that are not greenhouse gases. A considerable amount of emissions from this sector is, in fact, to be attributed to NMVOC.

Emission trends for CO₂ and N₂O from the sector are reported in Table 2.3 and Figure 2.10.

Table 2.3 Total emissions from the solvent and other product use sector by gas (1990-2011) (Gg CO₂ eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Gg CO₂ eq.										
Total emissions	2,455	2,235	2,301	2,123	2,126	2,075	1,954	1,829	1,677	1,656
CO ₂	1,642	1,463	1,275	1,299	1,317	1,287	1,226	1,146	1,050	1,080
N ₂ O	812	772	1,027	823	808	788	727	684	626	577

In 2011, solvent use is responsible for 0.3% of the total CO₂ equivalent emissions (excluding LULUCF). The share of CO₂ emissions, in this sector, is 65.2% out of the total, while N₂O emissions represent 34.8% of the sectoral total; a decrease by 32.5% is noted from this sector from 1990 to 2011, which is to be attributed to different sources. As regards CO₂, emission levels from paint application sector, which accounts for 50.4% of total CO₂ emissions from this sector, decreased by 35.6%; emissions from other use of solvents in related activities, such as domestic solvent use other than painting, application of glues and adhesives, printing industries, fat edible and non edible oil extraction, vehicle dewaxing, glass wool enduction, which account for 43.9% of the CO₂ total emissions, show a decrease of 23.8%. Finally, CO₂ emissions from metal degreasing and dry cleaning activities, decreased by 65.1% but they account for only 5.7% of the total.

N₂O emissions from this sector, in 2011, represent 2.1% of the total N₂O national emissions.

The level of N₂O emissions shows a decrease of 29%. From 1990 to 1995, a quite stable level of N₂O emissions is observed, afterwards from 1995 to 1998 emissions increased by 36.7%. From 1999 onwards, a reduction in N₂O emissions is observed, due to a decrease in the anaesthetic use of N₂O, which has been replaced by halogen gas.

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

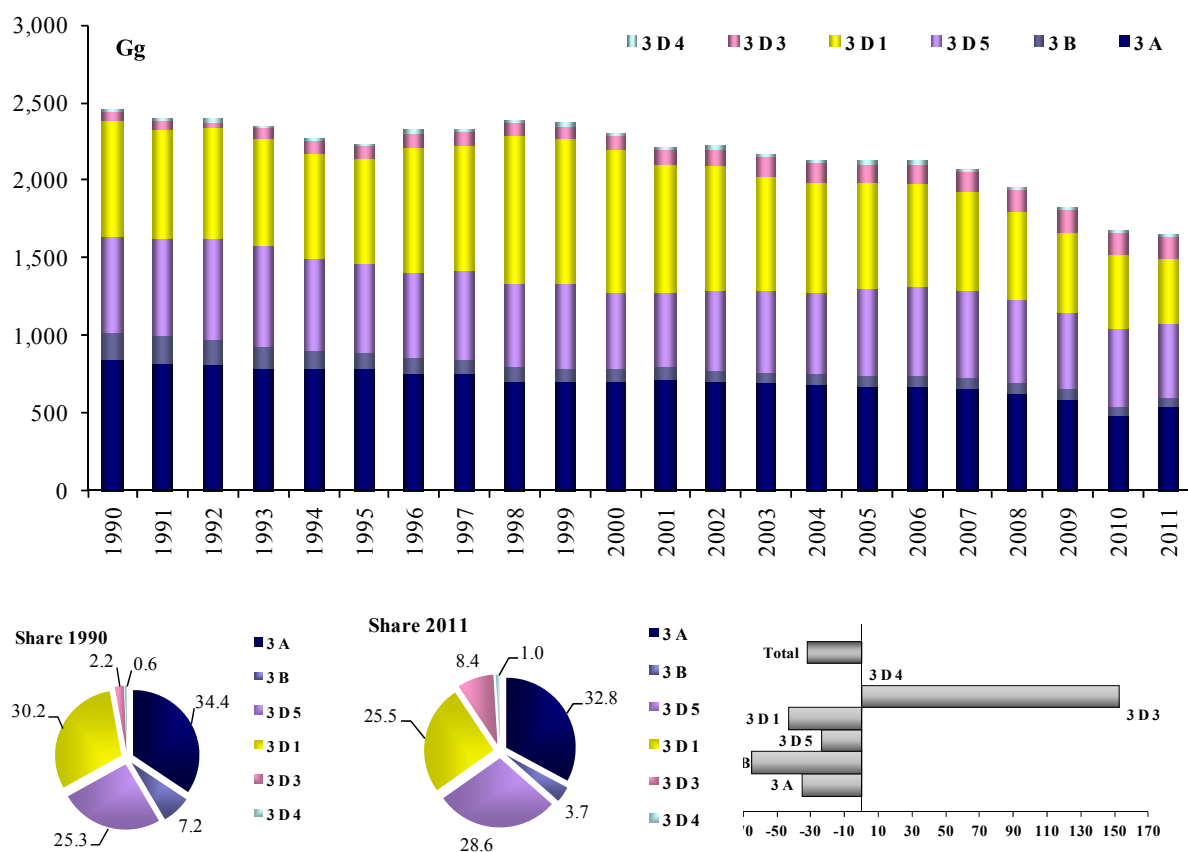


Figure 2.10 Trend of total emissions from the solvent and other product use sector (1990-2011) (Gg CO₂ eq.)

2.3.4 Agriculture

Emissions from the agriculture sector account for 6.9% of total national greenhouse gas emissions, excluding LULUCF.

Emissions from the agriculture sector are reported in Table 2.4 and Figure 2.11.

Table 2.4 Total emissions from the agriculture sector by source (1990-2011) (Gg CO₂ eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Gg CO₂ eq.										
Total emissions	40,739	40,520	40,135	37,363	36,767	37,380	36,015	34,777	33,723	33,530
Enteric Fermentation	12,278	12,348	12,246	10,914	10,699	11,099	10,996	11,007	10,732	10,761
Manure Management	7,383	7,068	7,140	6,857	6,629	6,833	6,736	6,685	6,268	5,830
Rice Cultivation	1,576	1,671	1,391	1,472	1,475	1,516	1,386	1,565	1,565	1,550
Agricultural Soils	19,484	19,417	19,341	18,100	17,947	17,914	16,879	15,502	15,139	15,372
Field Burning of Agricultural Residues	17	17	17	18	18	18	19	18	18	18

Emissions refer to CH₄ and N₂O levels, which account for 43.1% and 56.9% of the total emissions of the sector, respectively. The decrease observed in the total emissions (-17.7%) is mostly due to the decrease of CH₄ emissions from enteric fermentation (-12.4%) and to the decrease of N₂O (-21.1%) from agricultural soils, which account for 32.1% and 45.8% of the total sectoral emissions, respectively.

Detailed comments can be found in the specific chapter.

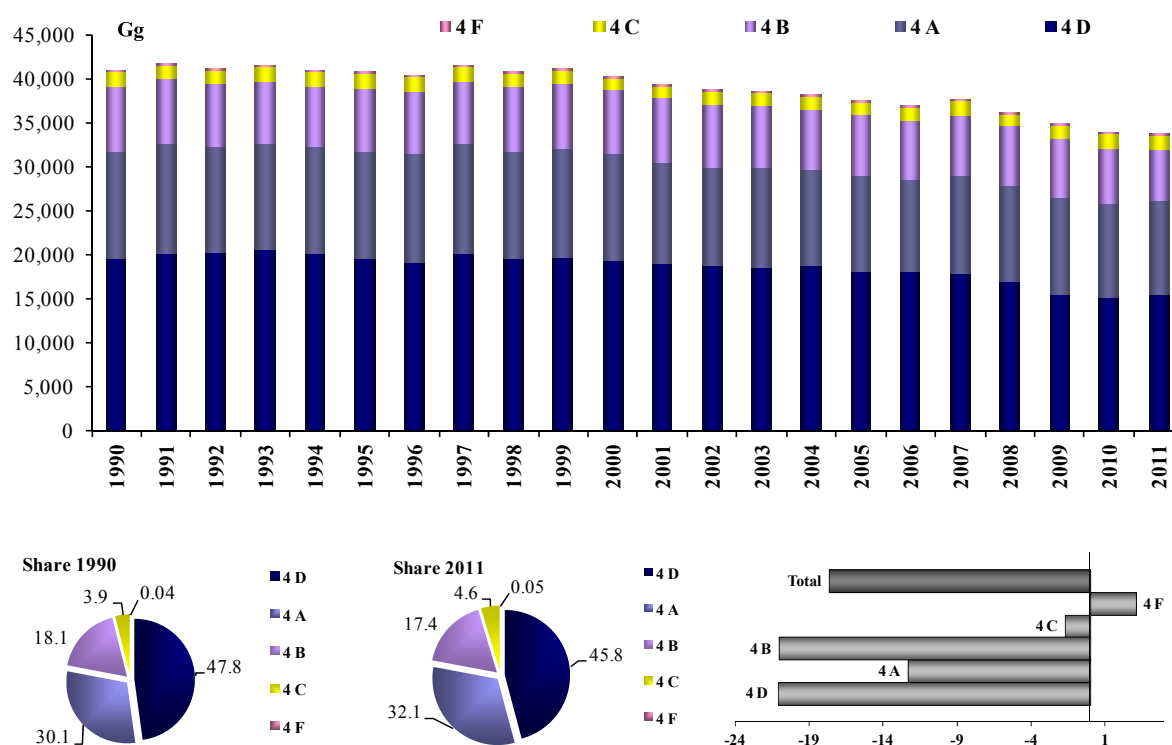


Figure 2.11 Trend of total emissions from the agriculture sector (1990-2011) (Gg CO₂ eq.)

2.3.5 LULUCF

Emissions from the LULUCF sector are reported in Table 2.5 and Figure 2.12.

Table 2.5 Total emissions from the LULUCF sector by source/sink (1990-2011) (Gg CO₂ eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Gg CO₂ eq.										
Total emissions	-12,154	-30,383	-25,835	-38,271	-39,167	-17,602	-36,670	-39,920	-43,341	-30,590
Forest Land	-17,098	-32,329	-26,883	-36,339	-36,723	-20,398	-33,483	-36,572	-38,204	-29,480
Cropland	-1,015	802	-543	-942	-1,020	-823	-1,032	-1,141	-1,183	3,344
Grassland	3,444	-1,370	-877	-4,339	-4,787	244	-5,571	-5,639	-7,376	-7,852
Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
Settlements	2,516	2,514	2,468	3,350	3,363	3,376	3,416	3,432	3,422	3,397
Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Total removals, in CO₂ equivalent, in the LULUCF sector, show an increase of 151.7% from the base year to 2011. CO₂ accounts for 99.2% of total emissions and removals of the sector.

Further details for LULUCF emissions and removals can be found in the specific chapter.

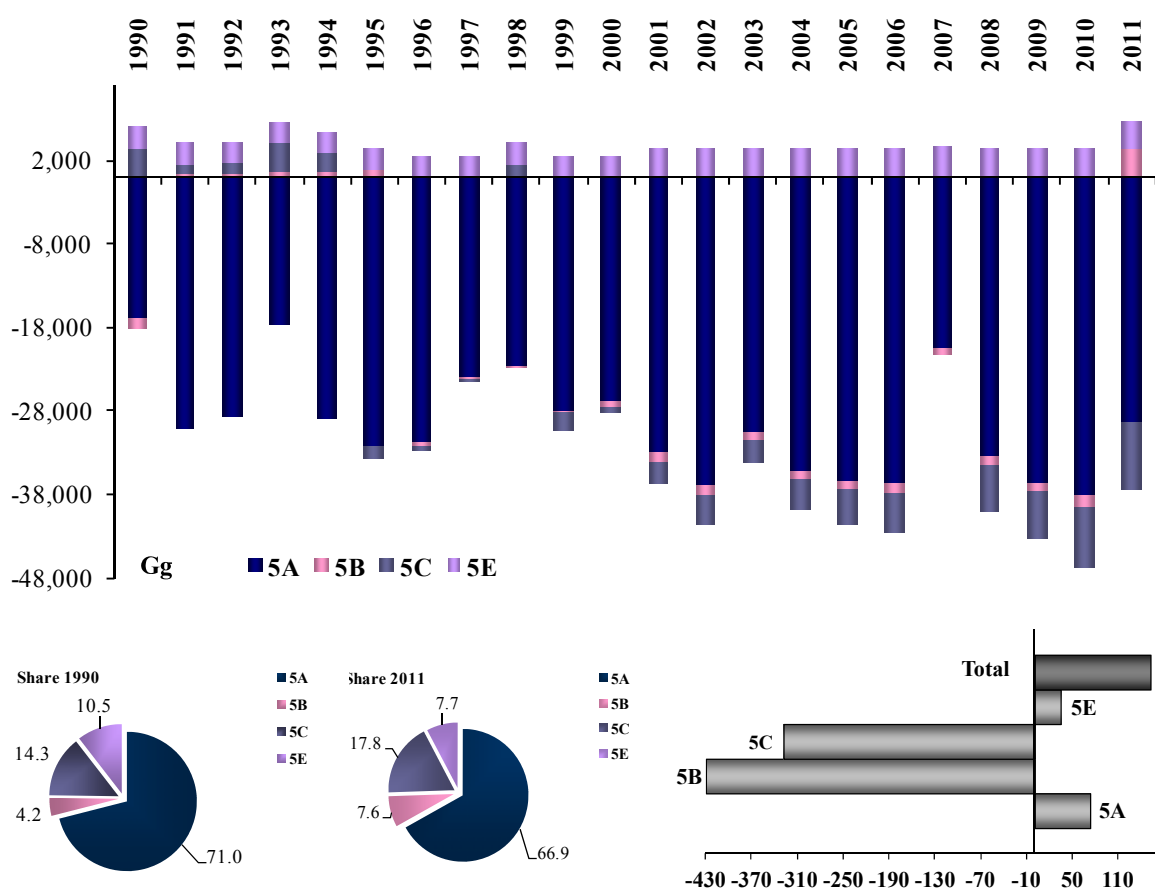


Figure 2.12 Trend of total emissions and removals from the LULUCF sector (1990-2011) (Gg CO₂ eq.)

2.3.6 Waste

Emissions from the waste sector account for 3.4% of total national greenhouse gas emissions, excluding LULUCF.

Emissions from the waste sector are shown in Table 2.6 and Figure 2.13.

Table 2.6 Total emissions from the waste sector by source (1990-2011) (Gg CO₂ eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Gg CO ₂ eq.										
Total emissions	19,665	20,445	22,929	20,454	19,818	19,147	18,338	18,238	17,785	17,521
Solid Waste Disposal on Land	15,254	15,909	18,357	15,514	14,851	14,194	13,364	13,237	12,767	12,533
Waste-water Handling	3,821	3,995	4,292	4,629	4,645	4,663	4,689	4,676	4,715	4,671
Waste Incineration	590	541	277	306	318	285	280	321	298	312
Other	0	0	2	4	4	5	4	4	5	5

Total emissions, in CO₂ equivalent, decreased by 10.9% from 1990 to 2011. The trend is mainly driven by the decrease in emissions from solid waste disposal on land (-17.8%), accounting for 71.5% of the total. Considering emissions by gas, the most important greenhouse gas is CH₄ which accounts for 87.5% of the total and shows a decrease of 11.4% from 1990 to 2011. N₂O levels have increased by 5.0% while CO₂ decreased by 53.8%; these gases account for 11.2% and 1.3%, respectively.

Further details can be found in the specific chapter.

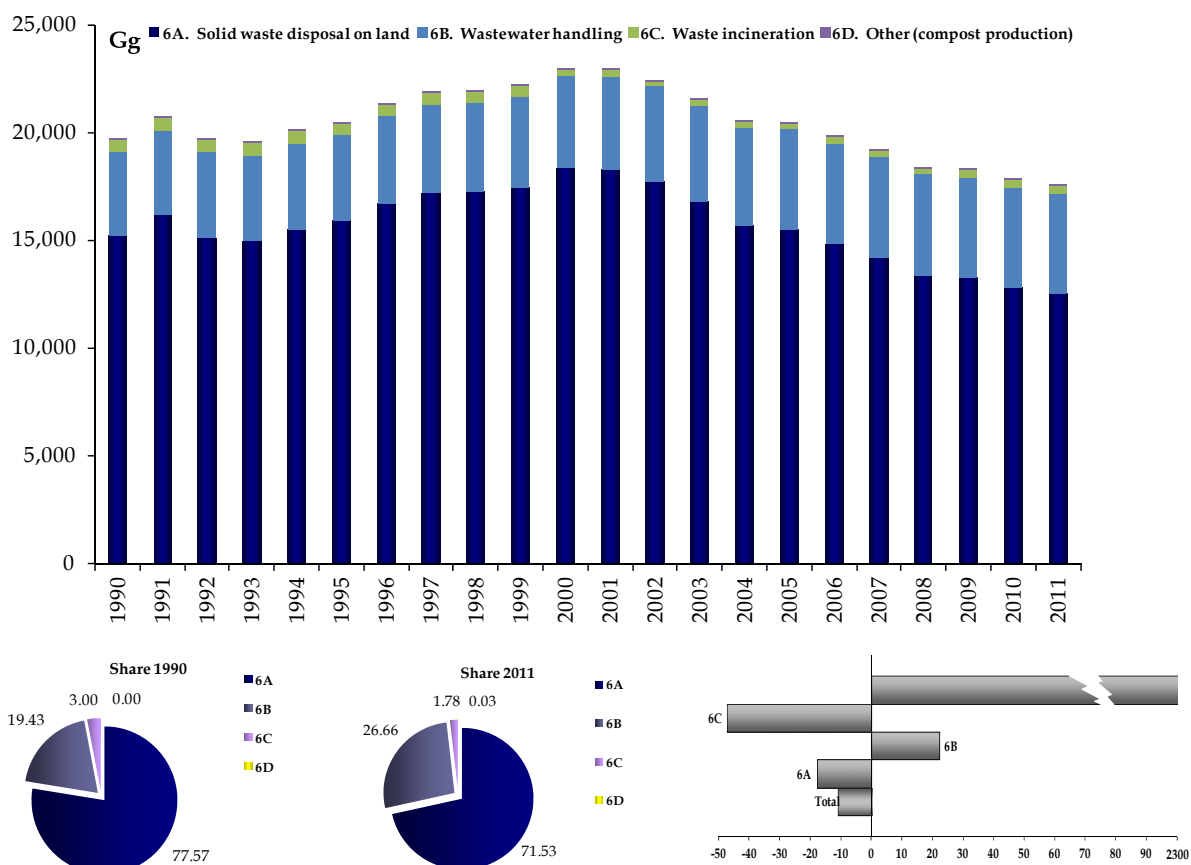


Figure 2.13 Trend of total emissions from the waste sector (1990-2011) (Gg CO₂ eq.)

2.4 Description and interpretation of emission trends for indirect greenhouse gases and SO₂

Emission trends of NO_x, CO, NMVOC and SO₂ from 1990 to 2011 are presented in Table 2.7 and Figure 2.14.

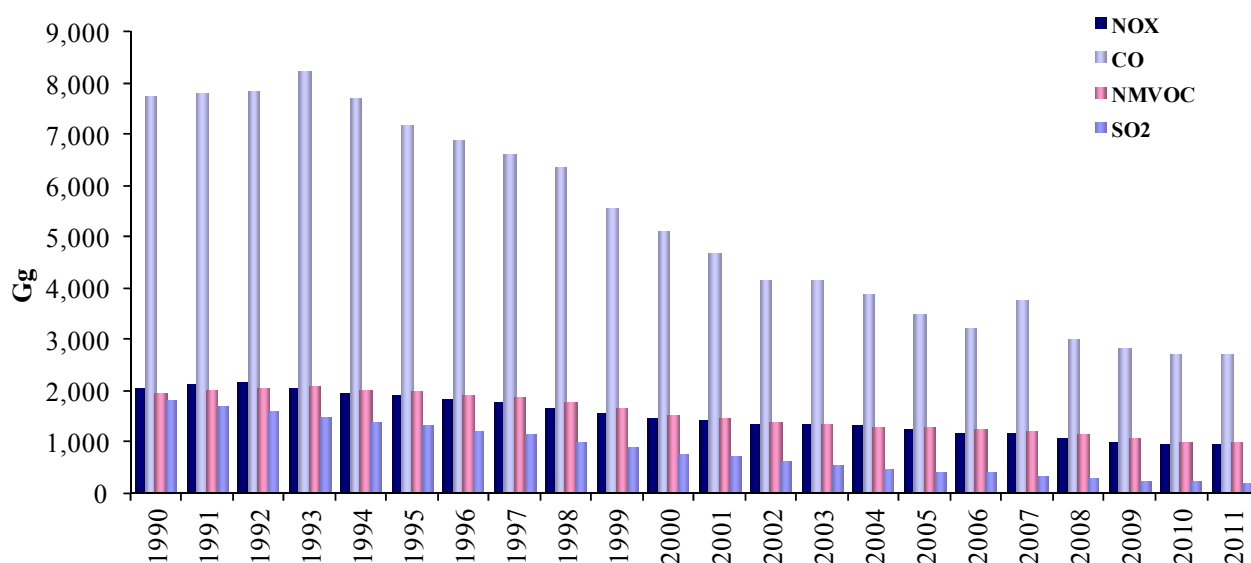
Table 2.7 Total emissions for indirect greenhouse gases and SO₂ (1990-2011) (Gg)

Indirect GHG and SO ₂	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	Gg									
NO _x	2,052	1,908	1,446	1,226	1,170	1,153	1,067	1,000	963	943
CO	7,734	7,172	5,098	3,472	3,214	3,759	2,990	2,819	2,722	2,703
NMVOC	1,955	1,966	1,531	1,260	1,231	1,209	1,125	1,070	1,010	998
SO ₂	1,800	1,326	753	406	383	341	285	233	215	196

All gases show a significant reduction in 2011 as compared to 1990 levels. The highest reduction is observed for CO (-65.0%), SO₂ levels have reduced by 89.1%, while NO_x and NMVOC show a decrease by 54.0% and 49.0%, 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 SO₂, NO_x, NMVOC and NH₃, as requested by the Directive 2001/81/EC.

The most relevant reductions occurred as a consequence of the Directive 75/716/EC, and successive ones related to the transport sector, and of 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 SO₂ (1990-2011) (Gg)



3 ENERGY [CRF sector 1]

3.1 Sector overview

For the pollutants and sources discussed in this section, emissions result from the combustion of fuel. The pollutants estimated are: carbon dioxide (CO₂), NO_x as nitrogen dioxide, nitrous oxide (N₂O), methane (CH₄), non methane volatile organic compounds (NMVOC), carbon monoxide (CO), and sulphur dioxide (SO₂). The sources covered 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 and Agriculture.

The national emission inventory is prepared using 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 many publications but the evaluation of emissions of methane and nitrous oxide is needed. 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 not regular especially in some sectors; hence, information is not often available on actual emissions over a specific period from an individual emission source. Therefore, the majority of emissions are estimated from different 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:

$$\text{Total Emission} = \text{Emission Factor} \times \text{Activity Statistic}$$

Emission factors are typically derived from measurements on a number of representative sources and the resulting factor applied to the whole country.

For some categories, emissions data are available at individual site. Hence, emissions for a specific category can be calculated as the sum of the emissions from these point sources. That is:

$$\text{Emission} = \Sigma \text{ Point Source Emissions}$$

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

For most of the combustion source categories, emissions are estimated from fuel consumption data reported in the National Energy Balance (BEN) and from 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 3.6);

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

Thus, the 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 relevant sections. 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 the national energy balance.

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”;
- refineries auto-generation is included in section 1.A.1.b;
- iron and steel auto-generation is included in section 1.A.1.c.

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

Emissions from waste incineration facilities with energy recovery are reported under category 1.A.4.a (Combustion activity, commercial/institutional sector), for the fossil and biomass fraction of waste incinerated in the other fuel and biomass sub categories respectively, whereas emissions from other types of waste incineration facilities are reported under category 6.C (Waste incineration). In fact, energy recovered by these plants is mainly used for district heating of commercial buildings. In particular, for 2011, more than 95% of the total amount of waste incinerated is treated in plants with energy recovery system. To estimate CO₂ emissions, considering the total amount of waste incinerated in plants with energy recovery, carbon content is calculated, as described in paragraph 8.4.2, in the waste chapter; the value is considered constant for the whole time series. Different emission factors for municipal, industrial and oils, hospital waste, and sewage sludge are applied, as reported in the waste chapter, Tables 8.23-8.27. Waste amount is then converted in energy content applying an emission factor equal to 9.2 GJ/t of waste. In 2011, the resulting average emission factor is equal to 114.9 kg CO₂/GJ.

Emissions from landfill gas recovered are used for heating and power in commercial facilities and reported under 1.A.4.a in biomass. Biogas recovered from the anaerobic digester of animal waste is used for utilities in the agriculture sector and relative emissions are reported under 1.A.4.c in biomass.

In consideration of the increasing of the share of waste used to produce electricity, we plan to revise the allocation of these emissions under category 1.A.1.a.

Emission trends

In 2011, the energy sector accounts for 94.8% of CO₂ emissions, 18.5% of CH₄ and 18.4% of N₂O. In terms of CO₂ equivalent, the energy sector shares 82.7% of total national greenhouse gas emissions excluding LULUCF.

Emission trends of greenhouse gases from the energy sector are reported in Table 3.1.

Table 3.1 GHG emission trends in the energy sector 1990-2011 (Mt CO₂ eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	Mt CO ₂ eq.									
Energy	417.7	431.1	449.7	471.9	466.8	458.2	449.2	405.2	415.3	404.4
CO₂	404.1	417.0	436.2	459.4	454.8	446.2	437.4	393.8	403.5	392.7

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	Mt CO₂ eq.									
CH₄	9.0	8.7	8.1	7.2	6.7	6.6	6.6	6.5	6.8	6.7
N₂O	4.6	5.4	5.4	5.3	5.4	5.4	5.2	4.9	5.0	4.9

Source: ISPRA elaborations

The emission trend is generally driven by the economic indicators as already shown in chapter 2. From 2004, GHG emissions from the sector are decreasing as a result of the policies adopted at European and national level to implement the production of energy from renewable sources. From the same year, a further shift from petrol products to natural gas in producing energy has been observed as a consequence of the starting of the EU greenhouse gas Emission Trading Scheme (EU ETS) in January, 1st 2005. From 2009, a further drop of the sectoral emissions is due to the economic recession. In Table 3.2, the electricity production distinguished by source for the whole time series is reported on the basis of data supplied by the national grid operator (ENEL, several years; TERNA, several years).

Table 3.2 Production of electricity by sources 1990-2011 (GWh)

Source	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	GWh									
Hydroelectric	35,079	41,907	50,900	42,927	43,425	38,481	47,227	53,443	54,407	47,757
Thermoelectric	178,590	196,123	220,455	253,073	262,165	265,764	261,328	226,638	231,248	228,507
- solid fuels	32,042	24,122	26,272	43,606	44,207	44,112	43,074	39,745	39,734	44,726
- natural gas	39,082	46,442	97,607	149,259	158,079	172,646	172,697	147,270	152,737	144,539
- derivated gases	3,552	3,443	4,252	5,837	6,251	5,645	5,543	3,701	4,731	5,442
- oil products	102,718	120,783	85,878	35,846	33,830	22,865	19,195	15,878	9,908	8,474
- other fuels	1,196	1,333	6,446	18,525	19,797	20,495	20,820	20,044	24,138	25,326
Geothermic	3,222	3,436	4,705	5,325	5,527	5,569	5,520	5,342	5,376	5,654
Eolic and Photovoltaic	0	14	569	2,347	2,973	4,073	5,054	7,219	11,032	20,652
Total	216,891	241,480	276,629	303,672	314,090	313,888	319,130	292,642	302,062	302,570

Source: TERNA

More in general the share of the total energy consumption by primary sources in the period 1990- 2011, reported in Table 3.3, shows an evident change from oil products to natural gas while the consumption of solid fuels and electricity maintain their share constant.

Table 3.3 Total energy consumptions by primary sources 1990-2011 (%)

Sources	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	%									
renewable	0.7	0.9	1.1	2.0	2.2	2.6	2.9	3.7	4.3	4.7
solid fuels	9.6	7.9	6.9	8.6	8.7	8.9	8.8	7.3	8.0	9.0
natural gas	23.7	25.7	31.4	36.0	35.5	36.0	36.4	35.4	36.2	34.6
crude oil	56.2	54.9	49.5	43.1	43.4	42.4	41.4	40.6	38.5	37.5
primary electricity	9.8	10.5	11.1	10.3	10.1	10.0	10.6	13.0	13.1	14.1

Source: Ministry of Economic Development

Recalculations

In 2013 submission, recalculations regarded different sub-sectors.

For the whole energy sector, natural gas CO₂ emission factors have been updated for 2009 and 2010 because of additional information collected on the energy conversion factor of imported fuels.

Coke oven gas, and blast furnace gas CO₂ average emission factors have also been revised from 2005 based on in depth analysis of information collected by the plants in the framework of EU ETS.

The whole time series of road transport emissions has been recalculated because of the updated version of the model/software, COPERT 4 version 10.0, used to estimate emissions. Recalculation affected CH₄ and N₂O emissions. Detailed information is reported in paragraph 3.5.3.

Biomass fuel combustion in residential activity data has been revised for the whole time series according to the relevant data supplied in the national Energy balance for 2010 and 2011. More in detail, pruning biomass activity data and their relevant emissions have been moved from the waste sector to the energy sector in the residential combustion category, from 1990 to 2009, affecting CH₄ and N₂O emission estimates.

Waste fuel consumption for commercial heating activity data has been updated from 2007 as a consequence of a check of the waste incinerators database with other sources of information at plant level.

Moreover CO₂ emissions from the use of carbonates in the ferroalloys production, reported in the industrial processes sector, have been deleted for the whole time series from the energy sector, iron and steel sub category, because of a double counting.

With regard to fugitive emissions, in response to the review process, some additional categories have been estimated and included in the inventory. More in detail CH₄, CO₂, and N₂O emissions by oil and gas exploration activities have been calculated since 1990 because new information was available on the number of wells for oil and gas exploration; CH₄ and CO₂ emissions by pipeline oil transport have been calculated since 1990. As concerns solid fuel production the CO₂ emissions have been calculated by mining and post mining activities.

Moreover, average CH₄ and N₂O emission factors for recreational boats have been updated from 2005 taking in account updates of the percentage of two-stroke engine equipped boats on total boats. Other minor changes in activity data occurred, including the addition of bioliquid fuel consumption, not considered before, for the last years.

Recalculations affected the whole time series 1990-2010 for all gases. The following table shows the percentage differences between the 2013 and 2012 submissions for the total energy sector and by gas. Recalculation resulted for the energy sector in a reduction of GHG emissions in the base year of 0.17% and 0.30% in 2010 mainly due to the subtraction from the energy sector of CO₂ emissions from the use of carbonates in the ferroalloys production already accounted in the industrial processes sector in 1990 and the update of waste fuel consumption activity data in 2010.

Table 3.4 Emission recalculations in the energy sector 1990-2010 (%)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	%																				
Energy	-0.02	0.04	0.03	-0.04	-0.22	-0.31	-0.41	-0.37	-0.32	-0.24	0.00	0.01	0.00	0.00	0.01	0.01	0.00	-0.03	-0.03	-0.08	-0.10
CO ₂	-0.09	-0.07	-0.06	-0.06	-0.04	-0.05	-0.08	-0.06	-0.06	-0.04	-0.05	-0.04	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.07	-0.12
CH ₄	2.06	3.47	2.82	2.99	2.86	3.14	2.94	3.28	3.01	3.67	3.14	3.05	1.62	1.52	1.82	1.33	1.17	-0.03	-0.13	-0.14	1.21
N ₂ O	1.66	3.00	2.20	-4.08	-16.37	-20.70	-23.04	-20.87	-18.50	-15.37	-0.40	-0.23	-0.89	-0.63	0.09	0.37	0.00	-0.70	-0.76	-1.07	-0.68

Source: ISPRA elaborations

Key categories

Key category analysis, for the years 1990 and 2011, identified 11 categories at level or trend assessment with Approach 1 and Approach 2 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 underlying data of most key categories.

In the following box, the relevant key categories are listed, making reference to the section of the text where they are quoted.

Key-categories identification in the energy sector with the IPCC Approach 1 and Approach 2 for 2011

KEY CATEGORIES	without LULUCF	with LULUCF	Relevant paragraphs	Notes
1. CO ₂ stationary combustion liquid fuels	L,T	L,T	3.3, 3.4 and 3.6	Table 3.8-3.11
2. CO ₂ stationary combustion solid fuels	L,T	L, T1	3.3, 3.4 and 3.6	Table 3.8-3.11
3. CO ₂ stationary combustion gaseous fuels	L,T	L,T	3.3, 3.4 and 3.6	Table 3.8-3.11
4. CO ₂ mobile combustion: Road Vehicles	L,T	L,T	3.5 and 3.5.3	Tables 3.26, 3.27
5. N ₂ O stationary combustion	L, T2	L	3.3, 3.4 and 3.6	Table 3.8-3.11
6. CO ₂ mobile combustion: Waterborne Navigation	L1	L1	3.5.4	Table 3.28
7. CH ₄ fugitive emissions from Oil and Gas Operations	L,T	L1,T	3.9	Table 3.40

KEY CATEGORIES	without LULUCF	with LULUCF	Relevant paragraphs	Notes
8. CO ₂ fugitive emissions from Oil and Gas Operations	L1, T2	L1	3.9	Table 3.40
9. CO ₂ stationary combustion other fuels	L1,T1	L1,T1	3.3, 3.4 and 3.6	Table 3.8-3.11
10. CH ₄ stationary combustion	T2		3.3, 3.4 and 3.6	Table 3.8-3.11
11. CO ₂ mobile combustion: aircraft	L1		3.5.1	Table 3.15-3.19

With reference to the box, six key categories (n. 1, 2, 3, 5, 9 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 Tables 1.A.4a and 1.A.4b. Four out of six key categories refer to CO₂ emissions. All these sectors refer to the national energy balance (MSE, several years [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 TERN publications (TERNA, several years). Evolution of energy consumptions/emissions is linked to the activity data of each sector; see paragraph 3.3, 3.4 and 3.6 and Annex 2 for the detailed analysis of those sectors.

Electricity production is the most “dynamic” sector and most of the emissions increase from 1990 to 2011, for CO₂, N₂O and CH₄, is due to the increase of thermoelectric production, see Tables A2.1 and A2.4 for more details.

In the following table key category emissions are summarized. From 1990 to 2011, an increase in use of natural gas instead of fuel oil and gas oil in stationary combustion plants is observed; it results in a decrease of CO₂ emissions from combustion of liquid fuels and an increase of emissions from gaseous fuels.

Table 3.5 Stationary combustion, GHG emissions in 1990 and 2011

	1990	2011
CO ₂ stationary combustion liquid fuels, Gg	153,467	58,282
CO ₂ stationary combustion solid fuels, Gg	58,993	61,736
CO ₂ stationary combustion gaseous fuels, Gg	85,066	148,023
CO ₂ stationary combustion other fuels, Gg	887	5,471
CH ₄ stationary combustion, Mg	784	1373
N ₂ O stationary combustion, Mg	3,533	3775

Source: ISPRA elaborations

Another group of key categories (n. 4, 6, 11) 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; see paragraph 3.5, transport, for an accurate analysis of these key sources. This sector also shows a remarkable increase in emissions, in particular CO₂ from air transport and road transport, as can be seen in Table 3.18 and Table 3.27, respectively. The trend of N₂O and CH₄ emissions is linked to technological changes occurred in the period.

Finally, the last two key categories (n.7, 8) refer to oil and gas operations. 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 ISPRA by the relevant operators, see paragraph 3.9.

Most of the categories described are also key categories for the years 1990 and 2011 taking into account LULUCF emissions and removals.

3.2 Methodology description

Emissions are calculated by 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 fuels covered are listed in Table A2.2 in Annex 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 are appropriate for Italy. Most of the emission factors have been crosschecked 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 has been carried out; the results suggest quite limited variations in liquid fuels and some differences in natural gas, explained by basic hydrocarbon composition, and in solid fuels.

Monitoring of the carbon content of the fuels nationally used is an ongoing activity at ISPRA. 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 Table 3.12 and Table 3.21. The specific procedure followed for each primary fuel (natural gas, oil, coal) is reported in Annex 6.

In response to the review process of the Initial report of the Kyoto Protocol, N₂O and CH₄ stationary combustion emission factors were revised, in the 2006 submission, for the whole time series taking into account default IPCC (IPCC, 1997; IPCC, 2000) and CORINAIR emission factors (EMEP/CORINAIR, 2007).

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 Table 3.21;
- 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 Annex 6 for details;
- derived gases produced in refineries, as petcoke, refinery gas and synthesis gas from heavy residual fuel, in iron and steel integrated plants, as coke oven gas, blast furnaces gas and oxygen converter gas, and in chemical and petrochemical plants have been calculated from 2005 on the basis of the analysis of information collected by the plants in the framework of EU ETS, see Annex 6 for details.

The activity statistics used to calculate emissions are fuel consumptions provided annually by the Ministry of Economic Development (MSE) in the National Energy Balance (MSE, several years [a]), by TERNA (TERNA, several years) for the power sector and some additional data sources to characterise the technologies used at sectoral level, quoted in the relevant sections.

Activity data collected in the framework of the EU ETS scheme do not cover the overall energy sector, whereas the official statistics available at national level, such as the National Energy Balance (BEN) and the energy production and consumption statistics supplied by TERNA, provide the complete basic data needed for the emission inventory.

Italian energy statistics are mainly based on the National Energy Balance. The report is 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 Economic Development, 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; excise duties are differentiated in products and 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);

- concerning energy consumption information, this scheme produces highly reliable data: BEN is based on registered quantities of energy consumption and 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 is estimated; anyway, it is nearly all imported and a limited number of operators use it and the Ministry of Economic Development monitors all of them on a monthly basis.

The energy balances of fuels used in Italy, published by the Ministry of Economic Development (MSE, several years [a]), 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, 2011 data are reported, while the full time series is available on website: <http://dgerm.sviluppoeconomico.gov.it/dgerm/ben.asp>.

Additionally to fossil fuel, the National Energy Balance 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, several years) 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 GHGs and other pollutants are included. CORINAIR methodology (EMEP/CORINAIR, 2007) includes emissions from the combustion of wood in the industrial and domestic sectors as well as the combustion of biomass in agriculture.

The inventory includes 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 feedstock", row "Productions", see Annex 5, Table A5.1- National energy balance, year 2011, Primary fuels. From 2001 onwards, it has been necessary to use also those quantities to calculate emissions in the reference approach, so as to minimize differences with sectoral approach. From 2001, the energy balances prepared by MSE include those quantities in the input while estimating final consumption; this procedure summarizes a complex stock change reporting by operators.

3.3 Energy industries

A detailed description of the methodology used to estimate greenhouse gas emissions from electricity production under 1.A.1.a, 1.A.1.b and 1.A.1.c is reported in Annex 2. Basic data, methodology and emission factors used to estimate emissions are derived from the same sources. In the following sub-paragraphs additional information on the specific categories are supplied.

3.3.1 Public Electricity and Heat Production

3.3.1.1 Source category description

This paragraph refers to the main electricity producers that produce electricity for the national grid. From 1998 onwards, the expansion of the industrial cogeneration of electricity and the split of the national monopoly have transformed many industrial producers into "independent producers", regularly supplying the national grid. Those producers account in 2011 for 92.2% of all electricity produced with combustion processes in Italy (TERNA, several years).

No data on consumption / emissions from heat production is reported in this section. In Italy, only limited data do exist about producers working for district heating grids; most of the cogenerated heat is produced and used on the same site by industrial operators. Therefore data on heat production is not reported here but in Table1.A(a)s2 for industry and Table1.A(a)s4 for district heating. In TERNA yearly publication, heat cogenerated while producing electricity is reported separately. Unfortunately, no details are reported on the final use of cogenerated heat, so it can be used in the inventory preparation just to cross check the total fuel amount with other sources as EU ETS or the consumption of fuels in the industry reported in BEN.

In the biomass subcategory wood and charcoal consumption and relevant emissions are reported; CO₂ emission factor is shown in Table 3.12.

Other fuels subcategory includes minor amounts of other liquid, solid and gaseous fuel consumptions such as industrial wastes, as plastics, rubber, and solvents, and synthesis gas from heavy residual; CO₂ emission factor equal to 94.0 kg/GJ have been used for these fuels.

3.3.1.2 Methodological issues

The data source 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, several years). The reports refer to the total of producers and the estimate of the part belonging to public electricity production is made by the inventory team on the basis of detailed electricity production statistics by industrial operators. Data on total electricity production for the year 2011 are reported in Annex 2. For the time series, see previous NIR reports. The emission factors used are listed in Table 3.12.

Another source of information is the National Energy Balance (MSE, several years [a]), which contains data on the total electricity producing sector. The data of the National Energy Balance (BEN) are also used to address the statistical survey of international organizations, IEA and Eurostat. Both BEN and TERNA publications could be used for the inventory preparation, as they are part of the national statistical system and published regularly.

A detailed analysis of both sources is reported in Annex 2; TERNA data appears to be more suitable for inventory preparation. From year 2005 onwards a valuable source of information is given by the reports prepared for each industrial installation subject to EU ETS scheme. Those reports are prepared by independent qualified verifiers and concern the CO₂ emissions, emission factors and activity data, including fuel used. ISPRA receives copy of the reports from the competent authority (Ministry of Environment) and has been able to extract the information relative to electricity production. The information available is very useful but not fully covering the electricity production sector or the public electricity production. The EU ETS does not include all installations, only those above 20 MWe, it is made on a point source basis so the data include electricity and heat production while the corresponding data from TERNA, concerning only the fuel used for electricity production, are commercially sensitive, confidential and they are not available to the inventory team. Anyway the comparison of data collected by TERNA with those submitted to the EU ETS allows identifying possible discrepancies in the different datasets and thus providing the Ministry of Economic Development experts with useful suggestions to improve the energy balance.

To estimate CO₂ emissions, and also N₂O and CH₄ emissions, a rather complex calculation sheet is used (APAT, 2003[a]). The data sheet summarizes all plants existing in Italy divided by technology, about 60 typologies, and type of fuel used; the calculation sheet is a model of the national power system. The model is aimed at estimating the emissions of pollutants different from CO₂ that are technology dependent. For each year, a run estimates the fuel consumed by each plant type, the pollutant emissions and GHG emissions. The model has many possible outputs, some of which are built up in order to reproduce the data available from statistical source. The model is revised every year to mirror the changes occurred in the power plants. 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 other energy industries, Tables 1.A.1.b and 1.A.1.c, and in the industrial sector section, Tables 1.A.2. More detailed information is supplied in Annex 2.

In Table 3.6, fuel consumptions and emissions of 1.A.1.a category are reported for the time series.

Table 3.6 Public electricity and heat production: Energy data (TJ) and GHG emissions (Mt), 1990-2011

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Fuel consumption (TJ)	1,428,137	1,468,278	1,668,305	1,799,929	1,822,784	1,838,270	1,727,715	1,482,944	1,425,570	1,417,296
GHG (Mt)	107,544	109,875	115,531	119,656	120,784	120,298	113,490	97,268	93,144	91,802
CO ₂ (Mt)	107,136	109,477	115,159	119,219	120,346	119,875	113,080	96,887	92,792	91,400
CH ₄ (Mt)	3.9	4.1	3.9	4.4	4.5	4.3	4.2	3.9	3.6	4.1
N ₂ O (Mt)	1.1	1.0	0.9	1.1	1.1	1.1	1.0	1.0	0.9	1.0

Source: ISPRA elaborations

Because the main data source refers to the whole electricity production sector, the uncertainty and time-series consistency, source-specific QA/QC and verification, recalculations and planned improvements are all addressed in Annex 2.

3.3.2 Refineries

3.3.2.1 Source category description

This subsector covers the energy emissions from the national refineries (16 plants), including the energy used to generate electricity for internal use and exported to the national grid by power plants that directly use off-gases or other residues of the refineries. Those power plants are generally owned by other companies but are located inside the refinery premises or just sideway. In 2011 the power plants included in this source category have generated 7.9% of all electricity produced with combustion processes in Italy.

The energy consumption and emissions are reported in CRF Table 1.A.1.b. Parts of refinery losses, flares, are reported in CRF Table 1.B.2.a and c, using IPCC emission factors.

3.3.2.2 Methodological issues

The consumption data used for refineries come from BEN (MSE, several years [a]); the same data are also reported by Unione Petrolifera, the industrial category association (UP, several years). From 2005 onwards, also the EU ETS “verifier’s reports” cover almost the entire sector, for energy consumptions, combustion emissions and process emissions. Other sources of information are the yearly reporting obligations for the large combustion plants under European Directive (LCP) and the E-PRTR Regulation; both data collections include most of refineries but not all the emission sources.

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.

For the part of the energy and related emissions due to the power plants the source is TERNA and please refers to Annex 2 for further details. The quota of total energy consumption from electricity production included in source category 1.A.1.b is estimated by the electricity production model on the basis of fuels used and plant location.

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. From 2002 particular attention has been paid to avoid double counting of CO₂ emissions checking if the refinery reports of emissions already include losses in their energy balances. IPCC Tier 2 emission factors and national emission factors are used as reported in Table 3.12.

From 2008, TERNA modified the detailed table of fuel consumption and related energy produced introducing a more complete list of fuels. Aim of the change was to revise the consumption values of waste fuels which are very important for estimating the contribution of renewable to electricity production and consequently greenhouse gases.

In Table 3.7, a sample calculation for the year 2011 is reported, with energy and emission data.

Table 3.7 Refineries, CO₂ emission calculation, year 2011

	Consumption, TJ				CO ₂ emissions, Gg			
	Petroleum coke	Ref. gas	Liquid fuels	Natural gas	Petroleum coke	Ref. gas	Liquid fuels	Natural gas
REFINERIES								
energy			115,986	57,758			9,508	3,278
furnaces	39,944	103,240	59,086		3,746	5,906	4,447	
TOTAL				376,014				26,885

Source: ISPRA elaborations

From 2005, the weighted average of CO₂ emission factor reported by operators in the framework of the EU ETS scheme is used for petroleum coke, refinery gas and synthesis gas from heavy residual fuels. The trend of the implied emission factor is driven by the mix of the fuels used in the sector. The main fuel used are refinery gases, fuel oil and petroleum coke, which have very different emission factors, and every year their amount used changes resulting in an annual variation of the IEF. The increase in the last years with respect to the nineties of the consumption of fuels with higher carbon content, as petroleum coke and synthesis gas

obtained from heavy residual fuels, explain the general growth of the IEF for liquid fuel reported in the CRF for this sector.

In the following box, fuel consumptions of 1.A.1.b category disaggregated by fuel are reported for the time series.

Liquid fuel consumptions in petroleum refining (TJ), 1990-2011

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Refinery gas	119,176.49	138,163.39	118,501.19	129,837.27	123,326.99	128,222.25	135,899.85	121,301.95	133,527.54	117,850.16
Naphta	526.34	868.59	4,444.06	2,449.30	1,209.59	1,468.16	1,324.65	1,856.01	1,220.05	1,092.02
Pet coke	29,120.50	28,652.73	40,594.48	49,868.02	43,443.52	45,978.59	40,890.45	40,716.82	42,796.26	45,396.60
Synthesis gas	-	-	36,400.63	64,977.21	81,043.69	83,763.28	79,328.26	57,320.53	78,575.14	63,010.74
Fuel oil	87,501.74	101,429.68	86,684.53	76,084.42	70,253.09	73,194.25	89,736.28	97,245.12	81,913.47	88,617.83
LPG	2,025.05	1,979.02	3,253.47	2,593.24	2,409.14	1,580.71	1,933.00	1,979.02	1,794.93	1,242.64
Gasoil	2,558.92	2,071.07	7,259.21	11,317.67	298.74	42.68	290.37	666.09	879.47	1,046.00
Gasoline	3,426.68	4,520.79	303.34	958.13	263.59	878.64	303.34	259.41	-	-
Total	244,335.72	277,685.28	297,440.90	338,085.26	322,248.36	335,128.56	349,706.21	321,344.95	340,706.86	318,255.99

3.3.2.3 Uncertainty and time-series consistency

The combined uncertainty in CO₂ emissions from refineries is estimated to be about 4.2% in annual emissions; a higher uncertainty, equal to 50.1%, is calculated for CH₄ and N₂O emissions because of the uncertainty levels attributed to the related emission factors.

Montecarlo analysis has been carried out to estimate uncertainty of CO₂ emissions from stationary combustion of solid, liquid and gaseous fuels emissions, resulting in 5.1%, 3.3% and 5.8%, respectively. Normal distributions have been assumed for all the parameters. A summary of the results is reported in Annex 1

In Table 3.8 GHG emissions from the sector in the years 1990, 1995, 2000, 2005-2011 are reported.

Table 3.8 Refineries, GHG emission time series

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CO ₂ emissions, Mt	16.3	18.6	22.4	27.1	26.2	27.2	28.1	25.3	28.0	26.9
CH ₄ emissions, Gg	0.46	0.53	0.59	0.67	0.67	0.70	0.75	0.70	0.74	0.71
N ₂ O emissions, Gg	0.49	0.56	0.60	0.68	0.65	0.67	0.71	0.65	0.70	0.65
Refinery, total, Mt CO ₂ eq	16.5	18.8	22.6	27.3	26.4	27.4	28.3	25.5	28.3	27.1

Source: ISPRA elaborations

An upward trend in emission levels is observed from 1990 to 2008 explained by the increasing quantities of crude oil processed and the complexity of process used to produce more environmentally friendly transportation fuels. Liquid fuel consumptions have reached a plateau in 2008 and they are now in a downward trend that is expected to continue, due to the reduced quantities of crude oil processed and electricity produced and to the gradual substitution with natural gas fuel consumption. In 2009 a drop is noted due to the effects of the economic recession that in 2010 and 2011 has partially recovered.

3.3.2.4 Source-specific QA/QC and verification

Basic data to estimate emissions have been reported by national energy balance and the national grid administrator. Data collected under other reporting obligations that include refineries (EU ETS, LCP and E-PRTR databases) have been used to cross-check the energy balance data, fuels used and emission factors. Differences and problems have been analysed in details and solved together with Ministry of Economic Development experts, who are in charge of preparing the National Energy Balance.

3.3.2.5 Source-specific recalculations

In 2013 submission, negligible recalculations occurred for this category due to the update of natural gas CO₂ emission factor for 2009 and 2010.

3.3.2.6 Source-specific planned improvements

No specific improvements are planned for the next submission.

3.3.3 Manufacture of Solid Fuels and Other Energy Industries

3.3.3.1 Source category description

In Italy, all the iron and steel plants are integrated, therefore 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 iron and steel plant sites (using coal gases and other fuels). In 2011 the power plants included in this source category have generated about 4% of all electricity produced with combustion processes in Italy.

3.3.3.2 Methodological issues

Fuel consumption data for the sector are reported in the BEN (MSE, several years [a]). Fuels used to produce energy are also reported with more detail as for fuel disaggregation level by TERNA (TERNA, several years). From 2005 onwards, also the EU ETS “verifier’s reports” cover almost the entire sector, for energy consumptions, combustion emissions and process emissions. Other sources of information are the yearly reporting obligations for the large combustion plants under European Directive (LCP) and for facilities under the E-PRTR Regulation; both reporting obligations include most of the iron and steel integrated plants and the only coke producing plant but not all the emission sources. A carbon balance is done, as suggested by the IPCC good practice guidance, to avoid over or under estimation from the sector. In Annex 3 further details on carbon balances of solid fuels and derived gases used are reported.

The high-implied emission factor for solid fuels is due to the large use of derived steel gases and in particular blast furnace gas to produce energy. These gases have been assimilated to the renewable sources and incentives are still provided for their use.

Other fuels are used in co-combustion with coal gases to produce electricity and they are reported by TERNA, see Annex 2. From 2008, natural gas and fuel oil consumptions reported in the CRF for this sector, are those communicated by the operators of the plants included in the sector in the framework of the EU ETS scheme. The consumptions of these fuels, especially for natural gas, are higher than those reported for the previous years. Fuel consumption reported in the sector is subtracted from the total fuel consumption to produce energy, guaranteeing that over and under estimation are avoided.

CH₄ emissions from coke ovens are estimated on the basis of production data to take in account additional volatile emissions due to the specific process. Average emission factors are calculated on the basis of information communicated by the four plants under the EPRTR registry.

3.3.3.3 Uncertainty and time-series consistency

The combined uncertainty in CO₂ emissions from integrated iron and steel plants is estimated to be about 4.2% in annual emissions; a higher uncertainty, equal to 50.1%, is calculated for CH₄ and N₂O emissions on account of the uncertainty levels attributed to the related emission factors.

Montecarlo analysis has been carried out to estimate uncertainty of CO₂ emissions from stationary combustion of solid, liquid and gaseous fuels emissions, resulting in 5.1%, 3.3% and 5.8%, respectively. Normal distributions have been assumed for all the parameters. A summary of the results is reported in Annex 1.

In Table 3.9 GHG emissions from the sector in the years 1990, 1995, 2000, 2005-2011 are reported.

Table 3.9 Manufacture of solid fuels, GHG emission time series

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CO ₂ emissions, Mt	13.0	11.8	14.4	13.5	14.4	13.7	15.0	9.0	11.7	12.3
CH ₄ emissions, Gg	4.9	3.8	2.3	1.2	1.0	0.7	0.7	0.6	0.7	0.7
N ₂ O emissions, Gg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total, Mt CO ₂ eq	13.2	11.9	14.5	13.6	14.5	13.8	15.0	9.1	11.8	12.3

Source: ISPRA elaborations

The trend of CO₂ and N₂O emissions is driven by the production trends combined with an increase in energy consumption required by more energy intensive products. In 2009 a strong reduction of emissions is observed due to the effects of the economic recession that in 2010 and 2011 has partially recovered.

The trend of CH₄ emissions is driven by the coke production trend, decreased from 6.4 Mt in 1990 to 4.5Mt in 2000 and by the renewal of the production plants. In particular the strong reduction of CH₄ emissions in the last years is the result of the renewal of the coke production plants in Taranto, started in 2005, and the implementation of best available technologies to reduce volatile organic compounds. In 2009, national coke production has reduced of about 40% with respect to the previous year, determining a loss in efficiency of the production plants and an increase of emissions by product unit (IEF) for that year.

3.3.3.4 Source-specific QA/QC and verification

Basic data to estimate emissions have been reported by national energy balance and the national grid administrator. Data collected under other reporting obligations that include integrated iron and steel plants, such as EU ETS Directive, LCP and E-PRTR databases, have been used to cross-check the energy balance data, fuels used and emission factors. Differences and problems have been analysed in details and solved together with Ministry of Economic Development experts, which are in charge to prepare the National Energy Balance. In particular, in the national PRTR register the integrated plants report every year the CO₂ emitted at each stage of the process, coke production, sinter production and iron and steel production, which result from separate carbon balances calculated in each phase of the production process. Moreover, total CO₂ emissions reported in the E-PRTR by the operators are equal to those reported under the EU ETS scheme.

The detailed analysis and comparison of the different data reported improved the allocation of fuel consumption and CO₂ emissions between 1.A.1.c and 1.A.2.a sectors. From the 2010 submission, in fact, coking coal losses for transformation process and related emissions have been reallocated under 1.A.1.c instead of 1.A.2.a.

3.3.3.5 Source-specific recalculations

In the 2013 submission, recalculations occurred for this category due to the update of natural gas CO₂ emission factor from 2009 and to the update of coke oven and blast furnace gases CO₂ emission factors from 2005, resulting in a decrease of CO₂ emission in the sector of 0.6% in 2010.

3.3.3.6 Source-specific planned improvements

No specific improvements are planned for the next submission.

3.4 Manufacturing industries and construction

3.4.1 Sector overview

Included in this category are emissions which originate from energy use in the manufacturing industries included in category 1.A.2. Where emissions are released simultaneously from the production process and from combustion, as in the cement, lime and glass industry, these are estimated separately and included in category 2.A. All greenhouse gases as well as CO, NO_x, NMVOC and SO₂ emissions are estimated.

In 2011, energy use in industry account for 15.6% of total national CO₂ emissions, 0.4% of CH₄, 4.6% of N₂O. In term of CO₂ equivalent, manufacturing industry share 12.5% of total national greenhouse gas emissions.

Six key categories have been identified for this sector in 2011, as for the energy industries, for level and trend assessment, using both the IPCC Approach 1 and Approach 2:

CO₂ Stationary combustion liquid fuels (L, T);
CO₂ Stationary combustion solid fuels (L, T);
CO₂ Stationary combustion gaseous fuels (L, T);
CO₂ Stationary combustion other fuels (L1, T1);
N₂O Stationary combustion (L, T2)
CH₄ Stationary combustion (T2).

All these categories, except CH₄ from Stationary combustion, are also key category including the LULUCF estimates in the key category assessment.

In the following Table 3.10, GHG emissions connected to the use of fossil fuels, process emissions excluded, are reported for the years 1990, 1995 and 2000-2011. Industrial emissions show oscillations, related to economic cycles.

Table 3.10 Manufacturing industry, GHG emission time series

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CO ₂ emissions, Gg	85,276	85,037	82,245	78,551	77,490	74,222	70,905	54,580	60,015	59,854
CH ₄ emissions, Mg	6.82	7.02	5.72	6.28	6.24	6.53	6.24	4.18	5.51	7.75
N ₂ O emissions, Mg	4.93	4.52	4.66	5.02	5.05	4.98	4.64	3.98	4.01	3.98
Industry, total, Gg CO ₂ eq	86,948	86,586	83,811	80,239	79,187	75,903	72,473	55,903	61,374	61,251

Source: ISPRA elaborations

In Table 3.11 emissions are reported by pollutant for all the subsectors included in the sector.

A general trend of reduction in emissions is observed from 1990 to 2008; some sub sectors reduced sharply (steel, chemical), other sub sectors (pulp and paper, food) increased their emissions. In 2009 an overall reduction of emissions for all the sectors is noted due to the effects of the economic recession. In 2010 and 2011 production levels has restored for the iron and steel and pulp and paper sectors while the other sectors still continue to suffer from the economical crisis.

Table 3.11 Trend in greenhouse gas emissions from the manufacturing industry sector, 1990-2011

GAS/SUBSOURCE	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CO₂ (Gg)										
1.A.2.a Iron and Steel	17,917	18,647	13,329	14,621	14,288	14,485	13,588	8,698	14,094	16,382
1.A.2.b Non-Ferrous Metals	738	907	1,252	1,167	1,173	1,142	1,096	1,021	1,130	1,111
1.A.2.c Chemicals	19,203	17,280	12,250	10,835	10,553	10,274	9,285	7,384	7,777	6,954
1.A.2.d Pulp, Paper and Print	3,076	4,163	4,223	4,563	4,563	5,194	4,289	3,803	4,578	4,425
1.A.2.e Food	3,853	5,062	6,238	6,441	5,688	5,429	5,568	4,661	4,397	4,267
1.A.2.f Other	40,489	38,978	44,954	40,924	41,225	37,698	37,079	29,014	28,038	26,715
CH₄ (Mg)										
1.A.2.a Iron and Steel	3,795	4,226	3,093	3,304	3,275	3,592	3,521	1,892	2,880	3,254
1.A.2.b Non-Ferrous Metals	13	16	27	24	25	23	22	20	21	21
1.A.2.c Chemicals	798	677	318	340	323	301	231	177	198	173
1.A.2.d Pulp, Paper and Print	77	94	91	104	114	124	115	77	85	81
1.A.2.e Food	105	127	175	410	390	428	455	464	819	2,767
1.A.2.f Other	2,031	1,880	2,019	2,094	2,116	2,057	1,900	1,550	1,504	1,452
N₂O (Mg)										
1.A.2.a Iron and Steel	362	370	302	330	326	316	295	191	292	335
1.A.2.b Non-Ferrous Metals	13	16	25	23	23	22	21	19	21	21
1.A.2.c Chemicals	346	285	159	152	148	143	125	94	109	94
1.A.2.d Pulp, Paper and Print	64	82	81	89	90	101	84	70	82	79
1.A.2.e Food	52	53	76	91	87	81	81	61	57	95
1.A.2.f Other	4,093	3,712	4,020	4,335	4,375	4,317	4,032	3,547	3,448	3,359

Source: ISPRA elaborations

3.4.2 Source category description

The category 1.A.2 comprises six sources: 1.A.2.a Iron and Steel, 1.A.2.b Non-Ferrous Metals, 1.A.2.c Chemicals, 1.A.2.d Pulp, Paper and Print, 1.A.2.e Food, 1.A.2.f Other.

Iron and steel

The main processes involved in iron and steel production are those related to sinter and blast furnace plants, to basic oxygen and electric furnaces and to rolling mills.

Most of emissions are connected to the integrated steel plants, while for the other plants, the main energy source is electricity (accounted for in 1.A.1.a) and the direct use of fossil fuels is limited to heating – re heating of steel in the intermediate part of the process.

There were four integrated steel plants in 1990 that from 2005 are reduced to two, with another plant that still has a limited production of pig iron. Nevertheless, the steel production in integrated plants has not changed significantly in the 1990-2008 period due to an expansion in capacity of the two operating plants. The maximum production was around 11 Mt/y in 1990, 1995 and in 2005-2008, with lower values in other years and the lowest of 6 Mt in 2009.

It has to be underlined that the integrated steel plants include also the cogeneration of heat and electricity using the recovered “coal gases” from various steps of the process, including steel furnace gas, BOF gas and coke oven gas. All emissions due to the “coal gases” used to produce electricity are included in the electricity grid operator yearly reports and are accounted in the category 1.A.1.c. No detailed info is available for the heat produced, so the emissions are included in source category 1.A.2.a.

Non-Ferrous Metals

In Italy there is a production of primary aluminium (232 Gg in 1990 and 142 Gg in 2011) and of secondary aluminium (350 Gg in 1990 and 795 in 2011). Those productions however use electricity as the primary energy source so the emissions due to the direct use of fossil fuels are limited. At present in Italy, there are two primary aluminium production plants.

The sub sector comprises also the production of other non-ferrous metals, both primary and secondary copper, lead, zinc and others; but also those productions have a limited share of emissions. The bulk of emissions are due to foundries that prepare mechanical pieces for the engineering industry or the market, using all kinds of alloys, including aluminium, steel and iron.

Chemicals

CO₂, CH₄ and N₂O emissions from chemical and petrochemical plants are included in this sector.

In Italy there are petrochemical plants integrated with a nearby refinery and stand alone plants that get the inputs from the market. Main products are Ethylene, Propylene, Styrene.

In particular, ethylene and propylene are produced in petrochemical industry by steam cracking. Ethylene is used to manufacture ethylene oxide, styrene monomer and polyethylene. Propylene is used to manufacture polypropylene but also acetone and phenol. Styrene, also known as vinyl benzene, is produced on industrial scale by catalytic dehydrogenation of ethyl benzene. Styrene is used in the rubber and plastic industry to manufacture through polymerisation processes such products as polystyrene, ABS, SBR rubber, SBR latex. Except for ethylene oxide production, which has stopped since 2002, the other productions of the above mentioned chemicals still occur in Italy. Activity data are stable from 1990 to 2011, with limited yearly variations.

Chemical industry includes non organic chemicals as chlorine/soda, sulphuric acid, nitric acid, ammonia. A limited production of fertilizers is also present in Italy. From 1990 to 2011 the production has been greatly reduced, with less than half of the 1990 production still occurring in 2011.

This source category does include some emissions from the cogeneration of electricity. Due to the transformation of some of those plants in power plants directly connected to the grid (and so reported in category 1.A.1.a) the percentage of the category 1.A.2.c CO₂ emissions due to electricity generation has changed from 22% in 1990 to 19% in 2010.

Pulp, Paper and Print

Emissions from the manufacturing of paper are included in this source category. In Italy the manufacture of virgin paper pulp is rather limited, with a production feeding less than 5% of the paper produced in 2011. Most of the pulp was imported in 1990, while in 2011 half of the pulp used is produced locally from recycled paper. The paper production is expanding and activity data (total paper produced) was 6.3 Mt in 1990 and 9.1 Mt in 2011. The printing industry represents a minor part of the source category emissions.

This source category includes also the emissions from the cogeneration of electricity. Due to the transformation of some of those plants in power plants directly connected to the grid (and so reported in category 1.A.1.a), the percentage of the category 1.A.2.d CO₂ emissions due to electricity generation has strongly reduced from 1990 to 2011.

Food

Emissions from the food production are included in this source category. In Italy the industrial food production is expanding. A comprehensive activity data for this sector is not available; energy consumption was estimated to be 62 PJ in 1990 and 89 PJ in 2010. Value added in constant money has increased of 0.6% per years from 1990 to 2003 and of 0.1% yearly from 2004 to 2011.

This source category also includes emissions from the cogeneration of electricity. Due to the transformation of those plants in power plants directly connected to the grid (and so reported in category 1.A.1.a) the percentage of the category 1.A.2.e CO₂ emissions due to electricity generation has reduced from 1990 to 2011.

Other

This sector comprises emissions from many different industrial subsectors, some of which are quite significant in Italy in terms of both value added and export capacity.

In particular, engineering sectors (vehicles and machines manufacturing) is the main industrial sub sector in terms of value added and revenues from export and textiles was the second subsector up to year 2000.

Another sub sector, construction materials, is also included here and it is also quite significant in terms of emissions due to the energy intensity of the processes involved. Construction materials subsector includes the production of cement, lime, bricks, tiles and glass. It comprises thousands of small and medium size enterprises, with only a few large operators, mainly connected to cement production. Some of the production is also exported. The description of the process used to produce cement, lime and glass is reported in chapter 4, industrial processes.

The fabrication of bricks is a rather standard practice in most countries and does not need additional description; fossil source is mainly natural gas. A peculiar national circumstance is the fabrication of tiles, in which are involved many specialised “industrial districts” where many different independent small size enterprises are able to manufacture world level products for both quality and style, exported everywhere. Generally speaking, the processes implemented are efficient with reference to the average European level and use mostly natural gas as the main fossil source since the year 2000.

The remaining “other industries” include furniture and other various “made in Italy” products that produce not negligible amounts of emissions.

The activity data of industries oriented to so different markets are, of course, peculiar to each subsector and it is difficult to identify a common trend. The productions of cement, lime and glass are the most relevant from the emissions point of view.

This short preface is needed to understand the reasons because this subsector is a key sector and accounts for in 2011 46.4% of total 1.A.2 CO₂ emission, and 5.7% of total national emissions.

This source category includes also emissions from the cogeneration of electricity. Due to the transformation of some of those plants in power plants directly connected to the grid (and so reported in category 1.A.1.a) the percentage of the category 1.A.2.f CO₂ emissions due to electricity generation has reduced in the last years.

3.4.3 Methodological issues

Energy consumption for this sector is reported in the BEN (see 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 sectors, with the details required by CRF format. With reference to coal used in the integrated steel production plants the quantities reported in BEN are not used as such but a procedure has been elaborated to estimate the carbon emissions linked to steel production and those attributable to the coal gases recovered for electricity generation, as already mentioned in paragraph 3.4.1. The detailed calculation procedure is described in Annex 3. Moreover, a part of the fuel input is considered in the estimation of process emissions, see chapter 4 for further details.

The balance of fuel (total consumption minus industrial processes consumption) is considered in the emission estimate; the emission factors used are listed in Table 3.12. The procedure used to estimate the national emission factors is described in Annex 6. These factors account for the fraction of carbon-oxidised equal to 0.98 for solid fuels, 0.99 for liquid fuels and 0.995 for natural gas, as suggested by the 1996 IPCC guidelines (IPCC, 1997).

Starting from 2005, for petroleum coke, synthesis gas from heavy residual and from 2007 for residual gases from chemical processes the oxidation factors have been modified based on the data reported by operators under the EU ETS scheme. See Annex 6 for further details.

During the revision of the aviation sector, for jet gasoline and jet kerosene, a fraction of carbon oxidised equal to 1 has been applied, as reported in the 2006 IPCC guidelines (IPCC, 2006), for the whole time series, on the basis of expert judgement.

Table 3.12 Emission Factors for Power, Industry and Civil sector

	t CO ₂ / TJ	t CO ₂ / t	t CO ₂ / toe
Liquid fuels			
Crude oil	72.549	3.035	3.035
Jet gasoline	70.000	3.075	2.929
Jet kerosene	71.500	3.111	2.992
Petroleum Coke, 2011 average	93.770	3.221	3.923
Gasoil	73.274	3.127	3.066
Orimulsion	77.733	2.177	3.252
Synthesis gas from heavy residual, 2011 average	99.620	0.883	4.168
Residual gases from chemical processes 2011	50.651	2.388	2.119
Gaseous fuels, national data			
Natural gas, 2011 average	56.762	1.945 (sm ³)	2.375
Solid fuels			
Steam coal, 2011 average	91.655	2.307	3.835
"sub-bituminous" coal	96.234	2.557	4.026
Lignite	99.106	1.037	4.147
Coke	108.161	3.168	4.525
Biomass			
Solid Biomass		(1.124)	(4.495)
Derived Gases, national data			
Refinery Gas, 2011 average	57.205	2.697 (sm ³)	2.393
Coke Gas, 2011 average	43.111	0.743 (sm ³)	1.804
Oxygen converter Gas, 2011 average	197.489	1.165 (sm ³)	8.263
Blast furnace, 2011 average	254.074	0.880 (sm ³)	10.630
Fossil fuels, national data			
Fuel oil, 2011 average	75.627	3.111	3.164
Coking coal	95.702	2.963	4.004
Other fuels			
Municipal solid waste	47.877	0.718	2.003

Source: ISPRA elaborations

Other sources of information are the yearly survey performed for the E-PRTR, since 2003, and the EU ETS; both surveys include main industrial operators, but not all emission sources. In particular from 2005 onwards the detailed reports by operators subject to EU ETS constitute a valuable source of data, as already said above with reference to oxidation factors and average emission factors.

In general, in the industrial sector ETS data source is used for cross checking BEN data. Energy/emissions data from EU ETS survey of industrial sectors should be normally lower than the corresponding BEN data because only part of the installations / sources of a certain industrial sub sector are subject to EU ETS. In case of missing sources or lower figures in BEN than ETS, at fuel sector level, a verification procedure starts.

Since 2007 data, ISPRA has been verifying actual data from both sources and communicating to MSE potential discrepancies. This starts a verification procedure that eventually can modify BEN data. However, we underline that EU ETS data do not include all industrial installations and cannot be used directly to estimate sectoral emissions for a series of reasons that will be analyzed in the following, sector by sector.

Iron and steel

For this sector, all main installations are included in EU ETS, but not all sources of emission. Only part of the processes of integrated steel making is subject to EU ETS, in particular the manufacturing process after the production of row steel was excluded up to 2007 and only the lamination processes have been included from 2008 onwards.

Moreover, the recovered coal gases used to produce electricity and steam are not included. So the EU ETS data is only of limited use for this subsector and the procedure set up starting from the total carbon input to the steel making process, is still the most comprehensive one to estimate the emissions to be reported in 1.A.2.a, see Annex 3 for further details.

Of course, data available from EU ETS are used for cross-checking the BEN data, with an aim to improve the consistency of the data set.

These plants are also reported in E-PRTR, but not all sources are included.

The low implied emission factors and annual variations in the average CO₂ emission factor for solid fuel are due to the fact that both activity data and emissions reported under this category include the results of the carbon balance (see Annex 3 for further details). The implied emission factor for 2011 is equal to 69.0 t/TJ and the trend is quite stable with figures around 60-65 t/TJ. CH₄ implied emission factor is equal to 18.4 kg/TJ in 2011 and it is higher than the default emission factors because of the specificities of the in-process combustion activities. The sintering process is a pre-treatment step in the production of iron in which metal ores, coke and other materials are roasted under burners, involving the mixing of combustion products and/or the fuel with the product or raw materials (EMEP/EEA, 2009). Apart from combustion emissions, the heating of plant feedstock and product can lead to substantial CH₄ emissions which are to be accounted for in the combustion process. According to the Good Practice Guidance these emissions are reported in the energy sector.

Non-Ferrous Metals

Those plants are mostly excluded from EU ETS; some aluminium producing plants will be included from 2013, but only for CO₂ and PFCs emissions by production process. Those plants are also in general not considered in E-PRTR survey, because they do not reach the emission ceilings for mandatory reporting. In this context emissions from the production processes are generally reported.

Chemicals

The use of EU ETS data for this subsector is rather complex because generally chemical plants are excluded from EU ETS while petrochemical plants are included. All plants reports under the E-PRTR. In this case, the latter data set is used for cross checking BEN data. As mentioned in paragraph 3.4.1, also a small amount of emissions connected to the production of electricity for the onsite use is reported in source 1.A.2.c, basic data are taken from TERN reports and the relative subsector amount is estimated with a model.

In this category, biomass refers to the steam wood fuel consumption as available in the BEN while other fuel includes the consumption of residual gases from chemical processes. Relevant CO₂ emission factors are reported in Table 3.12 above.

Pulp, Paper and Print

Most of the operators in the paper and pulp sector are included in EU ETS, while only a few of the printing installations are included. The problem for the EU ETS data source for this subsector is that the data are reported on a point source basis, including the production of electricity, but these data are not subject to verification and appear not reliable. On the other hand, the inventory team has no access to the detailed, plant by plant, database of electricity producing plants so the emissions reported in the ETS survey cannot be divided between those belonging to table 1.A.1.a and table 1.A.2.d.

From 2010 submission CH₄ and N₂O emissions from biomass fuel consumption in the sector, have been added to the inventory on the basis of the biomass fuel consumption reported in the annual environmental report by the industrial association (ASSOCARTA, several years) and to the EU ETS. Statistics on biomass fuel consumption appears from 1998. According to the information supplied by the industrial association of the sector, ASSOCARTA, a few plants started to use biomass from 1998. The use of biomass has an increasing trend till 2008 while from 2009 the use of biomass sharply reduced. From 2008 information is directly reported by the production plants in the framework of the EU ETS. For the years from 1990 to 1997 the use of biomass for energy purposes in the pulp and paper industry has been assumed not occurring. Biomass fuel consumption includes especially black liquor but also industrial sludge and biogas from industrial organic wastes. CO₂ emission factor is equal to 110.3 t/TJ.

Food

Emissions from the food production are included in this source category. A comprehensive activity data for this sector is not available; the subsector comprises many small and medium size enterprises, with thousands of different products. Limited info on this sector can be found in ETS survey, the sector is not included in the scope of ETS.

Biomass includes fuel consumption of steam wood and biogas from food industrial residual. The CH₄ implied emission factor time series is driven by the mix of these fuels. In this sector emissions are

prevalently from biogas from food industrial residual, with an EF of CH₄ equal to 153 kg/TJ, while in the other manufacturing industries biomass refers to wood and similar with an EF of CH₄ equal to 30 kg/TJ. Biogas from food industrial residual has a N₂O EF, equal to 3 kg/TJ, while wood and similar have an EF equal to 4 kg/TJ.

Other

This sector comprises emissions from many different industrial subsectors, some of which are subject to EU ETS and some not. Construction material subsector is energy intensive and it is subject to EU ETS. In the national energy database (BEN), the data for construction material are reported separately and they can be cross checked with ETS survey. However, in the construction material subsector, there are many small and medium size enterprises, so the operators subject to ETS are only a part of the total.

Biomass includes wood fuel consumption and other non conventional fuels especially used in the construction material subsector. CH₄ emission factor is equal to 27.4 kg/TJ and refers to the use of these non conventional fuels for the cement production (EMEP/EEA, 2009).

3.4.4 Uncertainty and time-series consistency

The combined uncertainty in CO₂ emissions in Industry is estimated to be about 4% in annual emissions; a higher uncertainty is calculated for CH₄ and N₂O emissions on account of the uncertainty levels attributed to the related emission factors and the difference in emission factors between the industrial subsectors, sources 1.a.2.a-f.

Montecarlo analysis has been carried out to estimate uncertainty of CO₂ emissions from stationary combustion of solid, liquid and gaseous fuels emissions, resulting in 5.1%, 3.3% and 5.8%, respectively. Normal distributions have been assumed for all the parameters. A summary of the results is reported in Annex 1.

Estimates of fuel consumption for industrial use in 2011 are reported in Annex 5, Tables A5.9 and A5.10. Time series of the industrial energy consumption data are contained in the BEN time series and in the CRFs and are reported in the following table.

Table 3.13 Fuel consumptions for Manufacturing Industry sector, 1990-2011 (TJ)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
1.A.2 Manufacturing Industries and Construction	1,265,428	1,308,830	1,305,976	1,258,635	1,240,363	1,186,848	1,114,333	869,818	948,361	969,133
a. Iron and Steel	271,413	273,216	231,016	250,701	245,646	240,587	225,891	147,637	220,112	250,336
b. Non-Ferrous Metals	12,067	15,145	20,609	19,950	20,010	19,545	18,371	17,184	19,200	19,066
c. Chemicals	290,074	269,682	203,069	180,188	176,096	172,116	154,054	123,562	133,950	121,289
d. Pulp, Paper and Print	50,520	70,371	74,175	79,633	79,610	91,069	73,674	65,142	79,014	77,383
e. Food Processing, Beverages and Tobacco	62,141	85,138	103,552	108,371	94,999	91,438	92,042	79,102	78,415	89,372
f. Other	579,213	595,277	673,555	619,793	624,002	572,093	550,300	437,192	417,670	411,687

Source: ISPRA elaborations

Emission levels observed from 1990 to 2000 are nearly constant with some oscillations, linked to the economic cycles. After year 2000 the general trend is downward, with oscillations due to the economic cycles, see Table 3.11 above. The underlining reason for the reduced emissions is the reduced industrial output, and the increase in efficiency.

3.4.5 Source-specific QA/QC and verification

Basic data to estimate emissions have been reported by national energy balance and the national grid administrator. Data collected by other surveys that include EU-ETS and E-PRTR surveys have been used to cross – check the energy balance data, fuels used and EFs. Differences and problems have been analysed in details and solved together with MSE experts.

The energy data used to estimate emissions reported in table 1.A.2 have two different levels of accuracy:

- in general they are quite reliable and their uncertainty is the same of the BEN; as reported in Annex 4 the BEN survey covers 100% of import, export and production of energy; the total industrial

consumption estimate is obtained subtracting from the total the known energy quantities (obtained by specialized surveys) used in electricity production, refineries and the civil sector.

- the energy consumption at sub sectoral level (sources 1.A.2.a-f) is estimated by MSE on the basis of sample surveys, actual production and economic data; therefore the internal distribution on energy consumption has not the same grade of accuracy of the total data.

3.4.6 Source-specific recalculations

There has been recalculation of emissions from the sector, due to the update of the emission factor based on detailed EU ETS operator's reports (paragraph 3.1). The recalculation refers to CO₂ emission factors, for the years 2005-2010 for coal derived gases and 2009-2010 for natural gas. Moreover CO₂ emissions from the use of carbonates in the ferroalloys production, already reported and estimated in the industrial processes sector, have been deleted from the iron and steel category for the whole time series because of double counting.

The recalculation affected the whole time series with differences ranging from -0.41% in 1990 to -0.001% in 2010 for CO₂ emissions of the 1.A.2 subsector, with respect to earlier submissions.

Activity production data and relevant CH₄ and N₂O emissions from brick tiles production have been updated for 2010 resulting in a recalculation equal to -0.01% and -0.02% for CH₄ and N₂O respectively.

3.4.7 Source-specific planned improvements

No specific improvements are planned for the next submission.

3.5 Transport

This sector shows a 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 increased in the period from 1990 to 2011, although since 2007 emissions from the sector slightly decreased.

The time series of CO₂, CH₄ and N₂O emissions, in Mt CO₂ equivalent, is reported in Table 3.14; figures comprise all the emissions reported in table 1.A.(a)s3 of the CRF.

Emission estimates are discussed below for each sub sector.

The trend of N₂O emissions is related to the evolution of the technologies in the road transport sector and the distribution between gasoline and diesel fuel consumption.

Methane emission trend is 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 10.6 million vehicles in 2010) that use gasoline and is increasing every year since 1990. Only a small part of this fleet complies with strict VOC emissions controls.

Table 3.14 GHG emissions for the transport sector (Mt CO₂ eq.)

		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CO ₂	Mt	101.3	111.4	120.1	125.8	127.1	127.2	122.3	117.9	117.5	116.4
CH ₄	Mt	0.82	0.91	0.70	0.46	0.42	0.38	0.35	0.34	0.31	0.29
N ₂ O	Mt	1.01	1.74	1.64	1.18	1.26	1.25	1.15	1.11	1.12	1.13
Total, Mt CO ₂ eq.	Mt	103.1	114.1	122.4	127.5	128.8	128.8	123.8	119.3	118.9	117.9

Source: ISPRA elaborations

CO₂ from road vehicles and CO₂ from waterborne navigation are key categories both in 1990 and in 2011, while CO₂ from aircraft is a key category in 2011.

3.5.1 Aviation

3.5.1.1 Source category description

The IPCC requires the estimation of emissions for category 1.A.3.a.i International Aviation and 1.A.3.a.ii Domestic Aviation, including figures both for the cruise phase of the flight and the landing and take-off cycles (LTO). Emissions from international aviation are reported as a memo item, and are not included in national totals.

Civil aviation contributes mainly in rising CO₂ emissions. CH₄ and N₂O emissions also occur and are estimated in this category but their contribution is insignificant.

In 2011 total GHG emissions from this source category were about 2.0% of the national total emissions from transport, and about 0.5% of the GHG national total; in terms of CO₂ only, the share is almost the same.

From 1990 to 2011, GHG emissions from the sector increased by 43% due to the expansion of the aviation transport mode. Therefore, emission fluctuations over time are mostly dictated by the growth rates in the number of flights.

Aviation is a key category with respect to CO₂ emissions in level with Tier1 for 1990.

3.5.1.2 Methodological issues

According to the IPCC Guidelines and Good Practice Guidance (IPCC, 1997; IPCC, 2006; IPCC, 2000) and the EMEP/CORINAIR Guidebook (EMEP/CORINAIR, 2007), a national technique has been developed and applied to estimate emissions.

The current method estimates emissions from the following assumptions and information.

Activity data comprise both fuel consumptions and aircraft movements, which are available in different level of aggregation and derive from different sources as specified here below:

- Total inland deliveries of aviation gasoline and jet fuel are provided in the national energy balance (MSE, several years [a]), see Annex 5 Table A5.10. This figure is the best approximation of aviation fuel consumption, for international and domestic use, but it is reported as a total and not split between domestic and international;
- 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 [a]), Ministry of Transport in the national transport statistics yearbooks (MIT, several years) and the Italian civil aviation in the national aviation statistics yearbooks (ENAC/MIT, several years).

As for emission and consumption factors, figures are derived by the EMEP/CORINAIR guidebook (EMEP/CORINAIR, 2007), both for LTO cycles and cruise phases, taking into account 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 national values for both domestic and international flights (Romano et al., 1999; ANPA, 2001; Trozzi et al., 2002 [a]) on the basis of the default emission and consumption factors reported in the EMEP/CORINAIR guidebook. National average emissions and consumption factors were therefore estimated for LTO cycles and cruise both for domestic and international flights from 1990 to 1999. At present, the study has been updated for the years 2005, 2006 and 2007 in order to consider most recent trends in civil aviation both in terms of modelling between domestic and international flights and technological progress of the fleet (TECHNE, 2009). Based on the results, national average emissions and consumption factors were updated from 2000.

Specifically, for the years referred to in the surveys, the current method estimates emissions from the number of aircraft movements broken down by aircraft and engine type (derived from ICAO database if not specified) at each of the principal Italian airports; information of whether the flight is international or domestic and the relevant distance travelled has also been considered.

For those years, a Tier 3 method has been applied. In fact, figures on the number of flights, destination, aircraft fleet and engines has been provided by the local airport authorities, national airlines (Alitalia, AirOne) and European Civil Aviation (EUROCONTROL), covering about 80% of the national official statistics on aircraft movements for the relevant years. Data on 'Times in mode' have also been supplied by

the four principal airports and estimates for the other minor airports have been carried out on the basis of previous sectoral studies at local level. Consumption and emission factors are those derived from the EMEP/CORINAIR guidebook (EMEP/CORINAIR, 2007). Based on sample information, estimates have been carried out at national level for the related years considering the official statistics of the aviation sector (ENAC/MIT, several years).

In general, to carry out national estimates of greenhouse gases and other pollutants in the Italian inventory for LTO cycles, both domestic and international, consumptions and emissions are calculated for the complete time series using the average consumption and emission factors multiplied by the total number of flights. The same method is used to estimate emissions for domestic cruise; on the other hand, for international cruise, consumptions are derived by difference from the total fuel consumption reported in the national energy balance and the estimated values as described above and emissions are therefore calculated.

The fuel split between national and international fuel use in aviation is then supplied to the Ministry of the Economical Development to be included in the official international submission of energy statistics to the IEA in the framework of the Joint Questionnaire OECD/Eurostat/IEA compilation together with other energy data.

Data on domestic and international aircraft movements from 1990 to 2011 are shown in Table 3.15 where domestic flights are those entirely within Italy. Emission factors are reported in Table 3.16 and Table 3.17. Total fuel consumptions, both domestic and international, are reported by LTO and cruise in Table 3.18.

Emissions from military aircrafts are also estimated and reported under category 1.A.5 Other.

The methodology to estimate military aviation emissions is simpler than the one described for civil aviation since LTO data are not available in this case.

As for activity data, total consumption for military aviation is published in the petrochemical bulletin (MSE, several years [b]) by fuel.

Emission factors are those provided in the EMEP/CORINAIR guidebook (EMEP/CORINAIR, 2007). Therefore, emissions are calculated by multiplying military fuel consumption data for the EMEP/CORINAIR default emission factors shown in Table 3.17.

Table 3.15 Aircraft Movement Data (LTO cycles)

<i>N° Flights</i>	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Domestic	186,446	199,585	319,963	311,218	324,779	346,724	331,004	312,257	329,145	331,561
International	139,733	184,233	303,747	363,140	385,159	420,021	403,436	378,888	387,466	393,701

Source: ISTAT, several years [a]; ENAC/MIT, several years

Table 3.16 CO₂ and SO₂ emission factors for Aviation (kg/t) 1990-2011

	CO ₂ ^a	SO ₂
Aviation jet fuel	849	1.0
Aviation gasoline	839	1.0

a Emission factor as kg carbon/t.

Table 3.17 Non-CO₂ emission factors for Aviation (2011)

	Units	CH ₄	N ₂ O	NO _x	CO	NMVOC	Fuel
Domestic LTO	kg/LTO	0.189	0.040	5.313	6.939	1.698	461.7
International LTO	kg/LTO	0.306	0.048	5.702	8.524	2.758	553.3
Domestic Cruise	kg/Mg fuel	-	0.087	13.747	1.898	0.471	-
International Cruise	kg/Mg fuel	-	0.087	11.544	1.170	0.418	-
Aircraft Military ^a	kg/Mg fuel	0.4	0.2	15.8	126	3.6	-

a EMEP/CORINAIR, 2007

Table 3.18 Aviation jet fuel consumptions for domestic and international flights (Gg)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	<i>Gg</i>									
Domestic LTO	121	129	198	150	153	160	153	144	152	153
International LTO	123	162	250	195	212	232	223	210	214	218
Domestic cruise	387	414	642	544	567	605	578	545	575	579
International cruise	1,215	1,662	2,327	2,733	2,948	3,120	3,019	2,673	2,820	2,908

Source: ISPRA elaborations

3.5.1.3 Uncertainty and time-series consistency

The combined uncertainty in CO₂ emissions from aviation is estimated to be about 4% in annual emissions; a higher uncertainty is calculated for CH₄ and N₂O emissions on account of the uncertainty levels attributed to the related emission factors.

Time series of domestic emissions from the aviation sector is reported in Table 3.19.

An upward trend in emission levels is observed from 1990 to 2011 which is explained by the increasing number of LTO cycles.

Nevertheless, the propagation of more modern aircrafts in the fleet slows down the trend in the most recent years. There has also been a decrease in the number of flights in the last two years.

Table 3.19 GHG emissions from domestic aviation

		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CO₂	<i>Gg</i>	1,613	1,709	2,649	2,204	2,291	2,428	2,301	2,197	2,319	2,299
CH₄	<i>Mg</i>	32	33	63	112	98	72	66	66	70	65
N₂O	<i>Mg</i>	45	48	74	62	64	68	64	61	65	64

Source: ISPRA elaborations

3.5.1.4 Source-specific QA/QC and verification

Data used for estimating emissions from the aviation sector derive from different sources: local airport authorities, national airlines operators, EUROCONTROL and official statistics by different Ministries and national authorities.

Specifically, the outcome of the estimation method derived from the 2009 research, applied at national and airport level, was shared with national experts in the framework of an ad hoc working group on air emissions instituted by the National Aviation Authority (ENAC). The group, chaired by ISPRA, meets regularly at least once a year and includes participants from ENAC, Ministry of Environment, Land and Sea, Ministry of Transport, national airlines and local airport authorities. The results reflect differences between airports, aircrafts used and times in mode spent for each operation. There is also an on going collaboration and data exchange with regional environmental agencies on this issue.

3.5.1.5 Source-specific recalculations

No recalculations were performed in this last submission.

3.5.1.6 Source-specific planned improvements

Improvements for the next submissions are planned on account of the investigation of data provided by ISTAT by aircraft type and origin destination and the possibility to built a specific database. The updating of relevant emission factors will be implemented consequently.

3.5.2 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 category 1.A.1.a Public Electricity.

Emissions from diesel trains are reported under the IPCC category 1.A.3.c Railways. Estimates are based on the gas oil consumption for railways reported in BEN (MSE, several years [a]).

Carbon dioxide, sulphur dioxide and N₂O 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, 2007). The emission factors shown in Table 3.20 are aggregate factors so that all factors are reported on the common basis of fuel consumption.

Table 3.20 Emission factors for railway (Gg/Mt)

	CO ₂	CH ₄	N ₂ O	NO _x Gg/Mt	CO	NMVOC	SO ₂
Diesel trains	857	0.14	1.2	40.5	4.9	3.6	2.8

Source: EMEP/CORINAIR, 2007

GHG emissions from railways accounted in 2011 for less than 0.2% of the total transport sector emissions. In this submission no recalculation affected this category. No specific improvements are planned for the next submission.

3.5.3 Road Transport

3.5.3.1 Source category description

The IPCC requires the estimation of emissions for category 1.A.3.b Road transportation.

In 2011, total GHG emissions from this category were about 93.1% of the total national emissions from transport, 27.1% of the energy sector and about 22.5% of the GHG national total.

From 1990 to 2011, GHG emissions from the sector increased by 15.4% due to the increase of vehicle fleet, total mileage and consequently fuel consumptions. In the last years, the trend of fuel consumption and emissions slightly changed. From 2007 GHG emissions from road transport started to decrease and in 2011 were about 0.2%, lower than those of 2010 (from 2007 onwards, the mean annual decrease is about -2.2%).

CO₂ emissions from road transport are a key category in 2011 with Approach 1 and Approach 2 at level and trend assessment, with and without LULUCF. N₂O emissions and CH₄ emissions are not key category.

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. Non CO₂ emissions from biomass fuel consumption are included and reported under diesel fuel category. Biomass fuel refers prevalently to the use of biodiesel which is mixed with diesel fuel. Whereas CO₂ emissions are calculated only on the basis of the amount of carbon in the fuel, and they could be easily take off by the total diesel CO₂ emissions, CH₄ and N₂O emissions depend from the technology of vehicles and could not be calculated without more detailed information regarding the type and technology of vehicles and the associated biodiesel consumption.

3.5.3.2 Methodological issues

According to the IPCC Guidelines and Good Practice Guidance (IPCC, 1997; IPCC, 2000; IPCC, 2006) and the EMEP/EEA air pollutant emission inventory guidebook 2009 (EMEP/EEA, 2009), a national methodology has been developed and applied to estimate emissions. In particular, the model COPERT 4 (EMISIA SA, 2012) has been used to estimate emissions for the whole time series. In the 2013 submission, the new version of the model has been used, in particular the version 10.0 which upgrade the methodology and the software, determining a recalculation of emission estimates. The annual update of the model is based on the availability of new measurements and studies regarding road transport emissions.

Methodologies are described in the following, distinguishing emissions calculated from fuel consumption and traffic data.

3.5.3.2.1 Fuel-based emissions

Emissions of carbon dioxide and sulphur dioxide from road transport are calculated from the consumption of gasoline, diesel, liquefied petroleum gas (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, several years [a]), see 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 CO₂, expressed as kg carbon per tonne of fuel, are based on the H/C and O/C ratios of the fuel. The increase in fuel consumption due to air conditioning use implies that extra CO₂ emissions in g/km are calculated as a function of temperature and relative humidity; nevertheless because of CO₂ emissions depend on total statistical fuel consumption, there is not impact on the CO₂ officially reported but instead on other pollutants.

Emissions of SO₂ are based on the sulphur content of the fuel, on the assumption that all the sulphur in the fuel is transformed completely into SO₂. As regards heavy metals (exhaust emissions of lead have been dropped because of the introduction of unleaded gasoline) apparent fuel metal contents are used in the emissions calculation which are indeed values taking into account also of lubricant content and engine wear (EMEP/EEA, 2009).

Values of the fuel-based emission factors for CO₂ from consumption of petrol and diesel fuels are shown in Table 3.21. These factors account for the fraction of carbon oxidised for liquid fuels equal to 0.99, as suggested by the 1996 IPCC guidelines (IPCC, 1997). From the nineties, different directives regulating the fuel quality in Europe have been implemented (Directive 93/12/EC, Directive 98/70/EC, Directive 2003/17/EC and Directive 2009/30/EC), in parallel with the evolution of vehicle fleet technologies; this resulted in remarkable differences in the characteristic of the fuels, including the content of carbon, hydrogen and oxygenates, parameters needed to derive the CO₂ emission factors. For this matter a specific survey was conducted to characterize the national fuel used in 2000-2001 and a similar survey was initiated in 2012 and it is still in progress. Regarding 1990-1999, a study has been done to evaluate the use of the default emission factors reported in the IPCC Guidelines 1996 in consideration of the available information on national fuels. Emission factors from the Guidelines have been considered representative for diesel and GPL while for gasoline a country specific emission factor has been calculated taking in account the IPCC default and the specific energy content of the national fuels. For further details see the relevant paragraph in Annex 6.

Values for SO₂ vary annually as the sulphur-content of fuels change and are calculated every year for gasoline and gas oil and officially communicated to the European Commission in the framework of European Directives on fuel quality; these figures are also published by the refineries industrial association (UP, several years). Directive 2003/17/EC introduced for 2005 new limit for S content in the fuels, both gasoline and diesel, 50% lower than the previous ones.

Table 3.21 Fuel-Based Emission Factors for Road Transport

National emission factors	Mg CO ₂ / TJ	Mg CO ₂ / Mg
Mtbe	73.121	-
Gasoline, 1990-'99, interpolated emission factor	71.034	3.121
Gasoline, test data, 2000-10 ^b	71.145	3.109
Gas oil, 1990-'99, IPCC OECD ^a	73.274	3.127
Gas oil, engines, test data, 2000-10 ^b	73.153	3.138
LPG, 1990-'99, IPCC ^a Europe	64.350	3.000
LPG, test data, 2000-10 ^b	64.936	2.994
Natural gas (dry) 1990	55.328	-
Natural gas (dry) 2011	56.762	-

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 ISPRA (APAT, 2003 [b])

Emissions of CO₂ and SO₂ 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 2011 inventory used fuel consumption factors expressed as g of fuel per kilometre for each vehicle type and average speed calculated from the emission functions and speed-coefficients provided by the model COPERT 4 (EMISIA SA, 2012). The updated version 10.0 of the model COPERT 4 has been used for the whole time series of the 2013 submission. As reported more in detail in the following, the updated version of the model considers, compared to the version 9.0, used for 2012 submission, a new subsector classification for gasoline and diesel passenger cars, updated emission factors for diesel passenger cars Euro 5 and 6, emissions update for mopeds, methane update for gasoline passenger cars, a new CNG subsector for passenger cars (Katsis P., Mellios G., Ntziachristos L., 2012).

Fuel consumptions calculated from COPERT functions are shown in Table 3.22 for each vehicle type, emission regulation and road type in Italy. A normalisation procedure was used to ensure that the breakdown of fuel 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).

Table 3.22 Average fuel consumption and mileage for main vehicle category and road type, year 2011

SNAP CODE	Sub sector	Type of fuel	Mg of fuel consumed	Mileage, km_kVeh
070101	PC Hway	cng	175,093	3,198,471
070101	PC Hway	diesel	3,867,582	73,612,210
070101	PC Hway	gasoline	1,836,376	37,536,031
070101	PC Hway	lpg	413,255	6,125,612
070102	PC rur	cng	200,483	4,264,628
070102	PC rur	diesel	5,721,172	126,661,428
070102	PC rur	gasoline	2,736,548	64,072,167
070102	PC rur	lpg	375,734	8,167,483
070103	PC urb	cng	216,099	3,198,471
070103	PC urb	diesel	2,307,965	33,251,409
070103	PC urb	gasoline	3,180,131	40,309,835
070103	PC urb	lpg	481,014	6,125,612
070201	LDV Hway	diesel	1,339,274	13,072,033
070201	LDV Hway	gasoline	47,294	671,359
070202	LDV rur	diesel	2,165,761	35,948,092
070202	LDV rur	gasoline	132,955	1,846,236
070203	LDV urb	diesel	1,775,097	16,340,042

SNAP CODE	Sub sector	Type of fuel	Mg of fuel consumed	Mileage, km_kVeh
070203	LDV urb	gasoline	139,172	839,198
070301	HDV Hway	diesel	3,658,377	19,276,837
070301	HDV Hway	gasoline	90	600
070302	CNG Buses rur	cng	2,795	9,423
070302	HDV rur	diesel	2,496,006	12,883,957
070302	HDV rur	gasoline	259	1,799
070303	CNG Buses urb	cng	34,831	84,810
070303	HDV urb	diesel	1,364,982	4,412,282
070303	HDV urb	gasoline	117	600
070400	mopeds	gasoline	339,577	16,075,734
070501	Moto Hway	gasoline	66,075	1,720,139
070502	Moto rur	gasoline	345,706	12,040,974
070503	Moto urb	gasoline	632,694	20,641,670
Total				562,389,141

Source: ISPRA 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

3.5.3.2.2 Traffic-based emissions

Emissions of NMVOC, NO_x, CO, CH₄ and N₂O are calculated from emission factors expressed in grams per kilometre and road traffic statistics estimated by ISPRA on account of data released from Ministry of Transport (MIT, 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 4 (EMISIA SA, 2012). 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. In addition N₂O emission factors differ according to the fuel sulphur level (EMEP/EEA, 2009).

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-fuelled 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.

It is beyond the scope of this paper to illustrate in details the COPERT 4 methodology: in brief, the emissions from motor vehicles fall into three different types calculated as hot exhaust emissions, cold-start emissions, for NMVOC evaporative emissions; in addition not exhaust emissions for PM deriving from road vehicle tyre and brake wear are contemplated.

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, 2007). 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 passenger cars;
- Diesel passenger cars;
- LPG passenger cars;
- CNG passenger cars;
- Gasoline Light Goods Vehicles (Gross Vehicle Weight (GVW) \leq 3.5 tonnes);
- Diesel Light Goods Vehicles (Gross Vehicle Weight (GVW) \leq 3.5 tonnes);
- Rigid-axle Heavy Goods Vehicles (GVW $>$ 3.5 tonnes);
- Articulated Heavy Goods Vehicles (GVW $>$ 3.5 tonnes);
- Diesel Buses and coaches;
- CNG Buses;
- Mopeds and motorcycles.

As regards CNG fuel, a detailed classification for passenger cars has been introduced for the Italian fleet for the whole time series, reflecting the classification scheme of gasoline passenger cars (subsectors: Natural Gas $<1.4l$; Natural Gas $1.4 - 2.0l$; Natural Gas $>2.0l$). Emissions deriving from these categories have been estimated for each subsector and legislation standard on the basis of MIT detailed fleet data and parameters derived from the comparison between Copert CNG passenger cars aggregated subsector and the three different engine capacity classes ($<1.4l$; $1.4 - 2.0l$; $>2.0l$) of Copert gasoline cars.

Basic data derive from different sources. Detailed data on the national fleet composition is found in the yearly report from ACI (ACI, several years). For the 2013 submission, specific fleet composition data were provided by the MIT for all vehicle categories from 2007, except for mopeds for which ANCMA (National Association of Cycle-Motorcycle Accessories) data were used for the whole time series. The National Association of Cycle-Motorcycle Accessories (ANCMA, several years) supplies useful information on mopeds fleet composition and mileages. The Ministry of Transport in the national transport yearbook (MIT, several years) reports passenger cars mileages time series. Furthermore in 2013 MIT supplied updated information relating the breakdown of the heavy duty trucks, buses and coaches fleet according to the different weight classes (data used for the updating of the whole time series from 1990 to 2011) and data about motorcycles fleet in the detail of subsector and legislation standard of both 2-stroke and 4-stroke categories (this kind of information has been used for the updating of the years 2005 – 2011). The National Institute of Statistics carries out annually a survey on heavy goods vehicles, including annual mileages (ISTAT, several years [b]). The National Association of concessionaries of motorways and tunnels produces monthly statistics on highway mileages by light and heavy vehicles (AISCAT, several years). The National General Confederation of Transport and Logistics (CONFETRA, several years) and the national Central Committee of road transporters (Giordano, 2007) supplied useful information and statistics about heavy goods vehicles fleet composition and mileages.

In the following Tables 3.23, 3.24 and 3.25 detailed data on the relevant vehicle mileages in the circulating fleet are reported, subdivided according to the main emission regulations.

Table 3.23 Passenger Cars and Light Duty Vehicles technological evolution: circulating fleet calculated as stock data multiplied by effective mileage (%)

	1990	1995	2000	2005	2010	2011
PRE ECE, pre-1972	0.05	0.03	0.01	0.01	0.00	0.00
ECE 15/00-01, 1972-1977	0.11	0.04	0.01	0.005	0.003	0.002
ECE 15/02-03, 1978-1986	0.32	0.15	0.03	0.01	0.01	0.005
ECE 15/04, 1987-1992	0.53	0.57	0.28	0.10	0.04	0.04
PC Euro 1 - 91/441/EEC, from 1/1/93	0.001	0.225	0.279	0.172	0.066	0.058
PC Euro 2 - 94/12/EEC, from 1/1/97	-	-	0.38	0.35	0.24	0.23
PC Euro 3 - 98/69/EC Stage2000, from 1/1/2001	-	-	-	0.26	0.21	0.20
PC Euro 4 - 98/69/EC Stage2005, from 1/1/2006	-	-	-	0.09	0.40	0.38
PC Euro 5 - EC 715/2007, from 1/1/2011	-	-	-	-	0.04	0.08
	-	-	-			0.00000
PC Euro 6 - EC 715/2007, from 9/1/2015				-	-	01

	1990	1995	2000	2005	2010	2011
Total	1.00	1.00	1.00	1.00	1.00	1.00
a. Gasoline cars technological evolution						
	1990	1995	2000	2005	2010	2011
Conventional, pre-1993	1.00	0.92	0.35	0.06	0.01	0.01
PC Euro 1 - 91/441/EEC, from 1/1/93	-	0.08	0.10	0.03	0.01	0.01
PC Euro 2 - 94/12/EEC, from 1/1/97	-	-	0.55	0.25	0.09	0.07
PC Euro 3 - 98/69/EC Stage2000, from 1/1/2001	-	-	-	0.53	0.26	0.23
PC Euro 4 - 98/69/EC Stage2005, from 1/1/2006	-	-	-	0.13	0.56	0.52
PC Euro 5 - EC 715/2007, from 1/1/2011	-	-	-	-	0.07	0.15
PC Euro 6 - EC 715/2007, from 9/1/2015	-	-	-	-	0.0001	0.0002
Total	1.00	1.00	1.00	1.00	1.00	1.00
b. Diesel cars technological evolution						
	1990	1995	2000	2005	2010	2011
Conventional, pre-1993	1.00	0.90	0.71	0.47	0.04	0.03
PC Euro 1 - 91/441/EEC, from 1/1/93	-	0.10	0.20	0.26	0.03	0.03
PC Euro 2 - 94/12/EEC, from 1/1/97	-	-	0.09	0.19	0.08	0.11
PC Euro 3 - 98/69/EC Stage2000, from 1/1/2001	-	-	-	0.06	0.08	0.10
PC Euro 4 - 98/69/EC Stage2005, from 1/1/2006	-	-	-	0.01	0.75	0.66
PC Euro 5 - EC 715/2007, from 1/1/2011	-	-	-	-	0.03	0.07
PC Euro 6 - EC 715/2007, from 9/1/2015	-	-	-	-	-	-
Total	1.00	1.00	1.00	1.00	1.00	1.00
c. Lpg cars technological evolution						
	1990	1995	2000	2005	2010	2011
Conventional, pre-1993	1.00	0.89	0.56	0.29	0.04	0.03
PC Euro 1 - 91/441/EEC, from 1/1/93	-	0.11	0.23	0.21	0.04	0.03
PC Euro 2 - 94/12/EEC, from 1/1/97	-	-	0.21	0.26	0.17	0.15
PC Euro 3 - 98/69/EC Stage2000, from 1/1/2001	-	-	-	0.19	0.12	0.11
PC Euro 4 - 98/69/EC Stage2005, from 1/1/2006	-	-	-	0.05	0.55	0.53
PC Euro 5 - EC 715/2007, from 1/1/2011	-	-	-	-	0.09	0.15
PC Euro 6 - EC 715/2007, from 9/1/2015	-	-	-	-	-	-
Total	1.00	1.00	1.00	1.00	1.00	1.00
d. CNG cars technological evolution						
	1990	1995	2000	2005	2010	2011
Conventional, pre 10/1/94	1.00	0.93	0.60	0.38	0.12	0.11
LD Euro 1 - 93/59/EEC, from 10/1/94	-	0.07	0.24	0.19	0.14	0.12
LD Euro 2 - 96/69/EEC, from 10/1/98	-	-	0.16	0.15	0.27	0.24
LD Euro 3 - 98/69/EC Stage2000, from 1/1/2002	-	-	-	0.28	0.24	0.22
LD Euro 4 - 98/69/EC Stage2005, from 1/1/2007	-	-	-	0.01	0.23	0.22
LD Euro 5 - 2008 Standards 715/2007/EC, from 1/1/2012	-	-	-	-	0.003	0.08
LD Euro 6 - EC 715/2007, from 9/1/2016	-	-	-	-	-	-
Total	1.00	1.00	1.00	1.00	1.00	1.00
e. Gasoline Light Duty Vehicles technological evolution						
	1990	1995	2000	2005	2010	2011
Conventional, pre 10/1/94	1.00	0.93	0.60	0.26	0.08	0.07
LD Euro 1 - 93/59/EEC, from 10/1/94	-	0.07	0.22	0.12	0.07	0.04
LD Euro 2 - 96/69/EEC, from 10/1/98	-	-	0.19	0.19	0.23	0.21

	1990	1995	2000	2005	2010	2011
LD Euro 3 - 98/69/EC Stage2000, from 1/1/2002	-	-	-	0.41	0.33	0.33
LD Euro 4 - 98/69/EC Stage2005, from 1/1/2007	-	-	-	0.01	0.28	0.31
LD Euro 5 - 2008 Standards 715/2007/EC, from 1/1/2012	-	-	-	-	0.01 0.00000	0.03 0.00000
LD Euro 6 - EC 715/2007, from 9/1/2016	-	-	-	-	03	04
Total	1.00	1.00	1.00	1.00	1.00	1.00
f. Diesel Light Duty Vehicles technological evolution						

Source: ISPRA elaborations on ACI and MIT data

Table 3.24 Heavy Duty Trucks and Buses technological evolution: circulating fleet calculated as stock data multiplied by effective mileage (%)

	1990	1995	2000	2005	2010	2011
Conventional, pre 10/1/93	1.00	0.90	0.67	0.39	0.19	0.18
HD Euro I - 91/542/EEC Stage I, from 10/1/93	-	0.10	0.10	0.06	0.05	0.05
HD Euro II - 91/542/EEC Stage II, from 10/1/96	-	-	0.22	0.27	0.22	0.21
HD Euro III - 2000 Standards, 99/96/EC, from 10/1/2001	-	-	-	0.28	0.35	0.33
HD Euro IV - 2005 Standards, 99/96/EC, from 10/1/2006	-	-	-	-	0.06	0.06
HD Euro V - 2008 Standards, 99/96/EC, from 10/1/2009	-	-	-	-	0.14	0.17
HD Euro VI – EC 595/2009, from 12/31/2013	-	-	-	-	-	-
Total	1.00	1.00	1.00	1.00	1.00	1.00
a. Heavy Duty Trucks technological evolution						
	1990	1995	2000	2005	2010	2011
Conventional, pre 10/1/93	1.00	0.93	0.65	0.34	0.17	0.16
HD Euro I - 91/542/EEC Stage I, from 10/1/93	-	0.07	0.07	0.08	0.06	0.05
HD Euro II - 91/542/EEC Stage II, from 10/1/96	-	-	0.28	0.32	0.29	0.27
HD Euro III - 2000 Standards, 99/96/EC, from 10/1/2001	-	-	-	0.26	0.30	0.29
HD Euro IV - 2005 Standards, 99/96/EC, from 10/1/2006	-	-	-	-	0.10	0.10
HD Euro V - 2008 Standards, 99/96/EC, from 10/1/2009	-	-	-	-	0.09	0.13
HD Euro VI – EC 595/2009, from 12/31/2013	-	-	-	-	-	-
Total	1.00	1.00	1.00	1.00	1.00	1.00
b. Diesel Buses technological evolution						
	1990	1995	2000	2005	2010	2011
Urban CNG Buses Euro I - 91/542/EEC Stage I, from 10/1/93	1.00	1.00	0.10	0.01	0.004	0.001
Urban CNG Buses Euro II - 91/542/EEC Stage II, from 10/1/96	-	-	0.90	0.22	0.10	0.09
Urban CNG Buses Euro III - 2000 Standards, 99/96/EC, from 10/1/2001	-	-	-	0.76	0.10	0.10
Urban CNG Buses Euro IV, Euro V and EEV (Enhanced environmentally friendly vehicle; ref. 2001/27/EC and 1999/96/EC line C, optional limit emission values)	-	-	-	-	0.80	0.81
Total	1.00	1.00	1.00	1.00	1.00	1.00
c. CNG Buses technological evolution						

Source: ISPRA elaborations on ACI and MIT data

Notes: The reported fleet classification derive from Copert, so as regards CNG buses, in the EEV category also Buses Euro IV and Euro V are included.

Table 3.25 Mopeds and motorcycles technological evolution: circulating fleet calculated as stock data multiplied by effective mileage (%)

	1990	1995	2000	2005	2010	2011
Conventional, pre 6/17/1999	1.00	1.00	0.86	0.53	0.37	0.35
Euro I, 97/24/EC, from 6/17/1999	-	-	0.14	0.27	0.22	0.22
Euro II, 2002/51/EC, 2003/77/EC, from 7/1/2004 (for mopeds: 97/24/EC, from 6/17/2002)	-	-	-	0.17	0.23	0.23
Euro III, 2002/51/EC, 2003/77/EC, from 1/1/2007 (for mopeds not defined yet)	-	-	-	0.03	0.18	0.20
Total	1.00	1.00	1.00	1.00	1.00	1.00

Source: ISPRA elaborations on ACI, ANCMA and MIT data

Average emission factors are calculated for average speeds by three driving modes, urban, rural and motorway, combined with the vehicle kilometres travelled and vehicle categories.

ISPRA estimates total annual vehicle kilometres for the road network in Italy by vehicle type, see Table 3.26, based on data from various sources:

- Ministry of Transport (MIT, several years) for rural roads and on other motorways; the latter estimates are based on traffic counts from the rotating census and core census surveys of ANAS;
- highway industrial association for fee-motorway (AISCAT, several years);
- local authorities for built-up areas (urban).

Table 3.26 Evolution of fleet consistency and mileage

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
All passenger vehicles, total mileage (10 ⁹ veh-km/y)	308	365	397	418	427	424	407	391	403	411
Car fleet (10 ⁶ veh)	27	30	33	35	35	36	37	37	37	38
Moto, total mileage (10 ⁹ veh-km/y)	31	39	45	48	48	50	51	52	51	50
Moto fleet (10 ⁶ veh)	7	7	9	10	10	10	10	10	11	11
Goods transport, total mileage (10 ⁹ veh-km/y)	70	75	89	99	102	105	105	106	105	101
Truck fleet (10 ⁶ veh), including LDV	2	3	3	4	4	5	5	5	5	5

Source: ISPRA elaborations

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 gasoline fuel vapour from the tank and fuel delivery system in vehicles constitute a significant fraction of total NMVOC and methane emissions from road transport. Nevertheless the contribution of evaporative emissions to total NMVOC emissions decreased significantly since the introduction of carbon canisters. Breathing losses through the tank vent and fuel permeations and leakages are considered the most important sources of evaporative emissions. The estimation of evaporative emissions takes into account three different mechanisms: diurnal emissions (depending on daily temperature variations), running losses (during the vehicles use) and hot soak emissions (following the vehicles use). The process of fuelling of vehicles is not considered here. The procedure for estimating evaporative emissions of NMVOCs takes account of gasoline volatility, the absolute ambient temperature and temperature changes, the characteristics of vehicles design; the driving pattern is also significant for hot soak emissions and running losses (EMEP/EEA, 2009).

3.5.3.3 Uncertainty and time-series consistency

The combined uncertainty in CO₂ emissions from road transport is estimated to be about 4% in annual emissions; a higher uncertainty is calculated for CH₄ and N₂O emissions because of the uncertainty levels attributed to the related emission factors.

Montecarlo analysis has been carried out by EMISIA¹ on behalf of the Joint Research Centre (Kouridis et al., 2010) in the framework of the study “Uncertainty estimates and guidance for road transport emission calculations” for 2005 emissions; a summary of main results of study are reported in Annex 1. The study shows an uncertainty assessment, at Italian level, for road transport emissions on the basis of 2005 input parameters of the COPERT 4 model (v. 7.0).

The following Table 3.27 summarizes the time series of GHG emissions in CO₂ equivalent from road transport, highlighting the evolution of this growing source. An upward trend in CO₂ emission levels is observed from 1990 to 2007, which is explained by the increasing of the fleet, total mileages, and fuel consumptions.

Nevertheless, the propagation of the number of vehicles, with low fuel consumption per kilometre, slows down the tendency in the last years. In 2011, with respect to 2007, a reduction in total mileages, especially for gasoline passenger cars and light duty vehicles, fuel consumptions and consequently CO₂ emissions has been noted.

CH₄ and N₂O emission trends are consequence of the penetration of new technologies according to the main emission regulations. Specifically CH₄ and more in general VOC emissions have reduced along the time

¹ EMISIA: www.emisia.com

series due to the introduction of VOC abatement devices on vehicles, in agreement with the legislation emission limits, and the rate of penetration of the new vehicles into the national fleet.

The time series of both N₂O emissions and implied emission factors are prevalently driven by the fleet composition and the penetration rate of the new vehicles/technologies,. Moreover, in the COPERT4 model, N₂O emission factors depend also on the sulphur content of the fuel. In particular, significant drops of emissions and implied emission factors are observed in 1999-2000 and in 2004-2005 which are explained by the different fuel specifications in those years due to the application of the relevant European Directives on fuel quality. The sulphur content %wt in gasoline was 0.05 and 0.015 respectively in 1999 and 2000 and 0.0055 and 0.0025 respectively in 2004 and 2005 and changed from 0.02263% in 2004 to 0.0038% in 2005 for diesel oil. .

Table 3.27 GHG emissions from road transport (Gg CO₂ equivalent)

		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CO ₂	Gg	93,387	103,552	110,377	117,029	118,263	118,718	113,919	109,906	108,678	108,426
CH ₄	Gg CO ₂ eq	791	880	664	424	388	352	327	309	286	271
N ₂ O	Gg CO ₂ eq	900	1,628	1,515	1,070	1,140	1,135	1,051	1,014	1,017	1,044
Total	Gg CO₂ eq	95,078	106,060	112,556	118,523	119,791	120,205	115,297	111,229	109,981	109,741

Source: ISPRA elaborations

3.5.3.4 Source-specific QA/QC and verification

Data used for estimating emissions from the road transport sector, derive from different sources, including official statistics providers and industrial associations.

A specific procedure undertaken for improving the inventory in the sector regards the establishment of a national expert panel in road transport which involves, on a voluntary basis, different institutions, local agencies and industrial associations cooperating for improving activity data and emission factors accuracy. In this group, emission estimates are presented annually, and new methodologies are shared and discussed. Reports and data of the meetings can be found at the following address: <http://www.sinanet.isprambiente.it/it/EPT/convegni/annunci-e-convegni>.

Besides, time series resulting from the recalculation due to the application of COPERT 4 have been discussed with national experts in the framework of an ad hoc working group on air emissions inventories. The group is chaired by ISPRA and includes participants from the local authorities responsible for the preparation of local inventories, sectoral experts, the Ministry of Environment, Land and Sea, and air quality model experts. Recalculations are comparable with those resulting from application of the new model at local level. Top-down and bottom-up approaches have been compared with the aim to identify the major problems and future possible improvements in the methodology to be addressed.

3.5.3.5 Source-specific recalculations

In 2013 submission the historical series has been revised according to new data and information availability and to the updating of the software.

The most recent update of the software is COPERT 4, version 10.0 (EMISIA SA, 2012). This is a user-friendly version that upgraded the methodology and the software, and it has been used to estimate emissions in the 2013 submission determining a recalculation of emission estimates, producing changes mainly regarding, among greenhouse gases, methane and nitrous oxide emission estimated values, with respect to the previous submission.

The updating to version COPERT 4 v 10.0 introduces important elements such as a new subsector classification of gasoline and diesel passenger cars, updated emission factors of Euro 5 and Euro 6 diesel passenger cars, updated emission factors for mopeds, updated methane emission factors for gasoline passenger cars, a new CNG subsector for passenger cars.

The updating of the tool also includes a CO₂ correction option for gasoline and diesel passenger cars and a new E85 subsector for passenger cars (updates currently not yet used).

Important changes with respect to the previous submission derive from the different classification used for input fleet data (MIT instead of ACI data) and from the introduction of CNG passenger cars categories (subsectors: Natural Gas <1.4l; Natural Gas 1.4 – 2.0l; Natural Gas >2.0l), reported in the following:

• Passenger Cars	Natural Gas < 1,4 l	Conventional
• Passenger Cars	Natural Gas < 1,4 l	PC Euro 1 - 91/441/EEC
• Passenger Cars	Natural Gas < 1,4 l	PC Euro 2 - 94/12/EEC
• Passenger Cars	Natural Gas < 1,4 l	PC Euro 3 - 98/69/EC Stage2000
• Passenger Cars	Natural Gas < 1,4 l	PC Euro 4 - 98/69/EC Stage2005
• Passenger Cars	Natural Gas < 1,4 l	PC Euro 5 - EC 715/2007
• Passenger Cars	Natural Gas < 1,4 l	PC Euro 6 - EC 715/2007
• Passenger Cars	Natural Gas 1,4 - 2,0 l	Conventional
• Passenger Cars	Natural Gas 1,4 - 2,0 l	PC Euro 1 - 91/441/EEC
• Passenger Cars	Natural Gas 1,4 - 2,0 l	PC Euro 2 - 94/12/EEC
• Passenger Cars	Natural Gas 1,4 - 2,0 l	PC Euro 3 - 98/69/EC Stage2000
• Passenger Cars	Natural Gas 1,4 - 2,0 l	PC Euro 4 - 98/69/EC Stage2005
• Passenger Cars	Natural Gas 1,4 - 2,0 l	PC Euro 5 - EC 715/2007
• Passenger Cars	Natural Gas 1,4 - 2,0 l	PC Euro 6 - EC 715/2007
• Passenger Cars	Natural Gas > 2,0 l	Conventional
• Passenger Cars	Natural Gas > 2,0 l	PC Euro 1 - 91/441/EEC
• Passenger Cars	Natural Gas > 2,0 l	PC Euro 2 - 94/12/EEC
• Passenger Cars	Natural Gas > 2,0 l	PC Euro 3 - 98/69/EC Stage2000
• Passenger Cars	Natural Gas > 2,0 l	PC Euro 4 - 98/69/EC Stage2005
• Passenger Cars	Natural Gas > 2,0 l	PC Euro 5 - EC 715/2007
• Passenger Cars	Natural Gas > 2,0 l	PC Euro 6 - EC 715/2007

As regards evaporative emissions, an update in both the methodology and the emission factors has been implemented. Compared to the previous versions of the model, the effect of (activated carbon) degradation, an updated parking table (extending over several days), a trip distribution (prior to parking), updated permeation factors, and other minor updates and corrections have been introduced.

Differences relate mainly to gasoline passenger cars, mopeds and motorcycles. In comparison with last submission, while differences in evaporative emissions show a strong increasing trend, due to the update of the evaporative model, total NMVOC emissions show discordant trends: higher emissions values for passenger cars and motorcycles and significantly lower values for mopeds, which compared to last submission 2012, present a mean decrease in annual emissions values by about -36.4%. Methane emissions do not show equally sensitive changes.

Differences between the two last submissions 2013 and 2012 in the total road transport GHG emissions, account for 0.03% in 1990 and -0.03% in 2010. Carbon dioxide values are the same in 1990 and in 2010 show a difference of -0.0001%. As regards methane and nitrous oxide, discrepancies vary respectively from 5.4% in 1990 to -4.4% in 2010 and from -1,4.7% in 1990 to -2.4% in 2010.

3.5.3.6 Source-specific planned improvements

Improvements for the next submission will be connected to the possible new availability of data and information regarding activity data, calculation factors and parameters, new developments of the methodology and the annual update of the software.

3.5.4 Navigation

3.5.4.1 Source category description

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

Mainly CO₂ emissions derive from this category, whereas CH₄ and N₂O emissions are less important.

Emissions from navigation constituted 4.2% of the total GHG in the transport sector in 2011 and about 1% of the national total. If considering CO₂ only, emissions from navigation are 1.2% out of the national CO₂ emissions. GHG emissions decreased by 10.2% from 1990 to 2011, because of the reduction in fuel consumed in harbour and navigation activities although the increase in the number of movements.

Navigation is a key category with respect to CO₂ emissions in level with Tier1.

3.5.4.2 *Methodological issues*

Emissions of the Italian inventory from the navigation sector are carried out according to the IPCC Guidelines and Good Practice Guidance (IPCC, 1997; IPCC, 2000) and the EMEP/CORINAIR Guidebook (EMEP/CORINAIR, 2007). In particular, a national methodology has been developed following the EMEP/CORINAIR Guidebook which provides details to estimate emissions from domestic navigation, specifying recreational craft, ocean-going ships by cruise and harbour activities; emissions from international navigation are also estimated and included as memo item but not included in national totals (EMEP/CORINAIR, 2007). Inland, coastal and deep-sea fishing are estimated and reported under 1.A.4.c.

The methodology developed to estimate emissions is based on the following assumptions and information. Activity data comprise both fuel consumptions and ship movements, which are available in different level of aggregation and derive from different sources as specified here below:

- Total deliveries of fuel oil, gas oil and marine diesel oil to marine transport are given in national energy balance (MSE, several years [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 as it is the fuel for shipping (MSE, several years [a]);
- Data on annual arrivals and departures of domestic and international shipping calling at Italian harbours are reported by the National Institute of Statistics in the statistics yearbooks (ISTAT, several years [a]) and Ministry of Transport in the national transport statistics yearbooks (MIT, several years).

As for emission and consumption factors, figures are derived by the EMEP/CORINAIR guidebook (EMEP/CORINAIR, 2007), both for recreational and harbour activities and national cruise, taking into account national specificities. These specificities derive from the results of a national study which, taking into account detailed information on the Italian marine fleet and the origin-destination movement matrix for the year 1997, calculated national values (ANPA, 2001; Trozzi et al., 2002 [b])) on the basis of the default emission and consumption factors reported in the EMEP/CORINAIR guidebook.

National average emissions and consumption factors were therefore estimated for harbour and cruise activities both for domestic and international shipping from 1990 to 1999. In 2009 submission, as in the case of aviation, the study was updated for the years 2004, 2005 and 2006 in order to consider most recent trends in the maritime sector both in terms of modelling between domestic and international consumptions and improvements of operational activities in harbour (TECHNE, 2009). On the basis of the results, national average emissions and consumption factors were updated from 2000.

Specifically, for the years referred to in the surveys, the current method estimates emissions from the number of ships movements broken down by ship type at each of the principal Italian ports considering the information of whether the ship movement is international or domestic, the average tonnage and the relevant distance travelled.

For those years, in fact, figures on the number of arrivals, destination, and fleet composition have been provided by the local port authorities and by the National Institute of Statistics (ISTAT, 2009), covering about 90% of the official national statistics on ship movements for the relevant years. Consumption and emission factors are those derived from the EMEP/CORINAIR guidebook (EMEP/CORINAIR, 2007) and refer to the Tier 3 ship movement methodology that takes into account origin-destination ship movements matrices as well as technical information on the ships, as engine size, gross tonnage of ships and operational times in harbours. On the basis of sample information, estimates have been carried out at national level for the relevant years considering the official statistics of the maritime sector.

In general, to carry out national estimates of greenhouse gases and other pollutants in the Italian inventory for harbour and domestic cruise activities, consumptions and emissions are calculated for the complete time series using the average consumption and emission factors multiplied by the total number of movements. On the other hand, for international cruise, consumptions are derived by difference from the total fuel consumption reported in the national energy balance and the estimated values as described above and emissions are therefore calculated.

The fuel split between national and international fuel use in maritime transportation is then supplied to the Ministry of the Economical Development to be included in the official international submission of energy statistics to the IEA in the framework of the Joint Questionnaire OECD/Eurostat/IEA compilation together with other energy data. A discrepancy with the international bunkers reported to the IEA still remains, especially for the nineties, because the time series of the energy statistics to the IEA are not updated

3.5.4.3 *Uncertainty and time-series consistency*

The combined uncertainty in CO₂ emissions from maritime is estimated to be about 4% in annual emissions; a higher uncertainty is calculated for CH₄ and N₂O emissions on account of the uncertainty levels attributed to the related emission factors.

Estimates of fuel consumption for domestic use, in the national harbours or for travel within two Italian destinations, and bunker fuels used for international travels are reported in Table 3.28. Time series of domestic GHG emissions for waterborne navigation are also shown in the same table.

An upward trend in emission levels is observed from 1990 to 2000, explained by the increasing number of ship movements. Nevertheless, the operational improvements in harbour activities and a reduction in ship domestic movements inverted the tendency in the last years.

Table 3.28 Marine fuel consumptions in domestic navigation and international bunkers (Gg) and GHG emissions from domestic navigation (Gg CO₂ eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Gasoline for recreational crafts (Gg)	182	210	213	199	199	199	189	179	169	149
Diesel oil for inland waterways (Gg)	20	23	20	25	24	23	22	22	18	22
Fuel in domestic cruise navigation (Gg)	778	706	811	740	709	673	670	650	725	683
Fuel in harbours (dom+int ships) (Gg)	748	693	818	759	727	690	687	667	744	700
Fuel in international bunkers (Gg)	1,398	1,286	1,333	2,203	2,369	2,468	2,685	2,309	2,219	2,279
CO ₂ (Gg)	5,420	5,117	5,842	5,403	5,204	4,970	4,914	4,762	5,194	4,873
CH ₄ (Gg CO ₂ eq.)	29	32	32	29	28	27	25	24	24	21
N ₂ O (Gg CO ₂ eq.)	39	37	43	40	38	36	36	35	39	37

Source: ISPRA elaborations

3.5.4.4 *Source-specific QA/QC and verification*

Basic data to estimate emissions are reconstructed starting from information on ship movements and fleet composition coming from different sources. Data collected in the framework of the national study from the local port authorities, carried out in 2009 (TECHNE, 2009), were compared with the official statistics supplied by ISTAT, which are collected from maritime operators with a yearly survey and communicated at international level to EUROSTAT. Differences and problems were analysed in details and solved together with ISTAT experts. Different sources of data are usually used and compared during the compilation of the annual inventory.

Besides, time series resulting from the recalculation have been presented to the national experts in the framework of an ad hoc working group on air emissions inventories. The group is chaired by ISPRA and includes participants from the local authorities responsible for the preparation of local inventories, sectoral experts, the Ministry of Environment, Land and Sea, and air quality model experts. Top-down and bottom-up approaches have been compared with the aim to identify the potential problems and future improvements to be addressed. There is also an ongoing collaboration and data exchange with regional environmental agencies on this issue.

3.5.4.5 Source-specific recalculations

In 2013 submission, a verification of activity data from different sources was undertaken. The update of the number of ship movements for 2010 resulted in an update of fuel consumption for both domestic and international navigation.

Gasoline fuel consumption for recreational craft have also been update for 2010 as well as emission factors of CH₄, N₂O, NMVOC, NO_x and CO from 2005 on the basis of the update of the composition of the fleet of gasoline fuelled recreational craft between two strokes and four strokes engine.

The recalculations affected CO₂, CH₄ and N₂O emissions and accounted for an increase of 1.93% of GHG emissions in 2010, and an average decrease of 0.004 GHG emissions for the years from 2005 to 2009, with respect to the previous submission.

3.5.4.6 Source-specific planned improvements

Further improvements will regard a verification of activity data on ship movements and emission estimates with regional environmental agencies, especially with those more affected by maritime pollution.

3.5.5 Other transportation

3.5.5.1 Source category description

This source category includes all emissions from fuels delivered to the transportation by pipelines and storage of natural gas.

Mainly CO₂ emissions derive from this category, as well as the other relevant pollutants typical of a combustion process, such as SO_x, NO_x, CO and PM. Also CH₄ and N₂O emissions are estimated and included in the inventory.

This category is not a key category.

3.5.5.2 Methodological issues

Emissions of the Italian inventory from pipeline compressors are carried out according to the IPCC Guidelines and are estimated on the basis of natural gas fuel consumption used for the compressors and the relevant emission factors. The amount of fuel consumption is estimated on the basis of data supplied for the whole time series by the national operators of natural gas distribution (SNAM, several years; STOGIT, several years) and refers to the fuel consumption for the gas storage and transportation; this consumption is part of the fuel consumption reported in the national energy balance in the consumption and losses sheet (MSE, several years). Emission factors are those reported in the EMEP/EEA Guidebook for gas turbines (EMEP/CORINAIR, 2007), except for CO₂ for natural gas which is the country specific value used for the whole energy sector reported in Table 3.12. Emissions communicated by the national operators in their environmental reports are also take in account to estimate air pollutants.

3.5.5.3 Uncertainty and time-series consistency

The combined uncertainty is estimated to be about 6% in annual emissions; a higher uncertainty is calculated for CH₄ and N₂O emissions on account of the uncertainty levels attributed to the related emission factors.

Fluctuations and time series are driven both by the general trend of total natural gas fuel consumed (and transported) and by the annual fluctuation of the storage activities, which are driven by the price fluctuation of the natural gas.

Natural gas fuel consumption for pipeline compressors increased from 7,359 TJ in 1990 to 12,148 TJ in 2011 with a peak of 19,098 TJ in 2010. GHG emissions follow the same trend of fuel consumption.

3.5.5.4 Source-specific QA/QC and verification

Basic data to estimate emissions are reconstructed starting from information on fuel consumptions coming from different sources. Fuel consumptions reported by the national operators for this activity are compared

with the amount of natural gas internal consumption and losses reported in the energy balance. Starting from the length of pipelines, the average energy consumptions by kilometre are calculated and used for verification of data collected by the operators. Energy consumptions and emissions by kilometre calculated on the basis of data supplied by the main national operator (SNAM, several years) are used to estimate the figures for the other operators when their annual data are not available.

3.5.5.5 Source-specific recalculations

No recalculations were performed in this submission.

3.5.5.6 Source-specific planned improvements

No further improvements are planned.

3.6 Other sectors

3.6.1 Sector overview

In this paragraph sectoral emissions are reported, which originate from energy use in the civil sector included in category 1.A.4. Commercial, institutional, residential, agriculture/fisheries, and emissions from military mobile activities which are also included in category 1.A.5. All greenhouse gases as well as CO, NO_x, NMVOC and SO₂ emissions are estimated.

In 2011, energy use in other sectors account for 20.2% of CO₂ emissions, 3.0% of CH₄, 7.5% of N₂O emissions. In term of CO₂ equivalent, other sectors share 17.7% of total national greenhouse gas emissions and 21.4% of total GHG emissions of the energy sector.

The trends of greenhouse gas emissions are summarised in Table 3.29. Emissions are reported in Gg for CO₂, and in Mg for CH₄ and N₂O. An increase in emissions is observed from 1990 to 2000, due to increase in activity data (numbers and size of building with heating); a sharp increase can be observed in 2005 due to exceptionally cold weather conditions. CH₄ and N₂O emissions increase in the period due to the growing use of woody biomass and biogas for heating.

Table 3.29 Trend in greenhouse gas emissions from the other sectors, 1990-2011

GAS/SUBSOURCE	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CO₂ (Gg)										
1.A.4.a Commercial/ Institutional	16,144	17,197	20,407	26,137	25,508	26,653	27,783	28,399	30,496	28,133
1.A.4.b Residential	52,118	50,103	50,159	57,339	52,239	46,456	49,741	51,014	52,786	47,840
1.A.4.c Agriculture/ Forestry/ Fisheries	8,372	8,747	8,030	8,371	8,239	7,849	7,593	7,679	7,261	7,120
1.A.5 Other (Not elsewhere specified)	1,046	1,440	806	1,198	982	896	738	844	627	495
CH₄ (Mg)										
1.A.4.a Commercial/ Institutional	1,129	1,390	2,301	3,435	3,618	3,806	4,052	4,148	4,366	4,559
1.A.4.b Residential	18,854	26,177	28,000	31,033	32,004	36,235	37,809	40,264	44,410	44,711
1.A.4.c Agriculture/ Forestry/ Fisheries	1,269	947	2,449	2,616	2,846	3,515	3,662	3,964	2,557	2,780
1.A.5 Other (Not elsewhere specified)	173	223	126	160	127	114	74	73	65	52
N₂O (Mg)										
1.A.4.a Commercial/ Institutional	427	500	697	981	969	1,060	1,082	1,123	1,214	1,215
1.A.4.b Residential	1,854	2,081	2,162	2,399	2,353	2,436	2,547	2,667	2,865	2,798
1.A.4.c Agriculture/ Forestry/ Fisheries	2,520	2,756	2,687	2,772	2,761	2,653	2,591	2,630	2,450	2,415

GAS/SUBSOURCE	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
1.A.5 Other (Not elsewhere specified)	225	215	135	291	239	227	199	239	131	98

Source: ISPRA elaborations

Six key categories have been identified for this sector for 2011, as for the energy and manufacturing industries, for level and trend assessment, using both the IPCC Approach 1 and Approach 2:

CO₂ Stationary combustion liquid fuels (L, T);
CO₂ Stationary combustion solid fuels (L, T);
CO₂ Stationary combustion gaseous fuels (L, T);
CO₂ Stationary combustion other fuels (L1, T1);
N₂O Stationary combustion (L, T2)
CH₄ Stationary combustion (T2).

All these categories, except CH₄ from Stationary combustion, are also key category including the LULUCF estimates in the key category assessment; see paragraph 3.1 for further details.

CH₄ and N₂O for stationary combustion are key categories especially for the increasing use of woody biomass for heating.

3.6.2 Source category description

The CRF Table 1.A(a)s4 comprises four sources: 1.A.4.a. Commercial/ Institutional, 1.A.4.b. Residential, 1.A.4.c. Agriculture/ Forestry/ Fisheries and 1.A.5 Other (Not elsewhere specified).

The estimation procedure follows that of the basic combustion data sheet. Emissions are estimated from the energy consumption data and the emission factor illustrated in Table 3.12.

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 the next paragraph 3.6.3 *Others*.

Commercial/ Institutional

Emissions from this sector arise from the energy used directly in the institutional, service and commercial buildings, mainly for heating. Additionally this category includes all emissions due to the non-renewable part of wastes used in electricity generation.

In the other fuel sub category, the amount of fossil waste burnt in incinerators with energy recovery is reported. Biomass refers to the consumption of biomass waste, biogas recovered for energy purposes from landfill and sludge treatments and wood and steam wood; from 2002 to 2005 minor amounts of biodiesel fuel consumption are also included.

In 2011, this sector has a share of 5.9% of total GHG national emissions.

Residential

Emissions from this sector arise from the energy used directly in residential buildings, mainly for heating. The sector includes emission from off-road household and gardening machinery.

Biomass refers to wood and steam wood fuel consumption; from 2002 to 2005 it also includes minor amount of biodiesel fuel consumptions.

In 2011, this sector has a share of 10.2% of total GHG national emissions.

Agriculture/ Forestry/ Fisheries

This subsector include all emissions due to the direct fossil fuel use in agriculture, mainly to produce mechanical energy, the fuel use in fisheries and for the machinery used in the forestry sector.

Biomass refers to the consumption of wood fuel and biogas recovered for energy purposes from the storage of animal manure and agriculture residuals.

In 2011, this sector has a share of 1.6% of total GHG national emissions.

Others

Emissions from military aircraft and naval vessels are reported under 1A.5.b Mobile.

The methods of estimation are discussed in paragraphs 3.5.1 and 3.5.4 for aviation and maritime respectively.

In 2011, this sector has a share of 0.1% of total GHG national emissions.

3.6.3 Methodological issues

For this sector, energy consumptions are reported in the BEN (see 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). The BEN 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 therefore subdivided between commercial and residential on the basis of the estimations reported by ENEA in its annual energy report (ENEA, several years).

Emissions from 1.A.4.b Residential and 1.A.4.c 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 this paragraph in the following. Emissions from fishing vessels are estimated from fuel consumption data (MSE, several years [a]). Emission factors are shown in Table 3.12.

In the solid fuel sub category, the following fuels are included: steam coal, coke oven coke and gas work gas. Since eighties there has been a sharp reduction in the use of these fuels due to air quality national legislation (in 1990 they accounted for about 1.1 % of total energy consumption of 1.A.4 category) and a further decrease is observed between 1997 and 1998 in consequence of the banning of coal used in residential heating in urban areas.

CH₄ emission factors used are those reported in the 1996 CORINAIR handbook, vol.1, for coal, equal to 200 kg/TJ (EMEP/CORINAIR, 1996), and in the EMEP/CORINAIR Guidebook for coke oven coke, equal to 15 kg/TJ which is the maximum value of emission factor for solid fuels without specification, and gas work gas, equal to 5 kg/TJ assuming the maximum value for natural gas (EMEP/CORINAIR, 2007).

For liquid fuel, the average emission factors are driven by the mix of fuel consumptions used in heating boilers, prevalently LPG, but also gasoil and fuel oil which was used especially in the past.

For these fuels we use the respective CH₄ emission factors: LPG 1 kg/TJ, fuel oil 3 kg/TJ and gasoil 7 kg/TJ. Regarding natural gas, the country specific CH₄ emission factor is equal to 2.5 kg/TJ.

All these emission factors have been calculated on the basis of the default and range emission factors published in the Guidebook EMEP/CORINAIR taking into account country specific circumstances by means of the type of boilers where these fuels are burnt. In the following box the default emission factors reported in the Guidebook EMEP/CORINAIR are shown.

Liquid fuel CH₄ default emission factor(kg/TJ) (EMEP/CORINAIR, 2007)

Fuel	Default EF	Range	National EF
LPG	-	1 - 2.5	1
Gasoil	0.6	0.1 - 8	7
Fuel oil	1.6	0.1 - 10	3
Natural gas	1.2	0.3 - 4	2.5

Average implied emission factors for other fuels, fossil waste, vary on an annual basis as a consequence of the mix of wastes used in incinerators, such as urban wastes, industrial, hospital, and oil wastes. In 2011 CO₂, CH₄ and N₂O average emission factors were equal to 114.8 kg/GJ, 6 kg/TJ and 11 kg/TJ respectively. Regarding biomass fuel consumption in the following box CO₂, CH₄ and N₂O emission factors used in the national inventory for the different type of fuels are reported.

Biomass CH₄ and N₂O emission factor for 2011 (kg/TJ)

Fuel	CH ₄	N ₂ O
Wood	320	14
Biogas	153	3

Waste	6	10
Biodiesel	12	2

Others

In this paragraph, the methodology used to estimate emissions from a range of portable or mobile equipment powered by reciprocating diesel or petrol driven engines is summarized. They include agricultural equipment such as tractors and combined 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, 2007):

- 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, 2007). This involves the estimation of emissions from around seventy classes of off-road source using the following equation for each class:

$$E_j = N_j \cdot H_j \cdot P_j \cdot L_j \cdot W_j \cdot (1 + Y_j \cdot a_j / 2) \cdot e_j$$

where

E_j = Emission of pollutant from class j	(kg/y)
N_j = Population of class j	
H_j = Annual usage of class j	(hours/year)
P_j = Average power rating of class j	(kW)
L_j = Load factor of class j	(-)
Y_j = Lifetime of class j	(years)
W_j = Engine design factor of class j	(-)
a_j = Age factor of class j	(y ⁻¹)
e_j = Emission factor of class j	(kg/kWh)

For gasoline engine sources, evaporative NMVOC emissions are also estimated as:

$$E_{vj} = N_j \cdot H_j \cdot e_{vj}$$

where

E_{vj} = Evaporative emission from class j	kg
e_{vj} = 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, 2007), 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, 2007). 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 1990-2011 for each of the main categories:

- A. Agricultural power units: Data on gas oil consumption were taken from ENEA (ENEA, several years). 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, several years [a]) on buildings and constructions. 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 consumptions increased markedly but they are still only a tiny proportion of total gasoline sales.

3.6.4 Uncertainty and time-series consistency

The combined uncertainty in CO₂ emissions in “Other sectors” is estimated to be about 4% in annual emissions; a higher uncertainty is calculated for CH₄ and N₂O emissions on account of the uncertainty levels attributed to the related emission factors.

Montecarlo analysis has been carried out to estimate uncertainty of CO₂ emissions from stationary combustion of solid, liquid and gaseous fuels emissions, resulting in 5.1%, 3.3% and 5.8%, respectively. Normal distributions have been assumed for all the parameters. A summary of the results is reported in Annex 1.

Estimates of fuel consumption used by other sectors in 2011 are reported in Annex 5, Tables A5.9 and A5.10, in physical units, row “DOMESTIC AND COMMERCIAL USES”. Time series of the other sectors energy consumption data are contained in the BEN time series and reported in Table 3.30.

Table 3.30 Trend in fuel consumption for the other sector, 1990-2011 (TJ)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
TJ										
1.A.4a.Commercial Institutional	267,848	295,625	357,283	460,231	455,641	469,814	483,547	497,408	535,374	498,802
1.A.4b. Residential	882,091	901,054	919,788	1,067,011	980,153	897,370	945,107	974,853	1,022,123	945,087
1.A.4c.Agriculture Forestry Fisheries	114,964	121,138	117,029	123,208	122,082	119,048	115,832	118,109	108,465	107,864
1.A.5 Other	14,830	20,800	11,587	16,935	13,887	12,654	10,411	11,898	8,995	7,110

Source: ISPRA elaborations

In the following Table 3.31, total GHG emissions connected to the use of fossil fuels and waste derived fuels are reported for the years 1990, 1995 and 2000-2011. Total emissions from the sector are reported in Gg for CO₂, and in Mg for CH₄ and N₂O. An increase in emissions is observed from 1990 to 2000, due to increase in activity data (numbers and size of building with heating); a sharp increase can be observed in 2005 due to exceptionally cold weather conditions. CH₄ and N₂O emissions increase in the period due to the growing use of woody biomass for heating.

Table 3.31 Other sectors, GHG emission time series 1990-2011

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CO ₂ (Gg)	77,681	77,487	79,402	93,045	86,968	81,855	85,855	87,937	91,170	83,588
CH ₄ (Mg)	21,425	28,736	32,876	37,244	38,595	43,670	45,598	48,449	51,398	52,101
N ₂ O (Mg)	5,025	5,552	5,682	6,443	6,323	6,375	6,419	6,659	6,660	6,527
GHG (Gg CO ₂ eq)	79,688	79,812	81,854	95,824	89,739	84,749	88,802	91,018	94,314	86,705

Source: ISPRA elaborations

In Table 3.32, other sectors emissions are summarized according to key categories. From 1990 to 2011, an increase in use of natural gas instead of fuel oil and gas oil in stationary combustion plants is observed; it results in a decrease of CO₂ emissions from combustion of liquid fuels and an increase of emissions from gaseous fuels. CH₄ and N₂O emissions increase in the period due to the crescent use of woody biomass for heating.

Table 3.32 Other sectors, GHG emissions in 1990 and 2011

		1990	2011
CO ₂ stationary combustion liquid fuels	Gg	39,817	18,021
CO ₂ stationary combustion solid fuels	Gg	920	17
CO ₂ stationary combustion gaseous fuels	Gg	36,418	61,144
CO ₂ stationary combustion other fuels	Gg	526	4,406
CH ₄ stationary combustion	Mg	21,425	52,101
N ₂ O stationary combustion	Mg	5,025	6,527

Source: ISPRA elaborations

3.6.5 Source-specific QA/QC and verification

Basic data to estimate emissions are reported by national energy balance and the national grid administrator (for the waste used to generate electricity).

The energy data used to estimate emissions reported in table 1.A.2 have different levels of accuracy:

- the overall sum of residential and institutional/service/commercial energy consumption is quite reliable and their uncertainty is the same of the BEN; the quantities of fuels used for those economic sector are routinely reported by main suppliers and the data are well documented.
- the energy consumption for agriculture and fisheries is also routinely reported by energy statistics and the underlying data are quite reliable because the energy use for those sector has special taxation regimes and they are accounted for separately.
- The energy use for military and off roads is instead partly reported and partly estimated with models, as described in paragraph 3.6.3 others.

3.6.6 Source-specific recalculations

CO₂ emission factors have been updated for the year 2009 and 2010 for natural gas. Biomass fuel combustion in commercial and residential activity data has been revised for the whole time series according to the relevant data supplied in the national energy balance for 2010 and 2011. More in detail, the amount of pruning biomass used for energy purposes previously reported in the waste sector, in the waste incineration category, have been added to the wood consumption reported in the BEN from 1990 to 2009. On the basis of the methodology adopted for the energy balance, from 2010 the wood fuel statistic includes also pruning biomass. Energy recovery from waste reported in the commercial heating has been updated from 2007 as a consequence of the check of the waste incinerators database with other sources at plant level and activity data have been updated for 2010; further details are reported in the waste chapter.

The recalculation affected only slightly CO₂ emissions with differences equal to -0.5% in 2010, with respect to the previous submission. CH₄ emissions increased of about 45% for the nineties but do not change in 2010 while N₂O emissions are 9% higher in the ninety years and -0.6% in 2010 with respect to the previous submission.

3.6.7 Source-specific planned improvements

No specific improvements are planned for the next submission.

3.7 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, 3.5.1 and 3.5.4. The methodology implements the IPCC guidelines according to the available statistical data.

3.8 Feedstock and non-energy use of fuels

3.8.1 Source category description

In Table 3.33 and 3.34 detailed data on petrochemical and other non-energy use for the year 2011 are given. The tables refer to all products produced starting from fossil fuels, solid, gas or liquid, and used for “non energy” purposes. A national methodology is used for the reporting and estimation of avoided emissions.

3.8.2 Methodological issues

Data are based on a detailed yearly report available by Ministry of Economic development (MSE, several years [b]). The report summarizes answers from a detailed questionnaire that all operators in Italy fill out monthly. The data are more detailed than those normally available are by international statistics and refer to:

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

National energy balances include only the input and output quantities from the petrochemical plants; so in the petrochemical transformation process the output quantity could be greater than the input quantity, in particular for light products as LPG, gasoline and refinery gas, due to chemical reactions. Therefore it is possible to have negative values for some products (mainly gasoline, refinery gas, fuel oil). For this matter, for the reporting on CRF tables, these fuels have been added to naphtha.

The quantities of fuels stored in products, in percentage on net and gross petrochemical input, are estimated with these data, see Table 3.34 for details by product and Table 3.33 for the overall figure. Specifically, the amount of quantity stored in products for each fuel is calculated as the difference between input (petrochemical input) and output (returns to refinery and internal consumption and losses); carbon stored is therefore calculated from the amounts of fuels stored (in tonnes) multiplied by the emission factors (tC/t) reported in Table 3.34.

Non-energy products quantity amount stored from refineries are reported in the BEN and the carbon stored is estimated with emission factors reported in Table 3.35.

As can be seen from the value reported for the year 2011, 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 products 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 (tables 1-5 of the IPCC Guidelines) and the amount of fuels reported as “petrochemical input” in Table 3.34. The resulting estimate of about 5,523 Gg of products, for the year 2011, is almost 50% bigger than the quantities reported, 3,579 Gg.

Table 3.33 Other non-energy uses, year 2011

Breakdown of total petrochemical flow				
	Petrochemical Input	Returns to refinery/market	Internal consumption / losses	Quantity stored in products
ALL ENERGY CARRIERS, Gg	8,742	3,106	2,057	3,579
% of total input		35.5%	23.5%	40.9%

% of net input	36.5%	63.5%
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Source: ISPRA elaborations

Table 3.34 Petrochemical, detailed data from MSE, year 2011 (MSE, detailed petrochemical breakdown)

FUEL TYPE	Petroch. Input Gg	Returns to refinery/ market Gg	Internal consumption / losses Gg	Quantity stored in products Gg	% on gross input	% on net input	Emission factor (IPCC) t C / t
LPG	538	563	15	-40			0.8137
Refinery gas	79	38	715	-674			0.8549
Virgin naphtha	4,417	0	0	4,417			0.8703
Gasoline	942	1,357	20	-435			0.8467
Kerosene	960	794	0	166			0.8485
Gas oil	324	186	0	138			0.8569
Fuel oil	424	93	325	6			0.8678
Petroleum coke	0	0	0	0			0.955
Others (feedstock)	249	75	173	1			0.8368
Losses			0	0			0.8368
Natural gas	809	0	809	0			0.748
total	8,742	3,106	2,057	3,579	41%	64%	

Source: ISPRA elaborations

Table 3.35 Other non-energy uses, year 2011, MSE several years [a]

NON ENERGY FROM REFINERIES	Quantity stored in products Gg	Energy content IPCC '96	Emission factor t C / t	Total energy content, IPCC values TJ
Bitumen + tar	3,461	40.19	0.8841	139.1
lubricants	1,222	40.19	0.8038	49.1
recovered lubricant oils	168	40.19	0.8038	6.8
paraffin	86	40.19	0.8368	3.5
others (benzene, others)	920	40.19	0.8368	37.0
Totals	5,857			235.4

Source: ISPRA elaborations

At national level, this methodology seems the most precise according to the available data. The European Project “Non Energy use-CO₂ 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 3.35, 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.

3.8.3 Uncertainty and time-series consistency

In Annex 4 the time series for comparison between reference and sectoral approach are reported showing percentage differences in a limited range.

3.8.4 Source-specific QA/QC and verification

Basic data to estimate emissions are directly reported to ISPRA by MSE. The energy data used to estimate emissions have a high level of accuracy because they summarize the results of a 100% legally binding monthly survey of all the concerned operators.

3.8.5 Source-specific recalculations

In response to the review process, recalculations have been performed for the whole time series including waste production data in other fuel and reporting refinery feedstock exports from 1992 to 1997 according to the IEA data. This recalculation resulted in a general reduction of the difference in percentage between the reference and the sectoral approach.

Moreover the fractions of carbon stored have been recalculated on the basis of the gross input fuel amount. Besides CO₂ emission factor for natural gas has been updated for 2009 and 2010.

3.8.6 Source-specific planned improvements

No specific improvements are planned for the next submission.

3.9 Fugitive emissions from solid fuels, oil and natural gas

3.9.1 Source category description

Fugitive emissions of GHG arise during the stages of fuel production, from extraction of fossil fuels to their final use. Emissions are mainly due to leaks or other irregular releases of gases from the production and transformation of solid fuels, the production of oil and gas, the transmission and distribution of gas and from oil refining.

Solid fuels category implies mainly methane emissions, while oil and natural gas categories include carbon dioxide and nitrous oxide too.

In 2011, GHG emissions from this source category account for 1.8% out of the total emissions in the energy sector. Trends in fugitive emissions are summarised in Table 3.42.

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

<i>Key-category identification in the fugitive sector with the IPCC Approach 1 and Approach 2</i>				
Year	IPCC category		without LULUCF	with LULUCF
2011	CH ₄	Fugitive emissions from oil and gas operations	L, T	L1,T
	CO ₂	Fugitive emissions from oil and gas operations	L1, T2	L1
1990	CH ₄	Fugitive emissions from oil and gas operations	L	L
	CO ₂	Fugitive emissions from oil and gas operations	L	L

Excluding LULUCF, methane emissions from oil and gas operations are a key category according to the level and trend assessment with Approach 1 and Approach 2, while CO₂ emissions are key category only for the level with Approach 1 and trend with Approach 2. Considering LULUCF methane emissions are key category for level with Approach 1 and trend assessment with Approach 1 and Approach 2, while CO₂ emissions are key category only for the level with Approach 1.

As concerns the level for the year 1990, CH₄ emissions and CO₂ emissions from oil and gas operations are key categories, either including or excluding LULUCF emissions and removals following both the Approaches.

Fugitive CH₄ and CO₂ emissions reported in 1.B.1 refer to coal mining for only two mines with very low production in the last ten years. One mine is underground and produces coal and the other one, a surface mine, produces lignite. The underground mine stopped the extraction activities between 1994 and 1999, whereas the surface mine stopped the activity in 2001. CH₄ emissions from solid fuel transformation refer to

fugitive emission from coke production in the iron and steel industry, which is also decreasing in the last years. N₂O emissions from 1.B.1 are not occurring.

Fugitive CO₂ emissions reported in 1.B.2 refer prevalently to fugitive emissions in refineries during petroleum production processes, e.g. fluid catalytic cracking and sulphur recovery plants and flaring, but include also emissions from the exploration, production, transport and distribution of oil and natural gas.

CH₄ 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, while N₂O emissions refer to flaring in the production of oil and natural gas and in refineries and emission from exploration.

For the completeness of the related CRF tables, in particular 1.B.2, the rationale beyond the values reported and not reported is explained below.

N₂O emissions in refining and storage are reported under flaring in refineries. According to Tier 1 and default EFs from the GPG 2000, CO₂ and CH₄ emissions from venting in gas production are included in fugitive emissions from gas production and reported under gas production. CO₂ and CH₄ emissions from other leakage are accounted for in the sectors where they occur.

A summary of the completeness of CO₂, CH₄ and N₂O fugitive emissions is shown in the following Table 3.36.

Table 3.36 Completeness of CO₂, CH₄ and N₂O fugitive emissions

1.B. 2.a. Oil		
iv. Refining/storage	N ₂ O	Included in 1.B.2.d flaring in refineries
1.B.2.b. Natural Gas		
v. Other leakage	CO ₂ ,CH ₄	Included in 1.A.1/1.A.2/1.A.4
1.B.2.c. Venting		
ii. Gas	CO ₂ ,CH ₄	Included in 1.B.2.b.ii production

3.9.2 Methodological issues

CH₄ emissions from coal mining have been estimated on the basis of activity data published on the National Energy Balance (MSE, several years [a]) and emission factors provided by the IPCC guidelines (IPCC, 1997). Mining and post mining emissions have been calculated. As concerns CO₂ emissions the calculations have been carried out considering the species profile in coal mine gas by literature data (EMEP/CORINAIR, 2007). The coal gas composition considered is 80% of CH₄ and 6% of CO₂ by volume (Williams, 1993).

CH₄ emissions from coke production have been estimated on the basis of activity data published in the national statistical yearbooks (ISTAT, several years [a]) and emission factors reported in the EMEP/CORINAIR Guidebook (EMEP/CORINAIR, 2007).

Fugitive emissions from oil refining are estimated starting from the total crude oil losses as reported in the National Energy Balance. Emissions have been reported in the Refining/Storage category (1.B.2.a.iv); they occur prevalently from processes in refineries.

Fugitive emissions from oil transport have been calculated according with the amount of transported oil (MIT, several years) and emission factors published on the IPCC Good practice Guidance (IPCC, 2000).

Most of the crude oil is imported in Italy by shipment and delivered at the refineries by pipelines as offshore national production of crude oil. Table 3.37 provides the length of pipelines for oil and the amount of oil products transported since 1990.

Table 3.37 Length of pipelines for oil transport (km) and amount of transported oil products (Gg)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011*
Length of pipelines (km)	4,140	4,235	4,346	4,328	4,336	4,359	4,360	4,291	4,291	4,290
Amount transported (Gg)	94,600	102,274	116,803	133,024	133,869	132,583	134,075	127,371	128,854	116,714

Source: MIT

*provisional values

Emissions in refineries have been estimated on the basis of activity data published in the National Energy Balance (MSE, several years [a]) or supplied by oil and gas industry association (UP, several years) and operators especially in the framework of the European Emissions Trading Scheme (EU-ETS), and emission factors published on the IPCC Good Practice Guidance (IPCC, 2000).

Fugitive CO₂ emissions in refineries are mainly due to catalytic cracking production processes, sulphur recovery plants, flaring and emissions by other production processes including transport of crude oil and oil products. Emissions are calculated on the basis of the total crude oil losses reported in the National Energy Balance. These emissions are then distributed among the different processes on the basis of average emission factors agreed and verified with the association of industrial operators (UP) and yearly updated, from 2000, on the basis of data supplied by the plants in the framework of the European Emissions Trading Scheme. In particular in the EU-ETS context, refineries report CO₂ emissions for flaring and for processes separately.

In Table 3.38, the time series of crude oil losses published in the BEN and crude oil processed in Italian refineries are shown.

Table 3.38 Refineries activities and losses

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Crude Oil losses (Mg)	1,004	937	757	576	608	603	642	624	664	658
Crude oil processing (Gg)	93,711	91,014	98,003	106,542	104,388	105,384	99,696	91,105	94,944	90,705

Source: MSE, UP

CO₂, CH₄, and N₂O fugitive emissions from oil and natural gas exploration have been calculated according with the number of exploration wells (MSE, several years [c]) and emission factors published on the IPCC Good practice Guidance (IPCC, 2000). Emissions factors for drilling, testing and servicing have been used for productive wells, while only emissions factor for drilling has been used for non productive wells.

CH₄ emissions from the production of oil and natural gas have been calculated according with activity data published on National Energy Balance (MSE, several years [a]), data by oil and gas industry association (UP, several years), data supplied by operators, and emission factors published on the IPCC Good practice Guidance (IPCC, 2000). CH₄ emission factors for the whole time series have been calculated taking into account this information. For CO₂, the IPCC default emission factor has not been modified, as no specific information is available. N₂O 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). As regards the decline of CH₄ IEF for natural gas production and processing, gas companies stated that along the time there has been an increasing awareness to reduce GHG emissions and new emergency management systems have been implemented periodically in order to reduce emissions from venting. Moreover, with the updating of management systems, more accurate methods to estimate vented gas have been adopted by the main gas company at regular intervals.

In Table 3.39, the time series of national production of oil and gas are reported. Natural gas production should further reduce in the next years.

Table 3.39 National production of oil and natural gas

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Oil (Gg)	4,668	5,236	4,586	6,111	5,781	5,860	5,243	4,573	5,106	5,309
Natural gas (Mm³)	17,296	20,383	16,766	11,962	10,836	9,634	9,070	7,909	8,265	8,339

Source: MSE

CH₄ and CO₂ emissions from the transmission in pipelines and distribution of natural gas have been estimated on the basis of activity data published by industry, the national authority, and information collected annually by the Italian gas operators.

Emission estimates take into account the information on: the amount of natural gas distributed (ENI, several years [a]; SNAM, several years); length of pipelines, distinct by low, medium and high pressure and by type, cast iron, grey cast iron, steel or polyethylene pipelines (AEEG, several years); natural gas losses reported in the national energy balance (MSE, several years [a]); methane emissions reported by operators in their environmental reports (ENI, several years [b]; EDISON, several years; SNAM, several years). CO₂ emissions have been calculated considering CO₂ content in the leaked natural gas.

The average natural gas chemical composition has been calculated from the composition of natural gas produced and imported. Main parameters of mixed natural gas, as calorific value, molecular weight, and density, have been calculated as well. Data on chemical composition and calorific value are supplied by the main national gas providers for domestic natural gas and for each country of origin.

Table 3.40 shows average data for national pipelines natural gas.

Table 3.40 Average composition for pipelines natural gas and main parameters

	1990	1995	2000	2005	2008	2009	2010	2011
HCV (kcal/m₃)	9,156	9,193	9,221	9,267	9,280	9,304	9,331	9,288
NCV (kcal/m₃)	8,255	8,290	8,325	8,360	8,365	8,393	8,418	8,376
Molecular weight	17.03	17.19	17.37	17.44	17.46	17.49	17.46	17.25
Density (kg/Sm₃)	0.72	0.73	0.74	0.74	0.74	0.74	0.74	0.73
CH₄ (molar %)	94.30	93.36	92.22	91.93	92.10	92.01	92.03	93.07
NMVOG (molar %)	3.45	4.09	4.84	5.35	5.35	5.54	5.74	5.01
CO₂ (molar %)	0.22	0.20	0.18	0.49	0.74	0.77	0.75	0.68
Other no carbon gas (molar %)	2.03	2.34	2.76	2.24	1.81	1.69	1.48	1.24
CH₄ (weight %)	88.83	87.14	85.16	84.53	84.61	84.36	84.52	86.52
NMVOG (weight %)	7.33	8.62	10.00	10.73	10.70	11.07	11.27	9.80
CO₂ (weight %)	0.57	0.51	0.47	1.23	1.86	1.93	1.89	1.74
Other no carbon gas (weight %)	3.27	3.74	4.37	3.51	2.84	2.64	2.30	1.93

More in details, emissions are estimated separately for the different phases: transmission in primary pipelines and distribution in low, medium, and high pressure network, losses in pumping stations and in reducing pressure stations (including venting and other accidental losses) with their relevant emission factors, considering also information regarding the length of the pipelines and their type.

Emissions from low pressure distribution include also the distribution of gas at industrial plants and in residential and commercial sector; data on gas distribution are only available at an aggregate level thus not allowing a separate reporting.

In addition, emissions from the use of natural gas in housing are estimated and included. Emissions calculated are compared and balanced with emissions reported by the main distribution operators.

Finally the emission estimates for the different phases are summed and reported in the most appropriate category (transmission/distribution).

Table 3.41 provides the trend of natural gas distribution network length for each pipeline material and the average CH₄ emission factor.

Table 3.41 Length of low and medium pressure distribution network (km) and network emission factors for CH₄

Material	1990	1995	2000	2005	2008	2009	2010	2011
Steel and cast iron (km)	102,061	131,271	141,848	154,886	191,567	195,918	198,706	197,369
Grey cast iron (km)	24,164	23,229	21,314	15,080	4,816	4,731	4,658	4,519
Polyethylene (km)	775	7,300	12,550	31,530	45,135	46,953	49,663	51,053
Total (km)	127,000	161,800	175,712	201,496	241,518	247,602	253,027	252,940
CH₄ Emission Factors (kg/km)	1,958	1,417	1,227	995	723	713	715	707

More details on the methodology used and on the basic information collected from operators are reported in a technical paper (Contaldi, 1999).

3.9.3 Uncertainty and time-series consistency

The uncertainty in CH₄, N₂O and CO₂ 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.

The uncertainty in methane emissions from coal mining and handling is estimated to be 200% as combination of 3% and 200% for activity data and emission factors, respectively.

Montecarlo analysis was applied last year to estimate uncertainty of CH₄ emissions; the resulting figure was 17.2% for 2009. Normal distributions have been assumed for most of the parameters; at the same time, whenever assumptions or constraints on variables were known this information has been appropriately reflected on the choice of type and shape of distributions. A summary of the results is reported in Annex 1. No variation could be conceived on assumptions as concern probability distributions and standard deviations.

Fugitive emissions, in CO₂ equivalent, account for 1.8% out of the total emissions in the energy sector in 2011. Both CH₄ and CO₂ emissions show a reduction from 1990 to 2011 by 31.6% and 30.8%, respectively.

The decrease of CO₂ fugitive emissions is driven by the reduction in crude oil losses in refineries.

The trend of CH₄ and CO₂ fugitive emissions from solid fuels is related to the extraction of coal and lignite that in Italy is quite low. The decrease of CH₄ fugitive emissions from oil and natural gas is due to the reduction of losses for gas transportation and distribution, because of the gradual replacement of old grey cast iron pipelines with steel and polyethylene pipelines for low and medium pressure network.

As regards the flaring activity from oil and gas production, N₂O emissions account for less than 1.1 Gg of CO₂ equivalent in the whole time series, with a reduction from 1990 to 2011 by 4.7%.

Fugitive emissions since 1990 are reported in Table 3.42.

Table 3.42 Fugitive emissions from oil and gas 1990-2010 (Gg CO₂ eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	<i>Gg CO₂ eq.</i>									
CO₂										
Oil and natural gas	3,344	3,178	2,588	2,117	2,194	2,181	2,264	2,170	2322	2315
CH₄										
Solid fuels	127	66	75	70	54	86	74	45	66	71
Oil and natural gas	7,298	6,817	6,349	5,625	5,106	4,928	4,933	4,910	5,117	5,008
N₂O										
Oil and natural gas	12	12	13	14	13	13	13	12	12	11
Total emissions	10,780	10,072	9,024	7,825	7,367	7,208	7,344	7,137	7,518	7,406

3.9.4 Source-specific QA/QC and verification

Different data sources are used for fugitive emissions estimates: official statistics by Economic Development Ministry (MSE, several years [a], [c]), by Transport of Infrastructure Ministry (MIT, several years); national authorities (AEEG, several years; ISTAT, several years), gas operators (ENI, several years [b]; EDISON, several years; SNAM, several years), and industrial association for oil and gas (UP, several years).

Concerning CO₂ fugitive emissions from refineries activities, the estimates are balanced with the amount of crude oil losses reported in the national Energy Balance (MSE, several years [a]).

CH₄ emissions from transmission and distribution of natural gas are verified considering emission factors reported in literature and detailed information supplied by the main operators (ENI, several years [b]; Riva, 1997).

3.9.5 Source-specific recalculations

In the 2013 submission, some recalculations affected emission estimates of the sector.

CH₄, CO₂, and N₂O emissions by oil and gas exploration activities have been calculated since 1990 because new information are available on the number of wells for oil and gas exploration. CH₄ and CO₂ emissions by pipeline oil transport have been calculated since 1990. As concerns solid fuel production the CO₂ emissions have been calculated by mining and post mining activities. Moreover the post mining CH₄ emission factors for underground mine have been revised and post mining CH₄ emissions for surface mine have been calculated.

New information has been provided by one gas distribution operator as regards fugitive emissions since 2009. The length of low and medium pressure network for natural gas distribution has been updated since 2009.

Recalculations accounted for an average increase by 0.061% of CO₂ eq. of fugitive emissions as compared to the previous submission.

3.9.6 *Source-specific planned improvements*

No further improvements are planned for the next submission.

4 INDUSTRIAL PROCESSES [CRF sector 2]

4.1 Sector overview

By-products or fugitive emissions, which originate from industrial processes, are included in this category. 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 1.A.2. All greenhouse gases as well as CO, NO_x, NMVOC and SO₂ emissions are estimated.

In 2011 industrial processes account for 4.87% of CO₂ emissions, 0.2% of CH₄, 1.1% of N₂O, 100% of PFCs, HFCs and SF₆. In terms of CO₂ equivalent, industrial processes share 6.5% 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 CO₂, CH₄ and N₂O and in Gg of CO₂ equivalent for F-gases.

An increase in HFC emissions is observed from 1990 to 2011, while CO₂ emissions from chemical and metal industry reduced sharply in the period.

Table 4.1 Trend in greenhouse gas emissions from the industrial processes sector, 1990-2011 (Gg)

GAS/SUBSOURCE	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CO₂ (Gg)										
2A. Mineral Products	21,303	20,976	21,455	23,481	23,536	24,027	21,729	17,466	17,553	16,980
2B. Chemical Industry	3,254	1,659	1,362	1,784	1,727	1,759	1,488	1,178	1,663	1,585
2C. Metal Production	3,878	3,403	1,754	1,922	1,942	1,925	1,875	1,307	1,465	1,610
CH₄ (Gg)										
2B. Chemical Industry	2.45	2.65	0.40	0.33	0.32	0.34	0.30	0.28	0.33	0.30
2C. Metal Production	2.71	2.71	2.61	2.72	2.81	2.75	2.61	1.54	2.17	2.47
N₂O (Gg)										
2B. Chemical Industry	21.54	23.35	25.54	25.03	8.54	6.10	3.44	3.64	2.09	0.95
HFCs (Gg CO₂ eq.)	351	671	1,986	5,401	6,106	6,855	7,513	8,164	8,745	9,306
PFCs (Gg CO₂ eq.)	2,487	1,266	1,217	1,715	1,714	1,652	1,501	1,063	1,331	1,455
SF₆ (Gg CO₂ eq.)	333	601	493	465	406	428	436	398	373	403

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

Key-category identification in the industrial processes sector with the IPCC Approach 1 and Approach 2 for 2011

KEY CATEGORIES			without LULUCF	with LULUCF
2F	HFC, PFC	Emissions from substitutes for ODS	L, T	L, T
2A	CO ₂	Emissions from cement production	L, T	L1, T1
2B	N ₂ O	Emissions from adipic acid	T	T
2C	CO ₂	Emissions from iron and steel production	T1	T1
2B	CO ₂	Emissions from ammonia production	T1	T1
2B	N ₂ O	Emissions from nitric acid production	T1	T1
2C	PFC	Aluminium production	T1	T1

HFC and PFC from substitutes for ODS are included in 2F; CO₂ emissions from cement are included in category 2A; N₂O emissions from adipic acid, nitric acid and CO₂ emissions from ammonia refer to 2B; CO₂ emissions from iron and steel production and PFC emissions from aluminium production are included in 2C. Methane emissions from the sector are not a key source.

All these categories are also key categories including the LULUCF estimates in the assessment, even if CO₂ emissions from iron and steel production, CO₂ emissions from ammonia production N₂O from nitric production and PFC from Aluminium production are not key category for trend assessment with the Approach 2; CO₂ emissions from cement production is not a key category for level and trend assessment with the Approach 2.

In addition CO₂ emissions from limestone and dolomite use are a key category in the base year at level assessment with the Approach 1 including and excluding LULUCF; CO₂ emissions from lime production are a key category in the base year at level assessment with the Approach 1 only including LULUCF.

4.2 Mineral Products (2A)

4.2.1 Source category description

In this sector CO₂ emissions from the following processes are estimated and reported: cement production, lime production, limestone and dolomite use, soda ash production. Asphalt roofing and road paving with asphalt activities are also included in this sector but they contribute only with NMVOC emissions; CO₂ emissions from decarbonising in glass production have been estimated and reported in “Other”.

Cement

Cement production (2A1) is the main source of CO₂ emissions in this sector. As already mentioned, it is a key source both at level and trend assessment with the Approach 1 and accounts for 3.04% of the total national emissions.

During the last 15 years, in Italy, changes in cement production sector have occurred, leading to a more stable structure. The oldest plants were closed, wet processes were abandoned in favour of dry processes so as to improve the implementation of more modern and efficient technologies. The effects of the global recession period have led at national level only to two plants closedown. In 2011 Italy was not the first cement producer country in the EU 27 and reduction of clinker production was observed too. Actually, 28 companies (81 plants of which: 57 full cycle and 24 grinding plants; i.e. 1 full cycle plant and 5 grinding plants were closed in 2011 compared to 2010) operate in this sector: multinational companies and small and medium size enterprises (operating at national or only at local level) are present in the country. As for the localization of the operating plants: 46% is in northern Italy, 16% is in the central regions of the country and 38% is in the southern regions and in the islands. There are 80 active sintering rotary kilns which belong to the “dry” or of “semidry” types. In 2011 the larger size cement plants (i.e. with cement production capacity > 1 Mt/y) contributed with 7.2% to the national cement production; due to resizing of plants during 2011, only 2 plants keep a cement production capacity >1 Mt/year. In Italy different types of cement are produced; as for 2011 AITEC, the national cement association, has characterised the national production as follows: 72% is CEM II (Portland composite cement); 14% is CEM IV (pozzolanic cement); 8.8% is CEM I (ordinary Portland Cement) and 3.9% is CEM III (blastfurnace cement). Clinker production has been decreasing since 2007 (about 10% in 2008 compared to 2007; about 19% in 2009 compared to 2008; about 4.7% in 2011 compared to 2010) and clinker demand in cement production was about 75% in 2011 (production of clinker out of production of cement). As CO₂ emissions and cement/clinker production are strictly related, a decrease in the CO₂ emissions from cement production has been observed in the same way.

Lime

CO₂ emissions occur also from processes where lime is produced and account for 0.50% of the total national emissions. Lime production can also occur, beside lime industry, in different industrial sectors such as iron and steel making, pulp and paper production, soda ash production, sugar production; lime can also be used in a number of processes concerning wastewater treatment, agriculture and the neutralization of acidic emissions in the industrial flue gases. In particular the other relevant lime productions accounted for in Italy are those occurring in the iron and steel making process and in the sugar production process.

Lime is basically produced by calcination of limestone (calcium carbonate) or dolomite (calcium/magnesium carbonate) at 900°C. The process leads to quicklime and CO₂ emissions according to the following reaction:



CO₂ is released because of the process reaction itself and also because of combustion to provide energy to the process. CaO and MgO are called quicklime. Quicklime, together with water, give another product of the lime industry which is called calcium hydroxide Ca(OH)₂.

CO₂ emissions estimation is related to lime production in mineral industry and it also includes the production of lime to feed another industrial processes (e.g. iron and steel making facilities).

The number of lime producing facilities has been relevantly changing through the years: 85 operating plants in 1990, 46 plants in 2003, 38 plants in 2008 and 35 plants in 2010 (figures for 2008 and 2010 are based on the European emissions trading scheme data). Moreover, 46% of the plants is in the southern regions and in the islands, 39% is in the northern regions and 15% in the central regions. The number of operating kilns has also decreased significantly through the years (about 171 in 1990, 75 in 2003). During the nineties, lime industry invested in technology implementation to replace the old kilns with regenerative and high efficiency kilns, rotary kilns are no longer used. Concerning fuel consumptions, 80% of the national lime industry uses natural gas, 20% uses coke.

Limestone and dolomite use (brick and tiles; fine ceramics; paper industry and power plants)

CO₂ emissions are also related to the use of limestone and dolomite in different industrial processes, and they account for 0.36% of the total national emissions. Limestone or dolomite can be added in different steps of the production process to obtain the desired product features (i.e. colour, porosity). Sometimes carbonates in limestone and dolomite may have to be calcined (“dead burned”) in order to be added to the manufacturing process. Limestone and dolomite are also used in paper production process and in the treatment of power plants flue gases. A steep decrease in the production processes and the relevant use of limestone can be observed between 2007 and 2009; use of limestone has been decreasing more gradually since 2009; the overall decrease being mainly driven by the use of limestone and dolomite in the brick and tiles sector.

Glass production

Glass industry in Italy can be characterised with regard to four glass product types: flat glass, container glass, borosilicate and lead/crystal glass. Flat glass is produced in facilities mainly located in the North; container glass is produced in facilities located all over the country; glass fibres and wool are produced in the North. About 80 companies carry out activities related to glass industry in Italy, 30 companies carry out glass production processes in about 54 production units.

With regard to glass chemical composition, the national glass production consists of 95% soda-lime glass, 4% borosilicate glass and 1% lead/crystal glass.

The main steps of the production process in glass industry are the following:

- raw materials storage and batch formulation;
- melting of the formulated batch at temperature ranging from 1400°C to 1600°C, in different furnaces according to the type of glass product;
- forming into glass products at specific temperature ranges;
- annealing of glass products to prevent weak glass due to stress.

The formulated batch is generally melted in continuous furnaces, whose size and features are related to the types of glass production. In Italy 80% of the glass industry production is carried out using natural gas as fuel, other fossil fuels consumption is limited to low sulphur content oil. Emissions are basically released by the high temperature melting step and depend on the type of glass product, raw materials and furnaces involved in the production process. Main pollutants are: dust, NO_x, SO_x, CO₂; occasionally and depending on the specific production process, heavy metals, fluorides and chlorides gases could be released. CO₂ emissions are mainly related to the decarbonisation of carbonates used in the process (soda ash, limestone, dolomite) during the melting phase, accounting for 0.14% of the total national emissions. The use of scrap glass (recycled cullets) in the production processes has been increasing in Italy since 1998 thus contributing to the reduction of emissions from decarbonation and from the melting phase. In the following box, values of the rate of glass recycling from 1998 are reported.

Rate of glass recycling

GLASS PRODUCTION	1998	2000	2005	2007	2008	2009	2010	2011
Rate of glass recycling (%)	38.8	46.9	57.2	59.6	64.3	65.4	68.4	69.9

Soda Ash production and use

In Italy only one facility operates soda ash production via Solvay process. Solvay process allows producing soda ash through the conversion of sodium chloride into sodium carbonate using calcium carbonate and ammonia. CO₂ is released and calcium chloride is the waste.

Up to the second half of year 2000 in the unit for the production of peroxidates there was one sodium carbonate line and a sodium perborate line which was then converted to sodium carbonate production. Soda ash is also used in glass production processes. CO₂ emissions from soda ash production account for 0.06% of the total national emissions.

Asphalt roofing and road paving with asphalt

In Italy 14 facilities have been producing bitumen roofing membranes and about 87 facilities operate in the production and laying of asphalt mix products for road paving. SITEB, the Italian asphalt and road association is the relevant source of information for these two source categories. NMVOC emissions have been estimated for these two source categories along the whole time series.

4.2.2 Methodological issues

IPCC Guidelines and Good Practice Guidance are used to estimate emissions from this sector (IPCC, 1997; IPCC, 2000; IPCC, 2006).

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; IPCC, 2006), by the EMEP/CORINAIR guidebook (EMEP/CORINAIR, 2007) or by other international Guidebooks (USEPA, 1997).

Cement

CO₂ emissions from cement production are estimated using the IPCC Tier 2 approach. Activity data comprise data on clinker production provided by the national Institute of Statistics (ISTAT, several years). Emission factors are estimated on the basis of information provided by the Italian Cement Association (AITEC, several years) and by cement facilities in the framework of the European pollutant emission register (EPER, now E-PRTR) and the European emissions trading scheme. In this latter context, all cement production plants reported fuel consumption and emissions, split between combustion process and decarbonising process. Basically, CO₂ emissions time series is related to clinker production time series. Specifically, main decreases in the national production of cement industry, which well reflects the economical trend, can be observed for the years 1993-1994; an increase in production can be observed from 1996 to 2001 and from 2003 to 2007, while a significant decrease in the production is observed for 2008 and 2009 due to the effects of the international economic crisis. Practically the same variations can be observed in CO₂ emissions trend. In order to enhance the transparency of the inventory, in Figure 4.1 clinker production time series together with CO₂ emissions time series is shown.

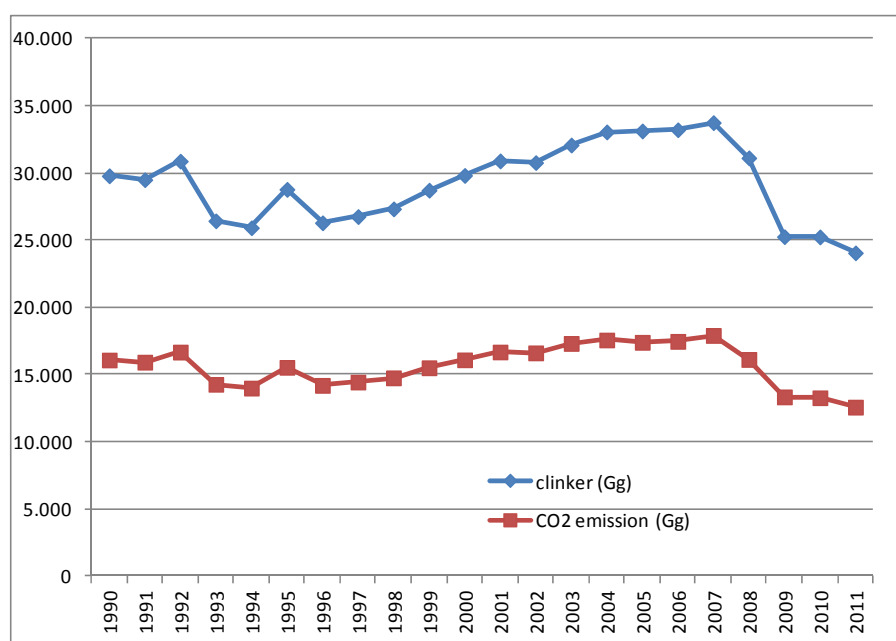


Figure 4.1 Trend of clinker production and CO₂ emissions 1990-2011 (Gg)

From 1990 to 2003 the resulting emission factor for cement production was equal to 540 kg CO₂/t clinker, based on the average CaO content in the clinker and taking into account the contribute of carbonates and additives. In lack of specific data from the plants, this value was suggested to the operators by AITEC (AITEC, 2004) on the basis of a tool provided by the World Business Council for Sustainable Development, available on website at the address <http://www.ghgprotocol.org/standard/tools.htm>.

From 2004, emission factors are based on the data reported within the frame of the EPER/EPRTTR and of the European Emissions Trading scheme. The EF resulted in 518 kg CO₂/t clinker in 2008, in 528 kg CO₂/t clinker in 2009 (EF value for this year has been checked and revised in the present submission) and in 523 kg CO₂/t in 2011 based on the average CaO content in the clinker and taking into account the contribute of carbonates and additives, as reported in Figure 4.2. The average emission factor varies year per year as a consequence of the different circumstances (e.g. quality of the raw materials and operating conditions) at the about 54 clinker facilities.

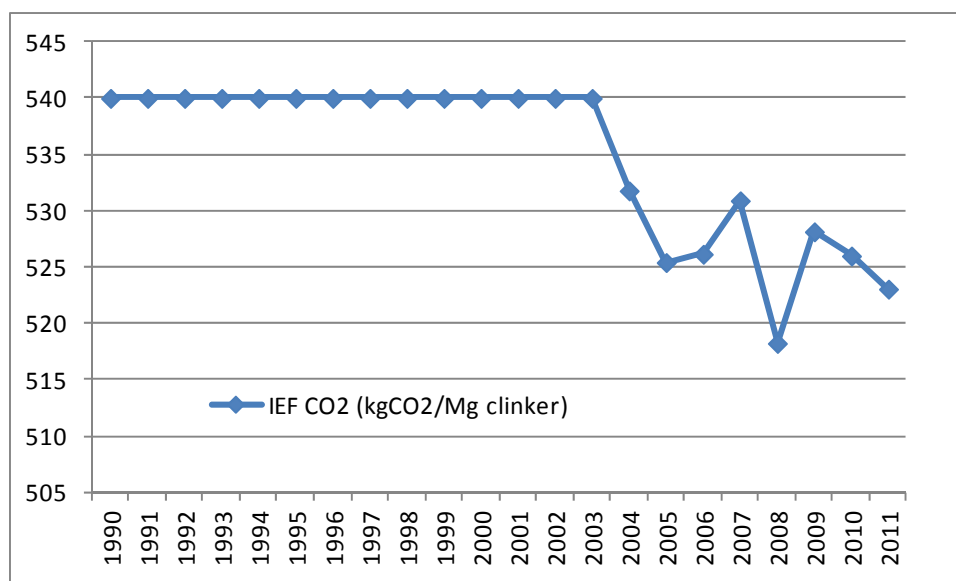


Figure 4.2 CO₂ IEF from decarbonation in clinker production, 1990-2011

As recommended by the ERT in the last review process (UNFCCC, 2012), the inventory team has further explored the fluctuation of the IEF for CO₂ from clinker production with the following findings over the years from 2005 to 2011:

- in 2005 73% of the clinker facilities had an IEF in the range 520÷544.99 (kg CO₂/t clinker) and 34.6% has IEF in the range 520÷529.99 (kg CO₂/t clinker);
- in 2006 81% of clinker facilities has an IEF in the range 515÷544.99 (kg CO₂/t clinker) and 54.2% has 515÷534.99 (kg CO₂/t clinker);
- in 2007 79.6% of clinker facilities an IEF in the range 515÷544.99 (kg CO₂/t clinker) and 48% has 525÷539.99 (kg CO₂/t clinker);
- in 2008 77% of clinker facilities an IEF in the range 505÷534.99 (kg CO₂/t clinker) and 39.6% has 510÷524.99 (kg CO₂/t clinker);
- in 2009 82.6% of clinker facilities an IEF in the range 520÷544.99 (kg CO₂/t clinker) and 59.6% has 525÷539.99 (kg CO₂/t clinker);
- in 2010 88.4% of clinker facilities an IEF in the range 515÷539.99 (kg CO₂/t clinker) and 50% has 520÷534.99 (kg CO₂/t clinker);
- in 2011 90% of clinker facilities an IEF in the range 510÷539.99 (kg CO₂/t clinker) and 64.7% has 510÷529.99 (kg CO₂/t clinker) and 33.3% are in the range 520÷529.99 (kg CO₂/t clinker).

The information related to activity data and emissions for the clinker facilities reporting to the national ETS system have been processed. The same analysis, performed on information referred to year 2003, shows that 88% of clinker facilities has an IEF in the range 535÷549.99 (kg CO₂/t clinker) and 75% are in the range 540÷544.99 (kg CO₂/t clinker) in line with the IEF value (540 kg CO₂/t clinker) reported for that year.

Finally, regarding industry data verification, the available activity data for the cement/clinker production in Italy are consistent to the information supplied by the Italian cement industry association, to the data reported under the national PRTR and also to the data collected in the frame of the national ETS. Emission data reported under the different obligations are in accordance for all the facilities.

In the framework of the EU-ETS as well as the EPRTR registry, 51 plants out of 58 reported in 2011 their data representing more than 98% of total national clinker production. Under the EU-ETS, cement plants communicate emissions and activity data split between energy and processes phases and specifying the amount of carbonates and additives; both activity data and emissions are independently verified and certified as requested by the EU-ETS directive.

Lime

CO₂ emissions from lime have been estimated on the basis of production activity data supplied by ISTAT (ISTAT, several years up to 2008) and by operators in the frame of the ETS reporting obligations adding the amount of lime produced and used in other industrial processes (e.g. iron and steel production); 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 national lime industrial association (CAGEMA, 2005). Since 2009, information available in the frame of the ETS reporting obligation has allowed to have the lime productions at facility level together with CO₂ emissions data (both activity data and CO₂ emissions are certified). In the following box, CO₂ implied emission factors are reported.

CO₂ implied emission factors for lime production

LIME PRODUCTION	2005	2006	2007	2008	2009	2010	2011
CO₂ IEF (kg CO₂/ t lime)	706	694	707	710	707	706	704

Under the EU-ETS, lime plants communicate emissions and activity data split between energy and processes phases specifying the amount of carbonates and additives; both activity data and emissions are independently verified and certified as requested by the EU-ETS directive.

Limestone and dolomite

CO₂ emissions from limestone and dolomite use are related to the use of limestone and dolomite in bricks, tiles and ceramic production, paper production and also in the treatment of flue gases from power plants. In general about 86% of the total limestone and dolomite is used in the production processes of bricks and tiles; about 6.9% is used for the fine ceramic material; 6.9% is used in the treatment of flue gases in the power plants and about 0.1% is used in the paper industry. CO₂ emissions have been estimated for the whole time series; the overall CO₂ emission time series is mainly driven by the CO₂ emissions from the use of limestone and dolomites in the bricks and tiles sector (the same percentages are observed in the distribution of CO₂ emissions among the contributing sectors as for the limestone and dolomite used amounts). In the CRFs 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 CaCO₃ in the different products. Detailed production activity data and emission factors have been supplied in the framework of the European emissions trading scheme and relevant data are annually provided by the Italian bricks and tiles industrial association and by the Italian ceramic industrial associations (ANDIL, 2000; ANDIL, several years; ASSOPIASTRELLE, several years; ASSOPIASTRELLE, 2004). The activity data for 2010 have been updated in the present submission. Additional information will be available from 2013, in the context of the EU ETS with the entry of new plants for sectors not previously included, which will be used to verify emission estimates.

Glass

CO₂ emissions from glass production have been estimated taking into account activity data (ISTAT, several years) and emission factors estimated on the basis of information supplied by 53 facilities in the framework of the European emissions trading scheme. Based on this approach, CO₂ emissions from the decarbonation, which already take into account the national circumstances concerning the use of cullets (recycled scrap glass which does not cause CO₂ emissions) in the production processes, have been estimated. Activity data for 2010 have been updated in the present submission.

Soda ash

CO₂ emissions from soda ash production have been estimated on account of information available about the Solvay process (Solvay, 2003), whereas those from soda ash use are included in glass production. In the present submission activity data from 2007 to 2010 have been revised based on additional information provided by the operator concerning the production of soda ash which have occurred at the facility since 2007.

Asphalt roofing and road paving

NM VOC emissions from the manufacturing of asphalt roofing materials have been estimated based on the total surface of bitumen roofing membranes (Federchimica, several years; Siteb, several years) and default emission factors (EMEP/CORINAIR, 2007; EMEP/EEA, 2009). The activity data for roof covering related to years from 2007 to 2010 have been updated in the present submission because additional information for the last years have become available to the inventory team (Siteb, several years; Siteb, 2010; Siteb, 2012).

NM VOC emissions from road paving operations have been estimated based on the amount of asphalt mix produced for each year (ISTAT, several years; Siteb, several years) and the emission factors also derived from data supplied by Siteb (EPA, 2000; Siteb, several years). NM VOC emissions from road paving related to 2010 have been revised in the present submission because activity data for 2010 have been updated by the industrial association (Siteb, several years; Siteb, 2010; Siteb, 2012).

4.2.3 Uncertainty and time-series consistency

The uncertainty in CO₂ emissions from cement, lime, limestone and dolomite use and glass production is estimated to be equal to 10.4% from each activity, resulting from 3% and 10% for activity data and emission factor, respectively. Official statistics of activity data for these categories are quite reliable when compared to the activity data reported by facilities under different data collections, thus leading to the considered uncertainty level for the activity data. 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; this is a conservative estimation because the range of values of the emission factors of the Italian cement plants would lead to a lower uncertainty level.

Montecarlo analysis has been applied to estimate uncertainty of CO₂ emissions from cement for 2009. The resulting figure is equal to 10.0%. Normal distributions have been assumed for the parameters and information deriving from the ETS has been considered in defining the shape of the distributions. A summary of the results is reported in Annex 1.

In Tables 4.2 and 4.3, the production of mineral products and CO₂ emission trend is reported.

Table 4.2 Production of mineral products, 1990 – 2011 (Gg)

ACTIVITY DATA	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	(Gg)									
Cement production (decarbonizing)	29,786	28,778	29,816	33,122	33,210	33,742	31,119	25,259	25,239	24,057
Glass (decarbonising)	3,779	4,259	4,930	5,328	5,327	5,385	5,365	4,736	5,063	5,188
Lime (decarbonizing)	2,583	2,873	2,760	3,344	3,496	3,444	3,206	2,390	2,789	2,939
Limestone and dolomite use	5,773	5,283	5,132	6,076	6,015	6,035	5,345	3,752	3,513	3,366
Soda ash production and use	610	1,070	1,000	915	883	874	836	573	620	726

Table 4.3 CO₂ emissions from mineral products, 1990 – 2011 (Gg)

CO ₂ EMISSIONS	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	(Gg)									
Cement production (decarbonizing)	16,084	15,540	16,101	17,403	17,474	17,914	16,127	13,341	13,276	12,583
Glass (decarbonizing)	453	511	611	768	742	756	709	611	559	584
Lime (decarbonizing)	2,042	2,279	2,185	2,361	2,426	2,434	2,276	1,689	1,969	2,069

CO ₂ EMISSIONS	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	(Gg)									
Limestone and dolomite use	2,540	2,325	2,258	2,674	2,647	2,655	2,352	1,651	1,546	1481
Soda ash production and use	183	321	300	275	247	268	265	174	203	263

Emission trends are generally related to the production level, which has been decreasing for the last years; in particular, for 2009, the decrease was mostly affected by the economic recession.

4.2.4 Source-specific QA/QC and verification

CO₂ emissions have been checked with the relevant industrial associations.

Both activity data and average emission factors are also compared every year with data reported in the national EPER/E-PRTR registry and in the European emissions trading scheme.

Under the EU-ETS, operators are requested to report activity data and CO₂ emissions as information verified and certified by auditors who check for consistency to the reporting criteria.

Activity data and emissions reported under EU-ETS and EPER/EPTR are compared to the information provided by the industrial associations. In particular, comparisons have been carried out for cement, lime, limestone and dolomite, and glass sectors. The general outcome of this verification step shows consistency among the information collected under different legislative framework and the information provided by the relevant industrial associations.

4.2.5 Source-specific recalculations

Recalculations occurred as, in the current submission, CO₂ emissions in 2010 from limestone and dolomite use have been revised; CO₂ emissions from the soda ash production for the time series from 2007 to 2010 have been revised due to an update of the activity data for the same time period. Consequently, for CO₂ emissions, recalculations for the mineral industry result in -0.001% increase in 2007 and 2008, -0.007% decrease in 2009 and 2010, mainly due to the update along the time series of the activity data for limestone and dolomite use and soda ash production and use as shown in the following box.

Recalculation also occurred in the current submission for NMVOC emission estimation from asphalt roofing and from road paving because more update activity data were supplied by the sectorial association. Consequently, for NMVOC emissions, recalculations for the mineral industry result in about -0.02% decrease in 2007, -0.03% decrease in 2008 and 2009, +0.17% increase in 2010, mainly due to the decreases along the time series for the activity data of the asphalt roofing and the minor increase in 2010 activity data for road paving with asphalt, as shown in the following box.

Recalculations (%) in CO₂ emissions time series for the limestone and dolomite use, 2010, soda ash production and use, 2007-2010 and Recalculation (%) in NMVOC emissions time series for the Asphalt roofing, 2007-2010 and for the Road Paving with Asphalt, 2010.

GAS/SUBSOURCE	1990	1995	2000	2005	2006	2007	2008	2009	2010
CO₂									
2A.3. Limestone and Dolomite Use									- 0,01
2A.4. Soda Ash Production and use						0,11	0,11	- 0,42	- 0.35
NMVOC									
2A.5. Asphalt Roofing						-12,00	- 17,00	- 14,00	- 15,00
2A.6. Road Paving with Asphalt									0,21

4.2.6 Source-specific planned improvements

No further improvements are planned.

4.3 Chemical industry (2B)

4.3.1 Source category description

CO₂, CH₄ and N₂O emissions from chemical productions are estimated and included in this sector.

Adipic acid

Adipic acid production is a multistep process which starts with the oxidation of cyclohexanol using nitric acid and Cu catalysts according to the following reaction:



Adipic acid is then used to produce nylon or is fed to other production processes. Together with adipic acid, N₂O is produced and CO₂ is one of the by-products (Radici Chimica, 1993).

Emissions data from adipic acid production are provided and referenced by one plant, which is the only producer in Italy (Radici Chimica, several years). Specifically for N₂O, adipic acid is a key source at trend assessment, both with Approach 1 and Approach 2. These emissions account for 16% of total N₂O emissions in 2005, 2.4% in 2008; 1.8% in 2010 and 0.43% in 2011; the notable decrease in share is due to the fact that the technology to reduce N₂O emissions has become fully operational at the existing producing facility since 2007.

N₂O emissions have relevantly decreased thanks to the implementation of a catalytic abatement system (pilot scale plant). The use of thermally stable catalysts in the pilot plant has allowed the treatment of highly N₂O concentrated flue gas from the adipic acid production plant, reducing the volume of treated gas and the size of the pilot plant itself. The abatement system is generally run together with the adipic acid production process. In 2004 this system was tested for one month resulting in complete decomposition of N₂O; in 2005 the catalytic process was started only at the end of the year because of technical changes in the system; in 2006 the abatement system had been operating continuously for 9 months (3 months were needed for maintenance and technical changes) leading to the decomposition of 92% (efficiency of the abatement system while in operation) of N₂O emissions. Since 2007 the operating time has been about 11 months (about one month was needed for maintenance operations) and the N₂O emissions abatement system while in operation has reached an efficiency exceeding 98% (Radici Chimica, several years). In 2011 further emissions reduction was achieved thanks to technical improvements implemented in the production process during 2010:

1. the number of scheduled outages of the adipic acid production process is reduced (from about 1/month to 2/year);
2. the abatement system is set to reach the operating level more quickly than in the previous years.

These two achievements allow reducing the significance of N₂O peak emissions related to the start&stop phases. Moreover an emission monitoring and recording system was implemented in compliance with Decision 2007/589/EC (Radici Chimica, 2013).

Also CO₂ emissions are estimated from this source.

Ammonia production

In Italy only one facility had been producing ammonia since 2009 as a consequence of the resizing of the production at national level after the crisis of the largest fertilizer producer, Enichem Agricoltura, and as a consequence of the international financial crisis in the last years. Two facilities had been producing ammonia in Italy up to 2008, in 2009 one plant stopped the production and the plant reconversion is currently under negotiation. Ammonia is obtained after processing in ammonia converters a “synthesis gas” which contains hydrogen and nitrogen. CO₂ is also contained in the synthesis gas, but it is removed in the decarbonising step within the ammonia production process. Part of CO₂ is recovered as a by-product and part is released to atmosphere. Recovered CO₂ can either be used as input for different production processes (e.g. urea or

calcium nitrate lines; liquefaction of CO₂ plant) on site or can be sold to technical gas manufacturers. The results of the investigation concerning the recovered CO₂ were accounted for in the previous submissions: operators provided the information used to revise both the emissions and the EF time series (YARA, several years). CO₂ emissions from ammonia production are also a key source, at trend assessment with the Approach 1.

Nitric acid

In early nineties seven facilities manufactured nitric acid, but since 2003 the production has been carried on only in three plants. In 2008 another plant stopped nitric acid production and the reconversion of the plant is currently under negotiation, so since 2009 nitric acid production has been carried out in only two plants. Nitric acid is produced from ammonia by catalytic oxidation (with air) of NH₃ to NO₂ and subsequent reaction with water. Currently the reactions involved take place in low and medium pressure processes.

N₂O emissions from nitric acid production are key source for trend assessment with Approach 1, although they also show a relevant decrease in emissions from 1990 due to a reduction in production. Moreover, as far as YARA is concerned, the decrease in N₂O emissions is also related to the implementation of catalytic N₂O decomposition in the oxidation reactor (YARA De-N₂O patented technology, based on the use of CeO₂ catalyst; YARA, several years).

Carbon black

Three facilities have been carrying out this production which consists basically on cracking of feedstock oil (a mixture of PAH) at 1200 – 1900 °C. Together with black carbon, tail gas is a by product of the process. Tail gas is a mixture of CO, H₂, H₂O, NO_x, SO_x and H₂S; it is generally burnt to reduce the emissions to air and to recover energy to be used in the production process.

CO₂ emissions from carbon black production have been estimated on the basis of information supplied directly by the Italian production plants also in the framework of the EU ETS for the last years.

Ethylene, Ethylene oxide, Propylene, Styrene

Ethylene, ethylene oxide, propylene and styrene productions belong to the organic chemical processes. In particular, ethylene is produced in petrochemical industry by steam cracking to manufacture ethylene oxide, styrene monomer and polyethylenes. Ethylene oxide is obtained via oxidation of ethylene and it is largely used as precursor of ethylene glycol and in the manufacture of surfactants and detergents. Propylene is obtained by cracking of oil and it is used to manufacture polypropylene but also acetone and phenol. Styrene, also known as vinyl benzene, is produced on industrial scale by catalytic dehydrogenation of ethyl benzene. Styrene is used in the rubber and plastic industry to manufacture through polymerisation processes such products as polystyrene, ABS, SBR rubber, SBR latex. Except for ethylene oxide production, which has stopped in 2002, the other productions of the above mentioned chemicals still occur in Italy.

As far as ethylene, ethylene oxide and propylene are concerned, Syndial Spa (ex Enichem) and Polimeri Europa (Syndial, several years; Polimeri Europa, several years) were the main producers in Italy up to 2006. Since 2007 Polimeri Europa has become the main producer for those products, while it has been the main producer of styrene since 2002.

Titanium dioxide

CO₂ emissions from dioxide titanium production have been estimated on the basis of information supplied directly by the Italian maker. TiO₂ is the most used white pigment especially for paint and plastic industries. In Italy there is only one facility where this production occurs and titanium dioxide is produced through the “sulphate process”. The “sulphate process” involves the use of sulphuric acid to concentrate the input raw mineral in terms of titanium dioxide content, then selective precipitation and calcination allow getting the final product.

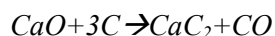
Caprolactame production

Caprolactame is a monomer used in the industrial production of nylon-6. It can be obtained by catalytic oxidation of toluene and cyclohexane. The process releases N₂O.

N₂O emissions from caprolactame production have been estimated and reported and are related to only one producing plant, which closed in 2003.

Calcium carbide production

Calcium carbide production process takes place in electric furnaces, CaO and coke are fed to the furnace and the product is obtained according to the following reaction:



CARBITALIA S.p.A. is the only facility which can operate calcium carbide production in Italy (CARBITALIA S.p.A., 2009). It produced calcium carbide up to 1995, when it stopped the production because of the increasing price of electricity. The plant still exists and it is maintained, but since 1995 it has just been supplying calcium carbide bought abroad.

4.3.2 Methodological issues

Adipic acid

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. Emissions estimates provided by the operator are based on the IPCC default EF, so the values provided and the estimates in the Italian emissions inventory are, basically, the result of the same methodology. More specifically, N₂O emissions from adipic acid production (category 2B3) have been estimated using the default IPCC emission factor equal to 0.30 kg N₂O/kg adipic acid produced, from 1990 to 2003.

Since 2004 the operator has started to study how to introduce an abatement system; although emission estimates provided by the operator have still been based on the IPCC default emission factor (0.30 kgN₂O/kg adipic acid produced), the operating hours of the abatement system and the abatement rates have also been included in the estimation process. The abatement system is generally run together with the adipic acid production process. In 2004, the N₂O catalytic decomposition 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, that the technology operated. From the end of 2005 the abatement technology is fully operational; the average emission factor in 2006 is equal to 0.05 kg N₂O/kg adipic acid produced and the abatement system had been operating continuously for 9 months; since 2007 the average emission factor has been 0.03 kg N₂O/kg adipic acid produced and the operating time of the abatement system has been 11 months. Technical improvements in operating the production process and the abatement system have allowed achieving significant reduction in N₂O emissions since 2009 (Radici Chimica, 2013): in 2010 the average emission factor was 0.019 kg N₂O/kg adipic acid produced while in 2011 the average EF is 0.005 kg N₂O/kg adipic acid produced with the abatement rate exceeding 98%.

Thus, both for the period 1990-2005 and from 2006 onwards the estimates are provided according to the IPCC Good Practice Guidance (default EF has been used when no abatement system was operational; abatement rates have been considered in estimating emission values since 2006). The operator reports also under EPER/E-PRTR both adipic acid production and the N₂O emissions related to this production; adipic production and N₂O emissions have been also reported by the operator to the national competent authority for the ETS (the facility is to be included in the ETS system in 2013) together with additional information such as abatement rates and operating times. Based on information from the national PRTR EFs are calculated for the plant, the resulting value is checked and verified by the formula included in the following box (based on the IPCC default EFs for adipic acid production, abatement rate and operating time of the abatement technology at the facility). In the formula the average emission factor is calculated subtracting from the default EF (0.300 kgN₂O /kg adipic acid produced) the default EF multiplied by the abatement technology rate and by the operating time factor, parameters and resulting EF values are indicated for the years 2005 to 2011.

The EFs submitted for the adipic acid production in the CRF and the EFs calculated for the plant in the following box are practically the same.

N₂O emission factors submitted vs calculations based on efficiency and utilization details

Parameter/Year	2005	2006	2007	2008	2009	2010	2011
EFp (IPCC default)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
A	0.925	0.9212	0.965	0.986	0.986	0.986	0.986
T	0.14	0.8825	0.93	0.91	0.91	0.952	0.999
EFs (average EF)	0.26	0.056	0.031	0.031	0.031	0.019	0.005

Values resulting according to the following formula

$$(1-A*T)*EF_p = EF_s$$

Where:

A= Abatement rate provided by the operator

EF_p= N₂O Emission Factor for Adipic Acid production (kg N₂O /kg adipic acid prod)

T = operating time of the abatement system/ operating time of the adipic acid production line

EF_s = N₂O actually released Emission Factor submitted (kg N₂O released/kg adipic acid prod)

CO₂ emissions from this source have been estimated according to the information communicated by the operator.

Ammonia

Ammonia production data are published in the international industrial statistical yearbooks (UN, several years), national statistical yearbooks (ISTAT, several years) and from 2002 they have been checked with information reported in the national EPER/E-PRTR registry. Since 2009 only one facility has been producing ammonia in Italy and reporting data to the national PRTR. Recovered CO₂ has been investigated with the cooperation of the operators and the resulting information has been used to revise the whole CO₂ emission time series and the emission factors as reported in the last submissions. The analysis has allowed understanding that CO₂ emissions recovered from ammonia production are used to produce urea and technical gases. According to IPCC Guidelines this CO₂ recovered should be accounted for emission and included in the estimate. Differently from the previous submissions the resulting average CO₂ emission factors were found to be higher than the IPCC defaults. In particular, for the years 1990-2001, CO₂ emission factor has been calculated on the basis of information reported by the production plants for 2002 and 2003 in the framework of the national EPER/E-PRTR registry and considering also the amounts of CO₂ recovered since the beginning of the recovery operations. CO₂ reported to the national EPER/E-PRTR registry has been used for the previous years in consideration that, as communicated by the operators, no modifications to the production plants have occurred along the period (YARA, 2007). Since 2002, the average emission factors result also from data reported by the plants in the national EPER/E-PRTR and they account for the recovered CO₂ data too. The following box shows the time series for the average CO₂ emission factor.

Ammonia production, time series for the average CO₂ EF (t CO₂/t ammonia production)

AMMONIA PRODUCTION	1990-2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
EF (t CO ₂ /t ammonia production)	1.90	1.90	1.93	1.94	1.93	1.92	1.90	1.86	1.96	1.90	1.76

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.

Nitric acid

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 they have been collected from industry (Norsk Hydro, several years; YARA, several years; Radici Chimica, several years). In 1990 there were seven production plants in Italy; three of them closed between 1992 and 1995, and another one closed in 2004, one more closedown in 2008 has left two plants still operating.

The N₂O average emission factors are calculated from 1990 on the basis of the emission factors provided by the existing production plants in the national EPER/E-PRTR 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. Thus, N₂O emissions are estimated at plant level also considering the operating unit level, if necessary. Activity data have been collected at plant level for the whole time series. Unit specific default IPCC EFs have been used for plants closed in the nineties because it was not possible to collect more detailed information. For the other plants, data supplied in the framework of the EPER/EPTR registry have been used from 2001 onwards, while for the years 1990-2000 EFs at unit level have been calculated as an average of 2001-2004 data provided by operators in the EPER/EPTR register. The implied emission factor varies year by year depending on the production levels of the different plants and it was equal to 6.49 and 7.07 kg N₂O/Mg nitric acid production, in 1990 and in 2007 respectively. Relevant reductions in N₂O emissions have been observed since 2008. Specifically, in 2008 the implementation of catalyst N₂O abatement technology in one of the major production plants (i.e. in one unit

of that plant) has led to a significant decrease in total N₂O emissions from nitric acid production, consequently a relevant reduction in the IEF can be observed too (YARA, several years): the implied emission factor for 2008 is in fact 2.29 kg N₂O/Mg nitric acid production (the abatement rate in one plant was 82% so far); in 2010 the implied emission factor is 1.21 kg N₂O/Mg nitric acid production; the relevant decrease is due to the installation of the abatement technology in the other unit of the same producing facility (Radici Chimica, 2011) and to the technical improvements implemented in 2011 (Radici Chimica, 2013).

Nitric acid production, time series for the average N₂O EF (t N₂O/t nitric acid production) since 2007

NITRIC ACID PRODUCTION	1990	2007	2008	2009	2010	2011
EF (t N ₂ O/t nitric acid production)	6.49	7.07	2.29	2.94	1.21	1.32

Caprolactame

N₂O 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 production and emission data reported in the national EPER/E-PRTR registry. The average emission factor is equal to 0.3 kg N₂O/Mg caprolactame production. The plant closed in 2003.

Carbon Black

CO₂ and CH₄ 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 national EPER/E-PRTR registry and the European emissions trading scheme. In 1996 a change in the production technology in the existing plants caused a reduction of CH₄, NMVOC, NO_x, SO_x and PM₁₀ emissions. The following box include the values of the IEF for CO₂ (t CO₂/t carbon black production) from 2005 to 2011.

Carbon black production, time series for the average CO₂ EF (t CO₂/t carbon black production)

CARBON BLACK PRODUCTION	2005	2006	2007	2008	2009	2010	2011
EF (t CO ₂ /t Carbon black production)	2.55	2.56	2.51	2.59	2.49	3.06	3.19

Calcium carbide

CO₂ emissions from calcium carbide production process have been estimated on the basis of the activity data provided by the sole Italian producer and referred to the years from 1990 to 1995 when the production stopped. The default IPCC CO₂ emission factor (IPCC, 2006) has been used to estimate the emissions.

4.3.3 Uncertainty and time-series consistency

The uncertainty in N₂O emissions from adipic and nitric acid and caprolactame production and in CO₂ emissions from ammonia and for other chemical production is estimated by 10.4%, for each activity, as combination of uncertainties related to activity data (3%) and emission factors (10%). Uncertainty level for activity data is an expert judgement, taking into account the basic source of information, while the uncertainty level for emission factors is equal to the level reported in the IPCC Good Practice Guidance (IPCC, 2000) for the adipic and nitric acid N₂O emissions and for CO₂ emissions from other industrial processes.

In Tables 4.4 and 4.5, the production of chemical industry, including non-key sources, and CO₂, CH₄ and N₂O emission trends are reported.

In general, total emission trends for all the chemical productions have been affected by reductions in productions over the years 2007-2009 (except for adipic acid and titanium dioxide activity data), whenever abatement technologies (e.g. nitric acid since 2008) or closures of plants cannot be regarded to as the specific causes for the decreasing emissions. In 2010 a general increase in productions determined a general increase in emissions estimates compared to 2009 estimates, while in 2011 an increase in production and in emission estimates can only be observed for carbon black compared to 2010 estimates.

Table 4.4 Production of chemical industry, 1990 – 2011 (Gg)

ACTIVITY DATA	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	(Gg)									
Adipic acid	49	64	71	75	84	84	76	78	85	83
Ammonia	1,455	592	414	607	559	578	474	354	505	476
Calcium carbide	12	7	-	-	-	-	-	-	-	-
Caprolactame	120	120	111	-	-	-	-	-	-	-
Carbon black	184	208	221	214	226	234	210	167	205	217
Ethylene	1,466	1,807	1,771	1,721	1,639	1,797	1,465	1,360	1,551	1,254
Ethylene oxide	61	54	13	-	-	-	-	-	-	-
Nitric acid	1,037	588	556	572	526	505	505	419	417	437
Propylene	774	693	690	1,037	988	971	870	760	880	716
Styrene	365	484	613	520	558	549	504	497	524	477
Titanium dioxide	58	69	72	60	68	72	59	64	70	51

Table 4.5 CO₂, CH₄ and N₂O emissions from chemical industry, 1990 – 2011 (Gg)

EMISSIONS	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CO₂ (Gg)										
Ammonia	2,764.50	1,124.80	786.18	1,171.94	1,075.54	1,097.36	881.72	694.83	959.37	839.01
Calcium carbide	13.08	7.09	-	-	-	-	-	-	-	-
Carbon black	422.05	477.48	508.83	548.22	579.21	585.73	544.24	414.96	629.43	691.30
Titanium dioxide	52.80	48.11	64.70	62.01	70.57	74.28	60.70	66.27	72.39	52.84
Adipic acid	1.33	1.72	1.93	1.50	1.68	1.68	1.52	1.61	1.76	1.70
CH₄ (Gg)										
Carbon black	1.84	2.08	0.11	0.10	0.10	0.10	0.10	0.10	0.12	0.13
Ethylene	0.12	0.15	0.15	0.15	0.14	0.15	0.12	0.12	0.13	0.11
Propylene	0.07	0.06	0.06	0.09	0.08	0.08	0.07	0.06	0.07	0.06
Styrene	0.01	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethylene oxide	0.42	0.37	0.09	-	-	-	-	-	-	-
N₂O (Gg)										
Nitric acid	6.73	4.22	4.09	5.44	3.95	3.58	1.16	1.23	0.51	0.58
Adipic acid	14.77	19.09	21.42	19.59	4.58	2.52	2.28	2.41	1.58	0.37
Caprolactame	0.04	0.04	0.03	-	-	-	-	-	-	-

4.3.4 Source-specific QA/QC and verification

Emissions from adipic acid, nitric acid, ammonia and other chemical industry production have been checked with the relevant process operators and with data reported to the national EPER/E-PRTR registry. Emissions and activity data for adipic acid, nitric acid and ammonia productions have also been checked against the relevant information reported by operator to the national competent authority for the ETS (those chemical processes are to be included in the ETS system in 2013), consistency of both emissions and activity data for those sectors is the outcome of this control.

4.3.5 Source-specific recalculations

No recalculations occurred in the estimates for the Chemical industry.

4.3.6 Source-specific planned improvements

Further investigations regarding completeness of CO₂ emissions sources from the activities of this sector are planned.

Additional checks regarding emissions for 2005-2009 will be carried out on account of information from new entrance installations that will be included in the ETS system from 2013.

A detailed balance of the natural gas reported in the Energy Balance, as no energy fuel consumption, and the fuel used for the production processes in the petrochemical sector is 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; CO₂ emissions from iron and steel production and PFC emissions from aluminium production are key sources at trend assessment, using Approach 1.

In 2011, the share of CO₂ emissions from metal production accounts for 0.39% of the national total CO₂ emissions, and 7.98% of the total CO₂ from industrial processes.

The share of CH₄ emissions is, in 2011, equal to 0.14% of the national total CH₄ emissions while N₂O emissions do not occur.

The share of F-gas emissions from metal production out of the national total F-gas levels was 52.8% in the base-year and has decreased to 0.76% (0.02% of the national total greenhouse gas emissions) in the year 2011.

Iron and steel

The main processes involved in iron and steel production are those related to sinter and blast furnace plants, to basic oxygen and electric furnaces.

The sintering process is a pre-treatment step in the production of iron where fine particles of metal ores are agglomerated. Agglomeration of the fine particles is necessary to increase the passageway for the gases during the blast furnace process and to improve physical features of the blast furnace burden. Coke and a mixture of sinter, lump ore and fluxes are introduced into the blast furnace. In the furnace the iron ore is increasingly reduced and liquid iron and slag are collected at the bottom of the furnace, from where they are tapped. The combustion of coke provides both the carbon monoxide (CO) needed for the reduction of iron oxide into iron and the additional heat needed to melt the iron and impurities.

The resulting material, pig iron (and also scrap), is transformed into steel in subsequent furnaces which may be a basic oxygen furnace (BOF) or electric arc furnace (EAF).

Oxygen steelmaking allows the oxidation of undesirable impurities contained in the metallic feedstock by blowing pure oxygen. The main elements thus converted into oxides are carbon, silicon, manganese, phosphorus and sulphur.

In an electric arc furnace steel is produced from polluted scrap. The scrap is mainly produced by cars shredding and does not have a constant quality.

The iron and steel cycle is closed by rolling mills with production of long products, flat products and pipes.

In 1990, there were four integrated iron and steel plants in Italy. In 2011, there are only three of the above mentioned plants, one of which lacks sintering facilities. Oxygen steel production represents about 34% of the total production and the arc furnace steel the remaining 66% (FEDERACCIAI, several years).

Currently, long products represent about 42% of steel production in Italy, flat products about 47% and pipes the remaining 10%. In 2011 long production has been equal to 12.9 Tg with an increase of 6% over the previous year but still below 23% compared to 2008; flat production has been equal to 14.4 Tg with an increase of 14% on the previous year and an increase of 3% compared to 2008 level. Almost the whole flat production derives from one only integrated iron and steel plant, while in steel plants equipped with electric ovens, almost all located in the northern regions, long products are produced (e.g. carbon steel, stainless steels) and seamless pipes (only one plant) (FEDERACCIAI, several years).

CO₂ emissions from steel production refer to carbonates used in basic oxygen furnaces and crude iron and electrodes in electric arc furnaces. CO₂ emissions from pig iron production refer to carbonates used in sinter and pig iron production. CO₂ 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.

CH₄ emissions from steel production refer to blast furnace charging, basic oxygen furnace, electric furnaces and rolling mills. CH₄ emissions from coke production are fugitive emissions during solid fuel transformation and have been reported under 1B1b category.

Ferroalloys

Ferroalloy is the term used to describe concentrated alloys of iron and one or more metals such as silicon, manganese, chromium, molybdenum, vanadium and tungsten. Usually alloy formation occurs in electric arc furnaces (EAF) and CO₂ emissions occur during oxidation of carbon still present in coke and because of consumption of the graphite electrodes.

In early nineties there were 13 plants producing various kinds of ferroalloys: FeCr, FeMn, FeSi, SiMn, Si-metal and other particular alloys, but since 2001 the production has been carried on only in one plant (ISPESL, 2005). The last remaining plant in Italy produces mainly ferro-manganese and silicon-manganese alloys.

Aluminium

From primary aluminium production CO₂ and PFCs (CF₄ and C₂F₆) are emitted. PFCs are formed during a phenomenon known as the ‘anode effect’, when alumina levels are low.

In 1990 primary aluminium production in Italy was carried out in 5 sites where different technologies were implemented:

- Fusina: Point Fed Prebake and Side Work Prebake (up to 1995);
- Portovesme: Point Fed Prebake and Side Work Prebake (up to 1990);
- Bolzano: Vertical Stud Soderberg;
- Fusina 2 and Porto Marghera: Side Work Prebake.

Since then the implemented technology has been upgraded from Side Work Prebake to Point Fed Prebake; while three old plants stopped the operations in 1991 (Bolzano) and in 1992 (Fusina 2 and Porto Marghera). Since 2000 Alcoa has replaced ENIRISORSE in operating the plants.

Up to 2010, two primary aluminium production plants, which use a prebake technology with point feeding, characterised by low emissions, have operated. Only one plant, located in Portovesme, was operating; in 2011, this plant produced 142 kt of primary aluminium. In 1990, primary aluminium production was 232 kt.

Magnesium foundries

In the magnesium foundries, SF₆ is used as a cover gas to prevent oxidation of molten magnesium. In Italy there is only one plant, located in the north, which started its activity in September 1995. Since the end of 2007, SF₆ has been replaced by HFC125, due to the enforcement of fluorinated gases regulation (EC, 2006) which, however, allows for the use of SF₆ in annual amounts less than 1 Mg. HFC125 emissions are reported in the category 2G and, in 2010, were equal to 605 kg. In 2011 HFC125 has been replaced by HFC134a (2,994 kg); these emissions are reported in the category 2G too.

4.4.2 Methodological issues

CO₂ and CH₄ emissions from the sector have been estimated on the basis of activity data published in the national statistical yearbooks (ISTAT, several years), data reported in the framework of the national EPER/E-PRTR registry and the European Emissions Trading Scheme, and supplied by industry (FEDERACCIAI, several years; ALCOA, several years). Emission factors reported in the EMEP/EEA Guidebook (EMEP/EEA, 2009), in sectoral studies (APAT, 2003; CTN/ACE, 2000) or supplied directly by industry (FEDERACCIAI, 2004; ALCOA, 2004; Italghisa, 2011) have been used.

Iron and steel

CO₂ emissions from iron and steel production refer to the carbonates used in sinter plants, in blast furnaces and in steel making plants to remove impurities; they are also related to the steel and pig iron scraps, and graphite electrodes consumed in electric arc furnaces.

Basic information for this sector derives from different sources in the period 1990-2011.

Activity data are supplied by official statistics published in the national statistics yearbook (ISTAT, several years) and by the sectoral industrial association (FEDERACCIAI, several years).

For the integrated plants, emission and production data have been communicated by the two largest plants for the years 1990-1995 in the framework of the CORINAIR emission inventory, distinguished by sinter,

blast furnace and BOF, and by combustion and processes emissions. From 2000, CO₂ emissions and production data have been supplied by all the plants in the framework of the ETS scheme, for the years 2000-2004 disaggregated for sinter, blast furnace and BOF plants, from 2005 specifying carbonates and fuels consumption and related CO₂ emissions. For 2002-2011 data have also been supplied by all the four integrated iron and steel plants in the framework of the European EPER/E-PRTR registry not distinguished for combustion and processes. Qualitative information and documentation available on the plants allowed reconstructing their history including closures or modifications of part of the plants; additional qualitative information regarding the plants collected and checked for other environmental issues or directly asked to the plant permitted to individuate the main driving of the emission trends for pig iron and steel productions.

Time series of carbonates used in basic oxygen furnaces have been reconstructed on the basis of the above mentioned information resulting in no emissions in the last years. Indeed, as regards the largest Italian producer of pig iron and steel, lime production has increased significantly from 2000 to 2008 by about 250,000 over 410,000 tonnes and the amount introduced in basic oxygen furnaces was, in 2004, about 490,000 tonnes (ILVA, 2006). In 2009 lime production, for the same plant, is equal to 216,000 tonnes but also steel production has sharply decreased; in 2010 lime production is 306,930 Mg and in 2011 is equal to 333,663 Mg. Emissions from lime production in steel making industries are reported in 1A2 Manufacturing Industries and Construction category.

Concerning the electric arc furnaces, additional information on the consumption of scraps, pig iron, graphite and electrodes and their average carbon content has been supplied together with the steel production by industry for a typical plant in 2004 (FEDERACCIAI, 2004) and checked with other sectoral study (APAT, 2003). On the basis of these figures an average emission factor has been calculated.

On account of the amount of carbonates estimated in sinter plants, average emission factor was equal in 1990 to 0.15 t CO₂/t pig iron production, while in 2011 it reduced to 0.06 t CO₂/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 CO₂ in the blast furnaces producing pig iron.

CO₂ average emission factor in basic oxygen furnaces results in 1990 equal to 0.079 t CO₂/t steel production, while from 2003 is null.

CO₂ average emission factor in electric arc furnaces, equal to 0.035 t CO₂/t steel production, 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 graphite electrodes used in the furnace and the amount of carbon stored in the final product. The same emission factor has been used for the whole time series.

Implied emission factors for steel production reduced from 0.053 to 0.023 t CO₂/t steel production, from 1990 to 2011, due to the reduction in the basic oxygen furnaces.

CO₂ 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. Following the encouragement of the ERT in the last review report, a survey has been started in order to collect further information about the emissions due to the consumption of coke exploring the possibility to disaggregate the relevant emissions between combustion and process.

The amount of carbon stored in steel produced in integrated plants has been considered and subtracted from the carbon balance (see Annex 3). The amount of carbon contained in steel has been estimated on the basis of EN standard and, from 2005, with emission trading data. Carbon stored is equal to 48,511 tonnes in 1990 and equal to 74,506 Mg in 2011.

CH₄ emissions from steel production have been estimated on the basis of emission factors derived from the specific IPPC BREF Report (IPPC, 2001 available at <http://eippcb.jrc.es>), sectoral study (APAT, 2003) and the EMEP/CORINAIR Guidebook (EMEP/CORINAIR, 2007) and refer to blast furnace, basic oxygen furnace, electric furnaces and rolling mills.

Ferroalloys

CO₂ emissions from ferroalloys have been estimated on the basis of activity data published in the national statistical yearbooks (ISTAT, several years) until 2001. Time series of ferroalloys activity data have been reconstructed from 2002 on the basis of statistical information (ISTAT, 2003), personal communication (Italghisa, 2011) and on the basis of production data communicated to E-PRTR register and to ETS from the only plant of ferroalloys in Italy. The comparison between E-PRTR and ETS data revealed some differences: further investigation led to a direct contact with the plant and to rectify the incorrect activity data.

The average emission factor has been calculated according to the IPCC Guidelines (IPCC, 2006) taking into consideration the different types of ferroalloys produced. The splitting up of national production in different types of ferroalloys was obtained from U.S. Geological Survey until 2001 (USGS, several years). Since 2002 only one plant of ferroalloys is located in Italy and different types of production are reconstructed on the basis of information listed above. This information is reported in the following box.

Splitting up of ferroalloys national production and IPCC 2006 emission factors

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	IPCC 2006 EF
<i>Ferroalloy</i>											kg/t
FeCr	0.30	0.26	-								1,300
FeMn	0.24	0.10	0.28	0.5	0.5	0.3	0.4	0.4	0.4	0.6	1,500
FeSi	0.02	-	-								4,800
SiMn	0.32	0.53	0.62	0.5	0.5	0.7	0.6	0.6	0.6	0.4	1,400
Si-Metal	0.06	0.05	0.03								5,000
Other	0.07	0.06	0.07								5,000

Implied emission factor for ferroalloys has been reduced from 1.90 to 1.46 t CO₂/t ferroalloys production, from 1990 to 2011 as a consequence of the sharp reduction in ferroalloys production, which is characterized by high emission factors (ferro-silicon and silicon-metal alloys). The simultaneous reduction of total production (from about 200 kt to 50 kt) has resulted in CO₂ emissions decreasing from 395 Gg in 1990 to 74 Gg in 2011.

Aluminium production

PFC emissions from aluminium production have been estimated using both Tier 1 and Tier 2 IPCC methodologies. The Tier 1 has been used to calculate PFC emissions from 1990 to 1999, while Tier 2 has been used since 2000; the use of different methods along the period is due to the lack of detailed data for the years previous to 2000. Although a number of attempts have been tried over the last years by the inventory team to retrieve the 1990-1999 historical operating data, it is not possible to retrieve the information: Alcoa can not provide operating data for the period from 1990 to 1999 as the plants were managed by a different company not operating anymore. Thus the decision to use both tiers, which was supported by previous review processes, confirming the transparency, accuracy and conservativeness of this approach.

PFC emissions, specifically CF₄ and C₂F₆, have been calculated on the basis of information provided by national statistics (ENIRISORSE, several years; ASSOMET, several years) and the national primary aluminium producer (ALCOA, several years), with reference to the documents drawn up by the International Aluminium Institute (IAI, 2003; IAI 2006) and the IPCC Good Practice Guidance (IPCC, 2000).

Tier 1 method has been used to calculate PFC emissions related to the entire period 1990-1999. The emission factors for CF₄ and C₂F₆ were provided by the main national producer (ALCOA, 2004) based on the IAI document (IAI, 2003).

The Tier 1 method used by ALCOA is based on the IAI methodology, which collected anode effect data from 1990 up to 2000, accounting also for reductions in specific emission for all technology categories (specific factors for Point Fed Prebake cells have been considered to estimate emissions).

In 1990 at the five production sites the following technologies were implemented:

- Fusina: Point Fed Prebake (16% of the cells) and Side Work Prebake (84% of the cells);
- Portovesme: Point Fed Prebake (84% of the cells) and Side Work Prebake (16% of the cells);
- Bolzano: Vertical Stud Soderberg (100% of the cells)
- Fusina 2 and Porto Marghera: Side Work Prebake (100% of the cells).

The EFs for PFCs were then calculated by ALCOA as weighted arithmetic mean values of EFs for the different technologies (IAI, 2003), the weights representing the implemented technologies.

In the following tables (Tables 4.6, 4.7) the emission factors and the default parameters used are reported; site specific values are confidential but they have been supplied to the inventory team and taken into account in the estimation process.

Table 4.6 Historical default Tetrafluoromethane (CF₄) emission values by reduction technology type (IAI, 2003)

	Technology specific emissions (kg CF ₄ / t Al)		
	1990 - 1993	1994 - 1997	1998 – 1999
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

Table 4.7 Multiplier factor for calculation of Hexafluoroethane (C₂F₆) by technology type (IAI, 2003)

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

PFC emissions for the period from the year 2000 are estimated by the IPCC Tier 2 method, based on default technology specific slope factors and facility specific anode effect minutes. Site-specific values (CF₄ and C₂F₆ emissions) and default coefficients (slope coefficients for CF₄ and C₂F₆) were provided by the main national producer (ALCOA, several years). Moreover, from 2005 certificated emission values and parameters, including anode effects, have been communicated under EU-ETS (ALCOA, 2010).

In Table 4.8 slope coefficients used for CF₄ and C₂F₆ are reported. ALCOA uses these values suggested by International Aluminium Institute (IAI, 2006), in accordance to the coefficients reported in the IPCC 2006 Guidelines (IPCC, 2006).

Table 4.8 CF₄ and C₂F₆ Slope Coefficients (IAI, 2006)

Type of Cell	CF ₄	C ₂ F ₆
	Slope Factor (kg PFC/tAl/AE-minutes/cell day)	
Center Work Prebake	0.143	0.0173

Anode Effects (minutes/cell day)

	2000	2005	2006	2007	2008	2009	2010	2011
Primary Aluminium Plant	0.96	0.73	0.65	0.90	0.46	0.74	0.58	0.53

CO₂ 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 CO₂/t primary aluminum production for the years 1990-2001, on the basis of data provided by the producer for 2002; this value is also consistent with the emission factors contained in the IPCC Guidelines and in the Aluminium Sector Greenhouse Gas Protocol. Since 2002 the emission factor has been calculated on account of information from the relevant plant supplied to the national EPER/EPTR registry (emissions and productions). Therefore, thanks to the availability of this additional information, CO₂ emission estimations have been carried out by the operator since 2002 according to the criteria defined by the International Aluminium Institute (IAI) and are given by the following three components:

- Electrolysis Emissions from Prebake Anode
- Pitch Volatile Matter Oxidation from Pitch Coking
- Bake Furnace Packing Material

This detailed information is not available for previous years (1990-2001) so the Tier 2 approach can not be extended to those years and Tier 1 has to be used. Although a number of attempts have been tried for the last years by the inventory team to retrieve the same information related to 1990-2001, those data cannot be retrieved. Therefore the Tier1+Tier2 approach allows ensuring the quality of the estimates and also the consistency of the CO₂ emissions time series depending on the quality of the available information.

In the following tables (Tables 4.9, 4.10) the emission factors and the default parameters used are reported; site specific values are confidential but they have been supplied to the inventory team.

Table 4.9 Coefficients used for estimation of CO₂ from aluminium production process with the Tier 2 methodology by plant

	Baked Anode Properties		
	Sulphur	Ash	Impurities
	Weight %	Weight %	Weight %
Portovesme	ssv*	ssv	DV** = 0.4
Fusina	DV = 1.6	ssv	DV = 0.4

* site specific value

** default value

Table 4.10 Coefficients used for estimation of CO₂ from aluminium production process with the Tier 2 methodology by plant

	Pitch content in green anodes	Hydrogen content in pitch	Recovered tar	Packing coke consumption	Sulphur content of packing coke	Ash content of packing coke
	Weight %	Weight %	kg/t BAP	t Pcc/ t BAP	Weight %	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

* site specific value

** default value

Magnesium foundries

For SF₆ used in magnesium foundries, according to the IPCC Guidelines (IPCC, 1997), emissions are estimated from consumption data made available by the company (Magnesium products of Italy, several years), assuming that all SF₆ used is emitted. In 2007, SF₆ has been used partially, replaced in November by HFC125, due to the enforcement of fluorinated gases regulation (EC, 2006). This regulation allows for the use of SF₆ in annual amounts less than 850 kg starting from 1 January 2008; for this reason SF₆ was still reported together with HFC 125 emissions for the years 2008, 2009 while for 2010 only HFC125 was reported. In 2011 HFC134a has replaced HFC125. HFC 125 emissions, as well as HFC134a, have been reported in the CRF category 2G Other.

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 SF₆ emissions from magnesium foundries is estimated to be about 7%, 5% for both activity data and emission factors. The uncertainty in CO₂ emissions from the sector is estimated to be 10.4%, for each activity, while for CH₄ emissions about 50%.

In Table 4.11 emission trends of CO₂, CH₄ and F-gases from metal production are reported. The decreasing of CO₂ 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 CO₂ emissions from aluminium and ferroalloys are driven by the production levels.

In Table 4.12 the emission trend of F-gases per compound from metal production is given. PFC emissions from aluminium production decreased because of the closure of three old plants in 1991 and 1992 and the update of technology for the two plants still operating. The decreasing of SF₆ consumption in the magnesium foundry from 2003 is due to the abandonment of recycling plant and the optimisation of mixing parameters.

Table 4.11 CO₂, CH₄ and F-gas emissions from metal production, 1990 – 2011 (Gg)

EMISSIONS	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CO₂ (Gg)										
Iron and steel	3,124	2,897	1,230	1,533	1,562	1,485	1,424	901	1,139	1,297
Aluminium	359	276	295	299	297	354	370	345	250	240

EMISSIONS	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
production										
Ferroalloys	395	230	229	89	83	86	81	61	77	74
CH₄ (Gg)										
Pig iron	2.13	2.10	2.02	2.06	2.07	2.00	1.88	1.02	1.54	1.77
Steel	0.58	0.60	0.60	0.67	0.74	0.75	0.73	0.52	0.63	0.70
PFC (Gg CO₂ eq.)										
Aluminium production	1,673	298	198	182	156	199	111	146	85	81
SF₆ (Gg)										
Magnesium foundries	-	-	0.0072	0.0035	0.0026	0.0023	0.0004	0.0004	0.0007	-
HFC125 - 2G										
Other (Gg)										
Magnesium foundries	-	-	-	-	-	0.0003	0.0023	0.0006	0.0006	-
HFC134a - 2G										
Other (Gg)										
Magnesium foundries	-	-	-	-	-	-	-	-	-	0.003-

Table 4.12 Actual F-gas emissions per compound from metal production in Gg CO₂ equivalent, 1990 – 2011

COMPOUND	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Gg CO₂ eq.										
CF ₄ (PFC-14)	1,289.2	235.8	169.2	155.5	133.0	170.3	94.6	124.3	72.7	69.5
C ₂ F ₆ (PFC-16)	384.1	61.7	29.0	26.6	22.8	29.1	16.2	21.3	12.4	11.9
<i>Total PFC emissions from aluminium production</i>	<i>1,673.4</i>	<i>297.5</i>	<i>198.2</i>	<i>182.1</i>	<i>155.7</i>	<i>199.4</i>	<i>110.8</i>	<i>145.6</i>	<i>85.2</i>	<i>81.4</i>
<i>Total SF₆ emissions from magnesium foundries</i>	<i>0.0</i>	<i>0.0</i>	<i>172.1</i>	<i>84.7</i>	<i>61.2</i>	<i>53.9</i>	<i>10.5</i>	<i>9.2</i>	<i>17.5</i>	<i>0.0</i>
<i>HFC-125 in Magnesium foundries</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.9</i>	<i>6.5</i>	<i>1.6</i>	<i>1.7</i>	<i>0.0</i>
<i>HFC-134a in Magnesium foundries</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>3.89</i>
Total F-gas emissions from metal production	1,673.4	297.5	370.3	266.8	217.0	254.3	127.9	156.4	104.3	85.3

In response to the 2010 review process (UNFCCC, 2010) a more robust Tier 1 comparison has been evaluated in order to strengthen the conservativeness of combined Tier 1 and Tier 2 approaches.

In particular, as suggested by previous review processes, several comparisons were analyzed, using Tier 1 and Tier 2 approach, and under Tier 1 approach using different emission factors available from the following references (IAI, 2003; IAI, 2006; IPCC 2000):

1. 2003 International Aluminium Institute document, supplied by ALCOA to calculate emissions from 1990 to 1999 and actually used by the Party;
2. the updated 2006 International Aluminium Institute document, which agree with new 2006 IPCC Guidelines;
3. 2000 IPCC Good Practice Guidance.

In Tables 4.13 and 4.14 CF₄ and C₂F₆ default emission factors (Tier 1) and slope coefficient data (Tier 2) by technology are reported, distinguished for different reference sources.

Table 4.13 Default CF₄ and C₂F₆ Emission Factors

	CF ₄ (kg/t)				C ₂ F ₆ (kg/t)			
Plant Technology	IAI 2003	IAI 2006	GPG 2000	GL 2006	IAI 2003	IAI 2006	GPG 2000	GL 2006
CWPB	0.4	0.4	0.31	0.4	0.17	0.04	0.04	0.04
PFPB	0.3*	-	-	-	0.17*	-	-	-
SWPB	1.4	1.6	1.7	1.6	0.24	0.4	0.17	0.4
VSS	0.6	0.8	0.61	0.8	0.06	0.04	0.061	0.04
HSS	0.7	0.4	0.6	0.4	0.09	0.03	0.06	0.03

*This value refer to period 1990 – 1993 (see Table 4.6)

Table 4.14 Default CF₄ and C₂F₆ Slope Coefficients

	CF ₄ (kg PFC / t Al / AE minutes/cell day)				C ₂ F ₆ (kg PFC / t Al / AE minutes/cell day)			
Plant Technology	IAI 2003	IAI 2006	GPG 2000	GL 2006	IAI 2003	IAI 2006	GPG 2000	GL 2006
CWPB	0.14	0.143	0.14	0.143	0.018	0.0173	0.018	0.0173
PFPB	-	-	-	-	-	-	-	-
SWPB	0.29	0.272	0.29	0.272	0.029	0.0685	0.029	0.0685
VSS	0.067	0.092	0.068	0.092	0.003	0.0049	0.003	0.0049
HSS	0.18	0.099	0.18	0.099	0.018	0.0084	0.018	0.0084

Worthy of remark is that, lacking specific plant data, IAI 2003 is the only document including emission factors for Point Fed Prebake technology, which is the technology implemented at the only remaining production site since 1990. Moreover, as reported in this document, IAI proposed lowest accuracy default method departs from the IPCC default method. In the IPCC default method a single specific emission value is specified for each of four reduction technology categories: Center Work Prebake, Side Work Prebake, Vertical Stud Søderberg and Horizontal Stud Søderberg. The IPCC expert working panel mostly based these default factors on 1990 average IAI anode effect data and the average technology specific slope factors. IAI survey data collected since the publication of the original IPCC default values shows substantial reductions over the period 1990 to 2000 in specific emissions in all technology categories. In addition it has been shown that among the overall category of Center Work Prebake cells, the more modern Point Fed Prebake cells have made progress at a faster rate than for the older bar broken Center Work Prebake cells. Thus the original category has been broken into two separate types.

This is one of the most important reasons that convinced Italy to use IAI 2003 default emission factors over the period 1990-1999, as indicated also by ALCOA, instead of IPCC Good Practice Guidance default emission factors. As reported in a recent publication supplied by ECOFYS (ECOFYS, 2009), currently all new aluminium plants are designed according to Point Fed Prebake technology and the first improvement in the primary aluminium industry advancement is to replace current technologies with PFPB. Other technologies, Vertical Stud Søderberg, Center Work Prebake and Side Work Prebake are expected to be gradually replaced by PFPB. Only 20% of the existing plants had not yet been upgraded to PFPB in EU27. Moreover, the mean implied emission factor value for CF₄ over the period 2000-2009 is 0.12 (kg/t), comprised between 0.3 and 0.1 kg/t indicated in IAI 2003 for PFPB technology (see Table 4.6).

Figures 4.2 and 4.3 report the comparison in CF₄ emissions time series following Tier 1 and Tier 1 + Tier 2: in each diagram the emissions time series out of different source for EFs are compared.

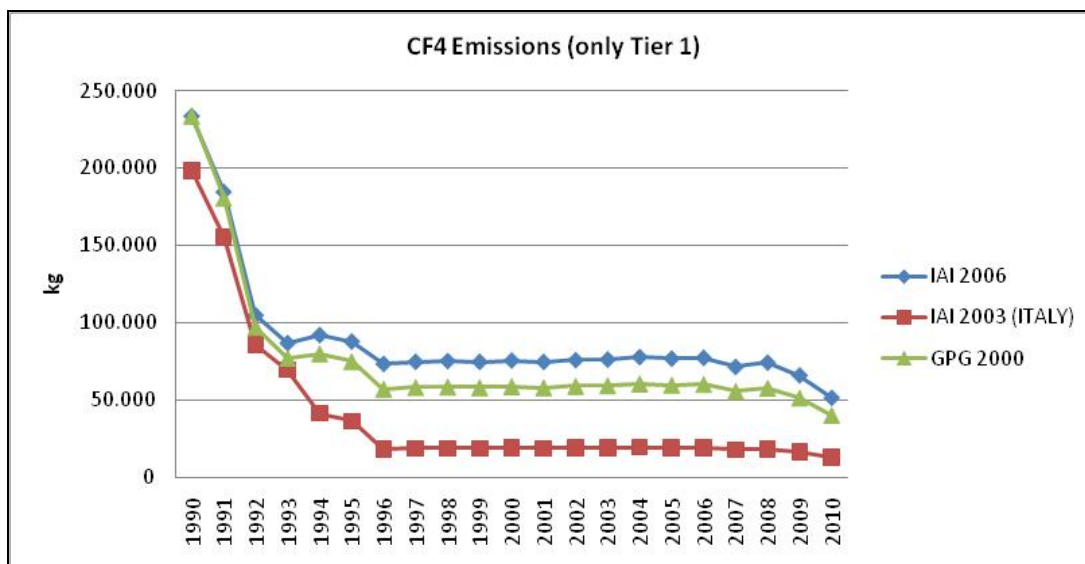


Figure 4.2 CF₄ emissions (only Tier 1)

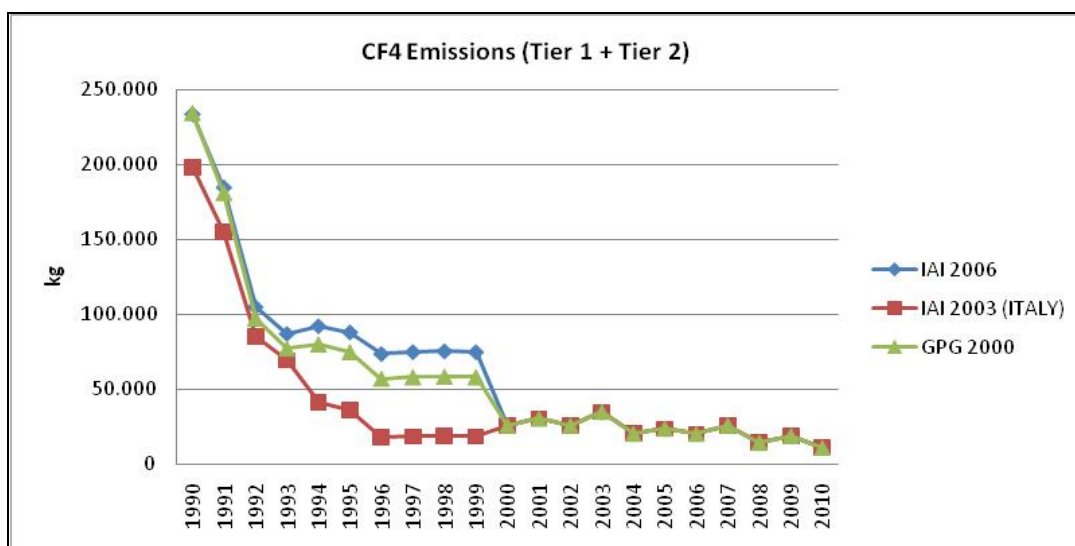


Figure 4.3 CF₄ emissions (Tier 1+Tier 2)

As for consistency, the Tier 1 + Tier 2 approach in estimating emissions is more reliable in producing the time series because it allows to use site specific data provided by the operator from 2000 onwards (and the use of the best available data is a good practice). Moreover, emission factor values reported in the IPCC Good Practice Guidance or in the 2006 IAI document (mean implied emission factor is 0.12 kg/t) lead to higher values for the emissions time series than those calculated out of emission factor values in 2003 IAI document (0.08 kg/t supplied by ALCOA and used by the Party), which means that national estimates can be considered conservative for the period. So for 1990 the use of EFs from IAI 2003, red line, results in CF₄ emission levels lower than those estimated by using the other EF references. This comparison was already done during the compilation of the 2006 submission and the Initial Report, which resulted in the establishment of the assigned amount.

Tier1 (1990-1999) and Tier 2 (2000-2009) time series are also better linked using IAI 2003 EFs (see Figure 4.3) because of the minor gap from 1999 to 2000 since the mean implied emission factor value for CF₄ over the period 2000-2009 is 0.12 (kg/t), comprised between 0.3 and 0.1 kg/t indicated in IAI 2003 for PFPB technology (see Table 4.6).

For this reason, the use of the combined Tier1+Tier2 approach, in this case, is conservative.

4.4.4 Source-specific QA/QC and verification

Emissions from the sector 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. Moreover, emissions from magnesium foundries are annually compared with those reported in the national EPER/E-PRTR registry while for the iron and steel sector emissions reported in the national EPER/E-PRTR registry and for the Emissions Trading Scheme are compared and checked. Emissions from primary aluminium production have been also checked with data reported under EU-ETS.

4.4.5 Source-specific recalculations

No recalculations occurred.

4.4.6 Source-specific planned improvements

The average emission factor of CO₂ from electric arc furnaces and from ferroalloys production will be checked with ETS data communicated in next years.

4.5 Other production (2D)

4.5.1 Source category description

Only indirect gases and SO₂ 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. CO₂ from food and drink production (e.g. CO₂ added to water or beverages) can be of biogenic or non-biogenic origin but only information on CO₂ emissions of non-biogenic origin should be reported in the CRF.

According to the information provided by industrial associations, CO₂ emissions do not occur, but only NMVOC emissions originate from these activities.

CO₂ emissions from food and beverages do not occur 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 SO₂ are estimated. NO_x and SO_x emissions have been referred to the paper and pulp production from acid sulphite and neutral sulphite semichemical processes up to 2009, activity data and emissions were provided by the two Italian production plants: in 2008 the bleached sulphite pulp production has stopped while in 2009 the neutral sulphite semi-chemical pulp process has closed (reconversion of the plant is currently under negotiation). NMVOC emissions are related to chipboard production and have been estimated and reported also for 2011.

4.6 Production of halocarbons and SF₆ (2E)

4.6.1 Source category description

The sub-sector production of halocarbons and SF₆ consists of two sources, “By-product emissions” and “Fugitive emissions”, identified as non-key sources. The production of halocarbons and SF₆ took place in two facilities in Italy up to 2008 (Spinetta Marengo and Porto Marghera). Since the very beginning of 2005 the plant in Spinetta Marengo has not been producing SF₆ any longer. In the first quarter of 2008 the production plant at Porto Marghera has stopped its activity, since then there is only one facility in Italy where halocarbons productions have been carried out.

Within by-product emissions, HFC23 emissions are released from HCFC22 manufacture, CF₄ emissions are released from SF₆ and HCFC22/TFM productions, whereas C₂F₆ and HFC143a emissions are released from the production of C₃F₆ (and also CFC115) and HFC134a, respectively. Production of CFC115 was carried out only in one facility and stopped in 1998. Since the very beginning of 2005 Spinetta Marengo plant has not been producing SF₆ any longer.

Production of HFC125, HFC134a, HFC227ea and SF₆ lead to fugitive emissions of the same gases. In particular, production of HFC227ea only occurred in 1999.

A focus on by-product emissions from this sector has led to revise emission estimates for the whole time series. The share of F-gas emissions from the production of halocarbons and SF₆ in the national total of F-gases was 40.5% in the base-year (1990), was 13.8% in 2008 and 11.34% in 2011. The share in the national total greenhouse gas emissions was 0.25% in the base-year, 0.24% in 2008 and 0.26% in 2011.

4.6.2 Methodological issues

For both source categories "By-product emissions" and "Fugitive emissions", the IPCC Tier 2 method is used, based on plant-level data. The communication is supplied annually by the only national producer, and includes productions, emissions, import and export data for each gas (Solvay, several years). In particular, the operator of the only producing facility has been reporting CF₄ emissions to the national PRTR register for four years since 2007; in the Revised 1996 IPCC Guidelines and in the IPCC Good Practice Guidance, no methodology is reported. CF₄ emissions represent additional by product emissions together with HFC23 emissions (those being well referenced instead). The operator supplied all the relevant information for a better understanding of the activities taking place at the site of Spinetta Marengo and to help the inventory team to allocate CF₄ emissions from HCFC22 production properly. In particular the operator explained that HCFC22 production has been carried out in Spinetta Marengo since '50s and up to 1990 part of HCFC22 was probably also sold as a marketable product. Since 1990 practically all the HCFC22 produced has been the input for the TFM (tetrafluoroethylene monomer) production process (by pyrolysis of HCFC22 at 600 °C), the TFM has been then used to produce TFE (tetrafluoroethylene, C₂F₄) and PTFE (polytetrafluoroethylene), HFP (hexafluoropropylene) and the other different fluoropolymers and fluoroelastomers. All the fluorinated flue gases from the different production lines are collected and treated in a centralized abatement unit (thermal oxidation system). The abatement unit is run continuously and allows reducing F-gas emissions not depending on the operating level of the main production process. In the treated flue gases CF₄ is still present (65% of CF₄ released to air pass through the abatement system untreated for thermodynamic reasons; 35% of CF₄ released to air is formed during the reactions occurring in the abatement unit). Estimations of CF₄ emissions released to air have been then reported to the national PRTR since 2007. The operator has provided the time series for the activity data from 2002 to 2010 (HCFC22 and TFM), since the activity data for the years before 2002 are not retrievable (the property of the facility has changed over the years before 2002 and the administrative systems and softwares have also been changed many times); in order to complete the activity data time series for the period 1990-2001 a linear increasing production level was assumed from 1990 to 2002. The ratio relating TFM production to HCFC22 production in 2002 has been taken also over the years 2001 back to 1990 to estimate the TFM productions. CF₄ emission factor for 2007 was set constant in order to estimate the CF₄ time series over the years from 1990 to 2006. CF₄ emissions time series have been then included in the estimates under the CRF category 2E1 (By-product emissions).

In order to provide detailed information on the methodology applied for this category, CF₄ emissions estimation from HCFC22 can be summarised as follows:

- 1) For the years 2007-2010 by-product CF₄ emissions from HCFC22 production has been supplied by the operator (through the national PRTR). Based on data reported to the national PRTR since 2007 and the activity data concerning HCFC production, the TFM/HCFC22 ratio along the timeseries, the EF for by-product CF₄ emission has been calculated.
- 2) CF₄ EF (by-product emissions from HCFC22 production) for 2007 has been set as default value for the period 1990-2006 in order to estimate by-product CF₄ emissions consistently along the whole time series.
- 3) Activity data for the facilities are available for the years 2002-2010, so the missing activity data were estimated based on the HCFC22 production capacity of the facility in 1990 and 2002 HCFC22 production figure assuming a linear increasing production level within the years. The

TFM/HCFC22 ratio for 2002 was assumed as a default ratio to estimate TFM production consistently from 1990 and 2002.

- 4) By product CF₄ emissions were estimated by applying the EF derived in point 2) to the TFM production levels along the years 1990-2002.

HFC23 is a by product of the HCFC22 production process, the HFC23/HCFC22 rate is about 3%. The abatement system, as previously mentioned, allows for treating all the fluorinated flue gases, vented gases originated in the processes at the facility before being released to air. Since 1989 the abatement system has allowed to reduce HFC23 released to air, up to 1996 HFC23 emissions had been about 30 t/y. In 1996 the abatement system was improved with a second operating unit, since 1996 the abatement rate has been 99.99% thus reducing drastically HFC23 emissions to zero. HFC23 emissions are included in the estimates under CRF category 2E1 (By-product emissions; Solvay Solexis, 2011).

4.6.3 Uncertainty and time-series consistency

The uncertainty in F-gas emissions from production of halocarbons and SF₆ is estimated to be about 11% in annual emissions.

HFC23 emissions from HCFC22 had been drastically reduced since 1996 due to the installation of a second thermal oxidation system in the facility located in Spinetta Marengo (the only facility currently producing HCFC22 in Italy). 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 oxidation system, thus allowing reduction of emissions to zero. CF₄ by-product emissions in HCFC22 production process have been fully investigated, information supplied by the operator has allowed estimating emissions for the whole time series.

This information about productions and emissions is yearly directly updated by the producer, and it is also reported in the framework of the national PRTR register, confirming that the technology is fully operating.

PFC (C₂F₆) by-product emissions and SF₆ fugitive emissions were constant from 1990 to 1995 (4 t/y for C₂F₆ emissions; 5 t/y for SF₆ emissions) and from 1996 to 1998 (1 t/y for C₂F₆ emissions; 2 t/y for SF₆ emissions) and have eventually reduced to zero since 1999 due to the stop of the CFC115 production in one facility and the upgrade of the thermal oxidation system mentioned above in the other facility. Besides, SF₆ production has stopped since the 1st of January 2005.

Regarding fugitive emissions, emissions of HFC125 and HFC134a have been cut in 1999 thanks to a rationalisation in the new production facility located in Porto Marghera, whereas HFC143 released as by-products from the production of HFC134a has been recovered and commercialised. The relevant productions in Italy which originate these fugitive emissions stopped in the first quarter of 2008.

In Table 4.15 an overview of the emissions from production of halocarbons and SF₆ is given for the 1990-2011 period, per compound.

Table 4.15 Actual emissions of F-gases per compound from production of halocarbons and SF₆ in Gg CO₂ equivalent, 1990 – 2011

COMPOUND	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Gg CO₂ eq.										
HFC 23	351.0	351.0	-	-	-	-	-	-	-	-
HFC 143a	-	22.8	3.8	4.2	4.6	4.6	-	-	-	-
CF ₄	776.6	873.1	872.1	1,361.1	1,429.9	1,365.0	1,300.0	845.0	1,144.0	1,266
PFC C2÷C3 (C ₂ F ₆)	36.8	36.8	-	-	-	-	-	-	-	-
<i>Total F-gas by product emissions</i>	<i>1,164</i>	<i>1,284</i>	<i>876</i>	<i>1,365</i>	<i>1,434</i>	<i>1,370</i>	<i>1,300</i>	<i>845</i>	<i>1,144</i>	<i>1,266</i>
HFC 125	-	28.0	2.8	3.4	3.9	5.0	0.01	-	-	-
HFC 134a	-	39.0	15.6	12.6	12.4	8.8	-	-	-	-
HFC 227ea	-	-	-	-	-	-	-	-	-	-
SF ₆	119.5	119.5	-	-	-	-	-	-	-	-
<i>Total F-gas fugitive emissions</i>	<i>119.5</i>	<i>186.5</i>	<i>18.4</i>	<i>16.0</i>	<i>16.3</i>	<i>13.9</i>	<i>0.01</i>	<i>-</i>	<i>-</i>	<i>-</i>
Total F-gas emissions from production of halocarbons and	1,284	1,470	894	1,381	1,451	1,383	1,300	845	1,144	1,266

COMPOUND	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Gg CO ₂ eq.										
SF ₆										

4.6.4 Source-specific QA/QC and verification

Emissions from production of halocarbons and SF₆ have been checked with data reported to the national EPER/E-PRTR registry. Additional CF₄ emissions have been then accounted for along the whole time series for category 2E.

4.6.5 Source-specific recalculations

No recalculations occurred for this source.

4.6.6 Source-specific planned improvements

No further improvements are planned.

4.7 Consumption of halocarbons and SF₆ (2F)

4.7.1 Source category description

The sub-sector consumption of halocarbons and SF₆ consists of three sources, “HFC, PFC emissions from ODS substitutes”, key category at level and trend assessment, both Tier 1 and 2 approaches, “PFC, HFC, SF₆ emissions from semiconductor manufacturing”, “SF₆ emissions from electrical equipment”, that are non-key categories.

Potential emissions are also reported in this section.

The share of F-gas emissions from the consumption of halocarbons and SF₆ in the national total of F-gases was 6.73% in the base-year 1990, 89.6% in 2009 and 87.44% in 2011; the share in the national total greenhouse gas emissions was 0.04% in the base-year, 176% in 2009 and 2.00% in 2011.

4.7.2 Methodological issues

The methods used to calculate F-gas emissions from the consumption of halocarbons and SF₆ 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 2a

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); for the other air conditioning equipment the producers supply detailed table of consumption data by gas (Solvay, 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; Numonyx, several years); finally, for the sub-source fire extinguishers, the European Association for Responsible Use of HFCs in Fire Fighting was contacted (ASSURE, 2005).

Losses rates have been checked with industry and they are distinguished by domestic equipment, small and large commercial equipment, industrial chillers, mobile air conditioning equipment, foaming, aerosols and fire extinguishers.

Refrigeration activities, such as commercial, transport, industrial and other stationary, are all reported under domestic refrigeration because no detailed information is available to split consumptions and emissions in the different sectors. Anyway, appropriate losses rates have been applied for each gas, taking into account the equipment where refrigerants are generally used. Therefore implied product life factors, especially for HFC134a, result from the weighted average of different losses rates, from 0.7% for domestic refrigeration to 10% for large chillers.

In general, concerning the air-conditioning and refrigeration sector, the emissions from equipment disposal have been included into the emissions during the product's life for the whole time series.

As regard SF₆ emissions from electrical equipment, these have been estimated according to the IPCC Tier 2a approach. Concerning manufacturing and installation emissions, since 1995 the methodology used is largely in accordance with the IPCC Tier 3b methodology. In response to the 2012 review process (UNFCCC, 2012) detailed information are provided in order to increase the transparency and demonstrate the consistency of the time series. In 1997, the ANIE Federation has began a statistical survey within their associated companies, in accordance with ISPRA, in order to monitorate yearly SF₆ used in electrical equipment > 1kV, and thus SF₆ manufacturing emissions (ANIE, 2001). ANIE Federation is the Confindustria member representing the electrotechnical and electronic companies operating in Italy. ANIE has developed data sheets for their associated companies in accordance with the methodology drawn up by CAPIEL, the Coordinating Committee for the Associations of Manufacturers of Switchgear and Controlgear equipments in the European Union: the CAPIEL inventory methodology covers all sorts of use of SF₆ in the electrical sector, from the SF₆ purchase till the end of life of the equipment and covers all aspects of the required data (CAPIEL, 2002). It is based on a Mass Balance Methodology, as given by IPCC Tier 3b, comparing the input and output on a yearly basis. In the Figure 4.4 the summary sheet used for manufacturing inventory, referred to the year 2011, is reported (ANIE, several years).

VOCI DELL'INVENTARIO/Inventory's categories		OGGETTO DEL RILEVAMENTO / observed feature		year 2011 (tonnes)
1. ACQUISTATA / purchased amount	1.1 In Italia / in Italy	Peso del gas contenuto nelle bombole / Weight of SF6 contained in the tanks		29,274
	1.2 All'Estero / abroad	Peso del gas contenuto nelle bombole / Weight of SF6 contained in the tanks		114,204
			TOTALE 1.	143,478
2. CONTENUTA NEGLI APPARECCHI VENDUTI ALLA PRESSIONE DI SPEDIZIONE E NELLE RELATIVE BOMBOLE A CORREDO / amount contained in the equipment at the terms of sale	2.1 In Italia / in Italy	2.1.1 ENEL		23,408
		2.1.2 Società elettriche e Ferrovie		25,534
		2.1.3 Altri (Industria, Terziario, Privati, ecc.)		20,573
	2.2 All'Estero / abroad	Peso del gas contenuto negli apparecchi e nelle bombole a corredo / Weight of SF6 contained in the equipments and in the tanks		62,135
			TOTALE 2.	131,650
3. CONTENUTA NEGLI APPARECCHI E NELLE BOMBOLE DI RITORNO IN FABBRICA / amount contained in the equipment returned to the manufacturer		Peso del gas contenuto negli apparecchi e nelle bombole a corredo / Weight of SF6 contained in the equipments and in the tanks	TOTALE 3.	2,176
4. a) DISTRUTTA /destroyed amount		Peso del gas inviato a ditta autorizzata alla distruzione / Weight of SF6 in the equipments sent to authorized disposal treatment		5,613
4. b) RESTITUITA AL PRODUTTORE / amount returned to the manufacturer		Peso del gas ritornato al produttore per il riciclaggio / Weight of SF6 returned to manufacturer for authorized recycling		2,255
			TOTALE 4.	7,868
5. VARIAZIONE ANNUALE DELLA QUANTITA' A MAGAZZINO / annual stock changes			TOTALE 5.	4,582
EMISSIONE DI GAS SF6 IN FABBRICA SU BASE ANNUA / SF6 emissions from manufacturing	DIFFERENZA ENTRATA / USCITA : (1+3-5) - (2+4) / Balance input-output (1+3-5)-(2+4)			1,554

Figure 4.4 SF₆ inventory at manufacturing level (ANIE, reporting year 2011)

From 1990 to 1994 emissions have been estimated on the basis of leakage rate during manufacturing and installation and the amount of SF₆ contained in the equipments sold to the end users, because, for this period, only data referred to point 1 and point 2 of the Figure 4.4, are available from ANIE. The loss rates during manufacturing and installation of the equipments, used to estimate the SF₆ emissions, are reported in the Table 4.16. Leakage rates have been derived from ANIE Federation expert judgement.

Table 4.16 Leakage rates used to estimate SF₆ emissions from manufacturing and installation from 1990 to 1994

	1990	1991	1992	1993	1994
Manufacturing	0.060	0.060	0.060	0.060	0.060
Installation	0.060	0.055	0.050	0.045	0.040

In Table 4.17, SF₆ emissions from manufacturing (which include installation), use and disposal are reported. Emissions from manufacturing were about 14 tons in 1995, whereas in 2011 are only 1.55 tons, starting from 110 tons of SF₆ purchased in 1995 and on the other hand 144 tons of SF₆ purchased in 2011. Emissions trend from manufacturing is strongly decreasing thanks to the diligence of the companies involved, which have taken voluntary actions to reduce emissions as much as technically possible. Probable fluctuations within the time series in manufacturing emissions are basically due to yearly variation of the stocked quantity of SF₆.

Table 4.17 SF₆ Emissions from Electrical Equipments 1990-2011

SF ₆ EMISSIONS	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	tons									
Manufacturing	8.470	14.657	5.637	3.562	3.235	3.413	3.478	2.254	3.185	1.554
Use	0.460	4.886	6.469	9.592	9.220	10.309	12.124	13.071	10.302	10.865
Disposal	0.000	0.623	0.464	0.199	0.018	0.395	0.870	0.032	0.059	0.065

SF₆ EMISSIONS	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Total	8.930	20.165	12.571	13.353	12.473	14.117	16.471	15.357	13.546	12.484

SF₆ use emissions are those from Closed Pressure Systems, including high voltage equipment that requires refilling with gas during its lifetime. Equipment use emissions are estimated by multiplying the quantity of SF₆ yearly accumulated by a use emission factor. The quantity of SF₆ accumulated is estimated using SF₆ annual sales activity data (ANIE, several years), multiplied for the factor 0.8, which take into account the percentage of the total sales referred to Closed Pressure Systems. Moreover, equipment use emissions are the sum of three components:

- emissions from ENEL (the former electricity monopoly);
- emissions from electricity utilities and the national railways company;
- emissions from industries and other private operators.

Since 1994, refilling data of SF₆ used in high voltage gas-insulated transmission lines have been supplied by the main energy distribution companies (in the past included in ENEL) checked with data reported under the national PRTR register (EDIPOWER, several years; ENDESA, 2004; ENDESA, several years [a] and [b]; ENEL, several years; TERNA, several years).

The leakage rate used to estimate the SF₆ use emissions is assumed equal to 0.01 from 1990 to 2009 and 0.005 from 2010, based on national expert judgment (AIET, 2007).

Finally, SF₆ disposal emissions from electrical equipments are estimated by multiplying the quantity of SF₆ contained in retired equipments by the fraction of SF₆ left in the equipment at the end of its life, assumed to be constant and equal to 0.15 from 1990 to 1995, and linearly decreasing until to 2010 value 0.03, as reported in Table 4.18. Since 1995, activity data (point 3 of the Figure 4.4) are directly supplied by ANIE (ANIE, several years), whereas from 1990 to 1994 the total amount of SF₆ accumulated in the equipments is multiplied by a disposal rate which is equal to zero in that period. Leakage disposal rate and disposal rate derived from personal communication.

Table 4.18 Disposal rates and leakage rate at disposal used to estimate SF₆ emissions from disposal, 1990-2011

	1990	1991	1992	1993	1994	1995	2000	2005	2010	2011
Disposal rate	0	0	0	0	0	0	0.01	0.02	0.03	0.03
Leakage rate at disposal	0.15	0.15	0.15	0.15	0.15	0.15	0.11	0.07	0.03	0.03

As for fluctuation in emissions within the years, Figure 4.5 is reported for a better understanding.

As regard the years from 1995 to 2000, please consider that the total SF₆ emission values result by the sum of emissions from “manufacturing”, “operating” and “retiring” and that concerning the trends of these contributions the following facts should be pointed out:

- 1) emissions from manufacturing reach a peak in 1997;
- 2) emissions from operating reach a peak in 1997;
- 3) emissions from retiring reach a peak in 1997 although the relevant contributions to total SF₆ emissions are those from manufacturing and operating.

Data between 1995 and 2000 are consistent and come from the SF₆ mass balance.

In Figure 4.5 the time series for SF₆ purchased amounts and of the three contributions to SF₆ emissions from electrical equipments are illustrated.

It could be noted that the trend of the amounts of SF₆ estimated for “manufacturing” is driven by the trend of purchased SF₆.

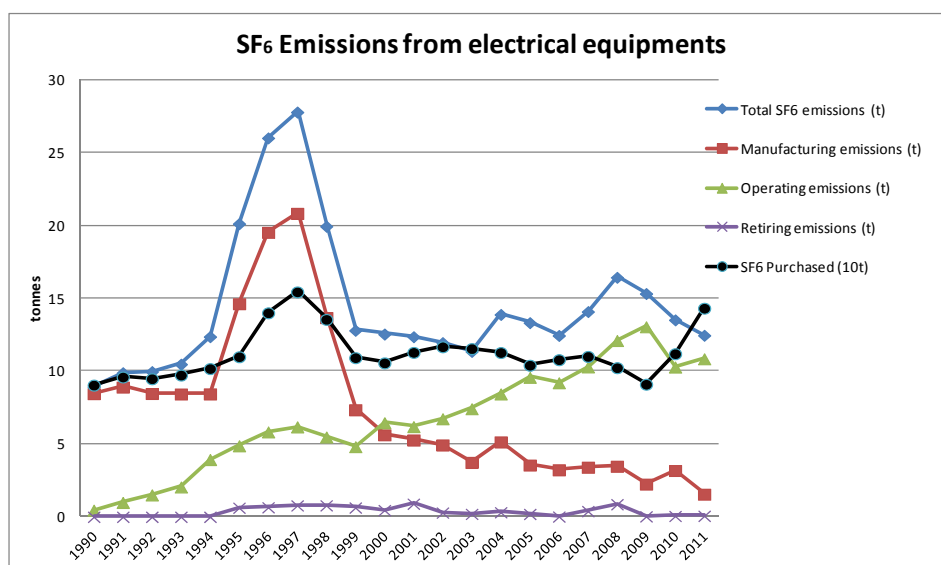


Figure 4.5 Time series for SF₆ purchased amounts and emissions from electrical equipments

Finally, 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, Numonyx, several years). Since 2007, in compliance with article 6 of the fluorinated gases European regulation (EC, 2006), producers, importers and exporters have communicated to the Ministry of the Environment and to the Commission the required data; unfortunately, only few companies (6 for 2007, 9 for 2008, 8 for 2009, 10 for 2010 and 12 for 2011) have reported data and we expect that more information will be available in the next years (Euro Gardian srl, several years; Green Chemicals srl, several years; General Gas, several years; Mariel, several years; Safety Hi Tech, several years; Solvay Fluor Italia, several years; Tazzetti, several years; Sinteco, several years; Synthesis Chimica, several years; Trench Italia, several years; Coferc, 2008; Wilhelmsen Ships Service spa, several years; Alstom Grid, 2011; Sirap Insulation srl, 2011). For the above mentioned companies data available since 2007 related to import, export and blends have been considered to revise the potential emissions time series since 2007. As regard PFC potential emissions, since no production occurs in Italy, export has been assumed as not occurring, whereas import corresponds to consumption of PFCs by semiconductor manufacturers that use these substances.

4.7.3 Uncertainty and time-series consistency

The combined uncertainty in F-gas emissions for HFC, PFC emissions from ozone depletion substances (ODS) substitutes and PFC, HFC, SF₆ 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 SF₆ emissions from electrical equipment is estimated to be about 11% in annual emissions, 5% and 10% concerning respectively activity data and emission factors.

In Table 4.19 an overview of the emissions from consumption of halocarbons and SF₆ is given for the 1990-2011 period, per compound.

HFC emissions from refrigeration and air conditioning equipment increased from 1994 driven by the increase of their consumptions, especially HFC134a consumption for mobile air conditioning. HFC emissions from ODS substitutes started in 1996 and they have been increasing since then, especially HFC134a from foam blowing and aerosols. Emissions from semiconductor manufacturing are driven by the consumption data provided by the producers, three companies are currently operating in Italy: ST Microelectronics (since 1995); Micron (since 1998) and Numonyx (since 2008). SF₆ emissions from electrical equipment increased from 1995 to 1997 and decreased in the following years; from 2004 emissions are enough stable: they are driven by emissions from manufacturing due to the amount of fluid filled in the new manufacturing products while emissions from stocks are slightly increasing.

Table 4.19 Actual F-gas emissions per compound from the consumption of halocarbons and SF₆ in Gg CO₂ equivalent. 1990-2011

COMPOUND	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Gg CO₂ eq.										
HFC 23	0.0	1.6	7.1	17.0	19.2	20.8	22.7	24.6	26.0	27.6
HFC 32	0.0	0.0	52.6	235.3	276.5	316.7	355.1	391.8	428.2	464.5
HFC 125	0.0	1.8	371.5	1,643.2	1,932.3	2,215.3	2,488.5	2,752.8	3,014.2	3,274
HFC 134a	0.0	224.3	1,128.6	1,888.8	2,056.4	2,209.0	2,329.8	2,432.8	2,528.4	2,609.4
HFC 143a	0.0	2.7	206.3	901.5	1,062.0	1,220.7	1,377.9	1,533.7	1,688.4	1,842.4
<i>Total HFC emissions from refrigeration and air conditioning equipment</i>	<i>0.0</i>	<i>230.5</i>	<i>1,766.1</i>	<i>4,685.7</i>	<i>5,346.4</i>	<i>5,982.6</i>	<i>6,574.1</i>	<i>7,135.63</i>	<i>7,685.1</i>	<i>8,217.9</i>
HFC 134a emissions from foam blowing	0.0	0.0	64.2	234.1	247.4	259.0	268.9	277.2	278.0	277.3
HFC 245fa emissions from foam blowing	0.0	0.0	0.0	133.5	150.0	166.6	183.4	200.4	217.7	235.2
HFC 227ea emissions from fire extinguishers	0.0	0.0	19.6	79.9	97.7	114.6	130.6	145.8	160.3	174.0
HFC 134a emissions from aerosols/metered dose inhalers	0.0	0.0	108.4	240.2	237.3	307.7	341.1	397.7	393.4	389.3
<i>Total HFC emissions from ODS substitutes</i>	<i>0.0</i>	<i>0.0</i>	<i>192.2</i>	<i>687.7</i>	<i>732.4</i>	<i>847.9</i>	<i>923.9</i>	<i>1,021.1</i>	<i>1,049.3</i>	<i>1,075.8</i>
HFC 23	0.0	0.0	5.1	7.0	6.5	5.4	8.4	5.6	8.5	8.4
HFC 134a	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CF ₄	0.0	24.4	64.8	96.8	87.0	71.5	59.4	42.6	58.5	64.5
C ₂ F ₆	0.0	34.6	82.0	62.8	30.8	11.4	12.9	11.3	20.7	23.2
C ₃ F ₈	0.0	0.0	0.0	3.5	3.5	0.1	0.1	0.0	0.0	0.1
C ₄ F ₈	0.0	0.0	0.4	8.7	6.6	4.6	17.4	18.3	22.4	19.7
SF ₆	0.0	0.0	20.9	61.5	46.5	36.3	31.4	21.8	32.1	53.0
<i>Total PFC. HFC. SF₆ emissions from semiconductor manufacturing</i>	<i>0.0</i>	<i>59.0</i>	<i>173.2</i>	<i>240.4</i>	<i>181.0</i>	<i>129.4</i>	<i>129.6</i>	<i>99.6</i>	<i>142.2</i>	<i>169.0</i>
<i>SF₆ emissions from electrical equipment</i>	<i>213.4</i>	<i>482.0</i>	<i>300.4</i>	<i>319.1</i>	<i>298.1</i>	<i>337.4</i>	<i>393.7</i>	<i>367.0</i>	<i>323.8</i>	<i>298.4</i>
Total F-gas emissions from consumption of halocarbons and SF₆	213.4	771.4	2,432.0	5,932.9	6,557.9	7,297.2	8,021.2	8,623.4	9,200.4	9,761.0

In Table 4.20 an overview of the potential emissions is given for the 1990-2011 period, per compound. In some years import data for HFC compounds are equal to zero while exports are greater than production data because of stocks availability thus leading to negative values for HFC compounds: in fact, the formula suggested by the UNFCCC guidelines to calculate potential emissions does not consider stock variations.

Table 4.20 Potential F-gas emissions per compound from the consumption of halocarbons and SF₆ in Gg CO₂ equivalent. 1990 – 2011

COMPOUND	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Gg CO₂ eq.										
HFC 32	0.0	0.0	10.4	31.9	129.4	115.4	174.9	98.7	224.3	74.7
HFC 125	0.0	148.4	268.8	1,131.2	1,456.0	4268.7	-1,610.4	1,661.6	1,462.3	234.3
HFC 134a	0.0	1,739.4	2,107.3	5,575.7	6,026.8	6,004.4	1,735.1	2,293.4	1,237.7	2,070.3
HFC 143a	0.0	11.4	68.4	801.8	1,691.0	905.9	2,177.4	1,586.4	1,428.9	-9.5
HFC 152a	0.0	0.0	0.0	0.0	0.0	163.0	237.0	131.4	141.2	241.1
HFC 227ea	0.0	0.0	72.5	0.0	0.0	34,486.8	58.0	88.0	-1,119.9	7.5
HFC 245fa	0.0	0.0	0.0	760.0	790.4	822.0	854.9	889.1	924.7	961.6
<i>Total HFC potential emissions</i>	<i>0.0</i>	<i>1,899.2</i>	<i>2,527.4</i>	<i>8,300.6</i>	<i>10,093.6</i>	<i>46,766.2</i>	<i>3,626.8</i>	<i>6,748.5</i>	<i>4,299.2</i>	<i>3,580.1</i>
CF ₄	0.0	0.0	55.8	148.9	159.9	141.3	112.3	83.3	123.9	128.7
C ₂ F ₆	0.0	0.0	65.5	111.4	67.8	54.9	67.0	65.7	103.1	111.7
C ₃ F ₈	0.0	0.0	0.0	17.9	17.9	1.5	1.5	0.6	0.6	1.5
C ₄ F ₈	0.0	0.0	0.5	29.0	28.8	53.5	59.2	58.7	69.6	95.3
<i>Total PFC potential emissions</i>	<i>0.0</i>	<i>0.0</i>	<i>121.8</i>	<i>307.2</i>	<i>274.4</i>	<i>251.2</i>	<i>239.9</i>	<i>208.3</i>	<i>297.2</i>	<i>337.2</i>
SF ₆	3,752.3	3,675.8	3,919.6	1,541.8	2,182.9	1,985.9	1,881.6	2,160.1	2,666.8	3,166.8
Total F-gas potential emissions	3,752.3	5,575.0	6,568.8	10,149.6	12,550.9	49,003.2	5,748.2	9,116.8	7,263.1	7,084.1

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 and consumption of halocarbons and SF₆ have been checked with data reported to the national EPER/E-PRTR registry.

4.7.5 Source-specific recalculations

Minor recalculations occurred for 2010 HFC134a emission estimation from refrigeration and air conditioning equipment (-0.4%).

Recalculations have occurred in Potential emissions time series since 2007 resulting in the changes reported in the following Table 4.21, per compound: available data (reported by operators under the fluorinated gas European Regulation) related to import, export and blends have been considered.

Table 4.21 Recalculations in potential F-gas emissions per compound in percentage since 2007

COMPOUND	2007	2008	2009	2010
HFC 32	-	-	-	-
HFC 125	-	-	-	-
HFC 134a	-	-	-	-
HFC 143a	-	-	-	-
HFC 152a	-	-	-	-
HFC 227ea	-	-	-	-
HFC 245fa	-	-	-	-
CF ₄	-	-	-	-
C ₂ F ₆	-	-	-	-
C ₃ F ₈	-	-	-	-
C ₄ F ₈	-	-	-	-
SF ₆	-	-	0.42	1.29

4.7.6 *Source-specific planned improvements*

Further investigation is planned on account of the implementation of the European Regulation on these gases.

5 SOLVENT AND OTHER PRODUCT USE [CRF sector 3]

5.1 Sector overview

In this sector all non-combustion emissions from other industrial sectors than the manufacturing and energy industry are reported. The indirect CO₂ 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, are estimated.

N₂O emissions are also estimated. These emissions arise from the use of N₂O in medical applications, such as anaesthesia, and in the food industry, where N₂O is used as a propelling agent in aerosol cans, specifically those for whipped cream. Emissions from the use of N₂O in explosives are also included.

In 2011, solvent use is responsible for about 0.3% of the total CO₂ emissions (excluding LULUCF) and 40.7% of total NMVOC emissions, and represents the main source of anthropogenic NMVOC national emissions. N₂O emissions, in 2011, share 2.1% of the total N₂O national emissions.

The sector is responsible, in 2011, for about 0.3% of the total CO₂ equivalent emissions (excluding LULUCF).

Table 5.1 Trend in NMVOC, CO₂ and N₂O emissions from the solvent use sector, 1990 – 2011 (Gg)

GAS/SUBSOURCE	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
NMVOC (Gg)										
3A. Paint application	270.67	252.49	226.00	214.13	215.90	211.96	200.85	189.78	156.37	174.43
3B. Degreasing and dry cleaning	56.66	34.12	26.40	23.10	22.50	21.92	21.36	20.81	20.28	19.76
3C. Chemical products	77.25	85.98	82.67	60.45	63.86	64.35	61.06	59.25	59.94	59.91
3D. Other	199.59	182.84	156.60	179.65	184.24	179.03	171.27	156.98	160.30	152.15
CO₂ (Gg)										
3A. Paint application	843.66	787.02	704.45	667.44	672.97	660.69	626.05	591.53	487.41	543.68
3B. Degreasing and dry cleaning	176.62	106.34	82.27	72.01	70.14	68.33	66.56	64.86	63.20	61.59
3D. Other	622.12	569.92	488.12	559.96	574.28	558.02	533.84	489.32	499.66	474.26
N₂O (Gg)										
3D. Other (use of N ₂ O for anaesthesia, aerosol cans and explosives)	2.62	2.49	3.31	2.66	2.61	2.54	2.35	2.21	2.02	1.86

CO₂ emissions from the sector are a key category, in 2011, for trend assessment calculated with Approach 2, because of the high level of uncertainty in the estimates and a reduction of emissions in the years. This source is not a key category if including the LULUCF sector in the uncertainty analysis. Results are reported in the following box. As for the base year, these emissions were a key category for the level assessment, according to Approach 2, even when considering the LULUCF sector.

Key-source identification in the solvent and other product use sector with the IPCC Approach 1 and Approach 2 approaches (without LULUCF) for 2011

3	CO ₂	Solvent and other product use	Key (T2)
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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, is considered both as NMVOC and CO₂ 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).

CO₂ emissions are estimated and included in this sector, as they are not already accounted for in the energy and industrial processes sectors.

N₂O emissions from the use of N₂O for anaesthesia, aerosol cans and explosives (3D) are also estimated. Emissions of N₂O from fire extinguishers do not occur.

5.3 Methodological issues

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

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

As regards household and car care products, information on VOC content and activity data has been supplied by the Sectoral Association of the Italian Federation of the Chemical Industry (Assocasa, several years) and by the Italian Association of Aerosol Producers (AIA, several years [a] and [b]). As regards cosmetics and toiletries, basic data have been supplied by the Italian Association of Aerosol Producers too (AIA, several years [a] and [b]) and by the national Institute of Statistics and industrial associations (ISTAT, several years [a], [b], [c] and [d]; UNIPRO, several years); 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 CO₂ emissions has been carried out considering that carbon content is equal to 85% as indicated by the European Environmental Agency for the CORINAIR project (EEA, 1997), except for CO₂ emissions from the 3C sub-sector which are not calculated to avoid double-counting. These emissions are, in fact, already accounted for in sectors 1A2c and 2B.

Emissions of N₂O have been estimated taking into account information available by industrial associations. Specifically, the manufacturers and distributors association of N₂O products has supplied data on the use of N₂O for anaesthesia from 1994 to 2011 (Assogastecnici, several years). 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 N₂O used will eventually be released to the atmosphere, therefore the emission factor for anaesthesia is equal to 1 Mg N₂O/Mg product use, while the emission factor used for aerosol cans is 0.025 Mg N₂O/Mg product use, because the N₂O content in aerosol cans is assumed to be 2.5% on average (Co.Da.P., 2005).

For the estimation of N₂O emissions from explosives, data on the annual consumption of explosives have been obtained by a specific study on the sector (Folchi and Zordan, 2004); as stated in the document, this figure is believed to be constant for all the time series with a variation within a range of 30%. As for the emission factor, the estimated N₂O emissions represent the theoretically maximum emittable amount; in fact, no figures are available on the amount of N₂O emissions actually emitted upon detonations and the value of 3,400 Mg N₂O/Mg explosive use is provided by a German reference (Benndford, 1999) which corresponds to the assumption of 68 g N₂O per kg ammonium nitrate.

N₂O emissions have been calculated multiplying activity data, total quantity of N₂O used for anaesthesia, total aerosol cans and explosives, by the related emission factors.

5.4 Uncertainty and time-series consistency

The combined uncertainty in CO₂ 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 N₂O emissions, the uncertainty is

estimated equal to 51% due to an uncertainty in activity data of N₂O use of 50% and 10% in the emission factor.

The European Directives (EC, 1999; EC, 2004) regarding NMVOC emission reduction in this sector entered into force, in Italy, in January 2004 and in March 2006, establishing a reduction of the solvent content in products. Figure 5.1 shows NMVOC emission trend from 1991 to 2011, by sub-sector, with respect to 1990. The decrease in NMVOC emission levels from 1990 to 2011 is about 32%, mainly to be attributed to the reduction of emissions in paint application, application of glue and adhesives and domestic solvent use; specifically, the reduction of emissions from paint application for domestic use, which drop by 30% from 1990, is due to the implementation of Italian Legislative Decree 161/2006.

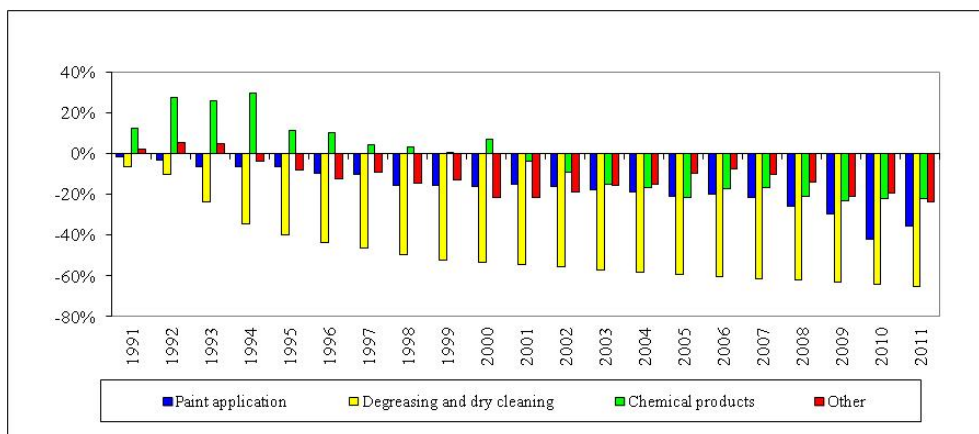


Figure 5.1 Trend of NMVOC emissions from 1991 to 2011 as compared to 1990

N₂O emissions remain almost at the same levels from 1990 onwards although, from 2000, a reduction is detected, due to a decrease in the anaesthetic use of N₂O that has been replaced by halogen gas.

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). For specific categories, emission factors and emissions are also shared with the relevant industrial associations; this is particularly the case of paint application for wood, some chemical processes and anaesthesia and aerosol cans.

In the framework of the MeditAIRaneo project, ISPRA commissioned to Techne Consulting S.r.l. a survey to collect national information on emission factors in the solvent sector. The results, published in the report *“Rassegna dei fattori di emissione nazionali ed internazionali relativamente al settore solventi”* (TECHNE, 2004), have been used to verify and validate the emission estimates. ISPRA commissioned to Techne Consulting S.r.l. another survey to compare emission factors with the last update published in the EMEP/EEA guidebook (EMEP/EEA, 2009). The results are reported in *“Fattori di emissione per l'utilizzo di solventi”* (TECHNE, 2008) and have been used to update emission factors for polyurethane and polystyrene foam processing activities.

In addition, for paint application, data communicated from the industries in the framework of the EU Directive 2004/42, implemented by the Italian Legislative Decree 161/2006, on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products have been used as a verification of emission estimates. These data refer to the composition of the total amount of paints and varnishes (water and solvent contents) in different subcategories for interior and exterior use and the total amount of products used for vehicle refinishing and they are available from the year 2007.

Additional verifications of the emissions from the sector occurred last year, on account of the bilateral independent review between Italy and Spain and the revision of national estimates and projections in the context of the National emission ceilings Directive for the EU Member States and the Gothenburg Protocol of the Convention on Long-Range Transboundary Air Pollution (CLRTAP).

In the case of the bilateral review, national emissions from the solvent sector were revised by the Spanish team in October 2012. The analysis by category has not highlighted the need of major methodological revisions of the sector; an additional source of emissions has been added affecting only NMVOC emissions. A change of NMVOC emission factors for the last years in two chemical categories was the result of the other review process.

5.6 Source-specific recalculations

In Table 5.2 the comparison of CO₂ and NMVOC emissions between the actual and last year submission is reported only for those years where recalculations actually occurred.

The main modification involved the chemical products subsector with respect to NMVOC emissions, due to the update of emission factors for polyurethane processing. On the basis of the industrial association communication, the phase out of CFC gases occurred in the second half of nineties and the blowing agent currently used is penthane, which resulted in a strong reduction of emissions. In the same subsector NMVOC emissions from asphalt bowling have been added for the whole time series. Recalculations are also observed in paint application, for NMVOC and CO₂, due to the update of emission factors in paint application in wood from 2005 to 2010 and for car repairing in 2010. Minor recalculations occurred in other use of solvents, considering an updating of the activity data in fat, edible and non edible oil extraction and application of glues and adhesives for the whole time series.

Table 5.2 Differences in CO₂ and NMVOC emissions between the updated time series and the 2012 submission

	CO ₂ /NMVOC 3A. Paint application	CO ₂ /NMVOC 3D. Other	NMVOC 3C. Chemical products
1990	-0.05%		0.05%
1991	-0.04%	0.07%	0.04%
1992	-0.04%	0.20%	0.04%
1993	-0.04%	-0.10%	0.04%
1994	-0.04%	-0.17%	0.04%
1995	-0.04%	0.05%	-2.57%
1996	-0.03%	-0.13%	-5.11%
1997	-0.06%	-0.26%	-7.87%
1998	-0.02%	-0.18%	-11.07%
1999	-0.03%	-0.07%	-14.32%
2000	-0.03%	-0.18%	-20.23%
2001	-0.02%	-0.65%	-17.03%
2002	-0.01%	-0.76%	-17.71%
2003		-0.95%	-17.89%
2004	-1.20%	-1.56%	-19.65%
2005	-0.68%	-0.02%	-16.84%
2006	-0.75%	1.49%	-18.22%
2007	0.06%	1.61%	-18.91%
2008	0.53%	0.86%	-18.60%
2009	1.69%	1.01%	-19.34%
2010	4.00%	-0.05%	-22.34%

5.7 Source-specific planned improvements

No further improvements are planned.

6 AGRICULTURE [CRF sector 4]

6.1 Sector overview

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 (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 (CH₄) and nitrous oxide (N₂O) emissions are estimated and reported. Savannas areas (4E) are not present in Italy. Emissions from other sources (4G) have not been estimated. CO₂ and F-gas emissions do not occur.

To provide update information on the characteristics of the agriculture sector in Italy, figures from the Agricultural Census 2010 are reported. In Italy, there are 1.6 millions of agricultural holdings with a Utilized Agricultural Area (UAA) of 12.9 million hectares, +0.9% more than Farm Structure Survey 2007 (FSS 2007). Looking at the data from the last four censuses (see box below), the number of agricultural holdings and the agricultural area have decreased, in particular, between 2000 and 2010, the reduction of agricultural holdings is equal to 32% (775,390 units). At national level, the average size of the agricultural holdings varied from 5.5 hectares in 2000 to 7.9 hectares in 2010. Census data confirm the findings of the FSS, according to which the average size of the agricultural holdings varied from 7.4 hectares in 2005 to 7.6 hectares in 2007. However, more than 50% of agricultural holdings have an area of less than 2 hectares of UAA. The distribution of agricultural holdings by type confirms a typical family conduction system, which characterized the Italian agriculture. Direct conduction of holdings by farmers is around 1.5 million (95.4% of total agricultural holdings with UAA) which hold 11 million hectares of UAA (82.8% of total)² (EUROSTAT, 2007[a], [b], 2012; ISTAT, 2008[a]).

Updated figures of the agriculture sector such as added value, employment, productivity are available (INEA, 2012).

Agricultural holding characteristics from Agricultural Censuses

Agricultural holding characteristics	1982	1990	2000	2010
Number of agricultural holdings	3,133,118	2,848,136	2,396,274	1,620,884
Utilized agricultural area - hectares	15,832,613	15,025,954	13,181,859	12,856,048
Total agricultural area - hectares	22,397,833	21,628,355	18,766,895	17,081,099
Average size of the agricultural holdings	5.1	5.3	5.5	7.9

6.1.1 Emission trends

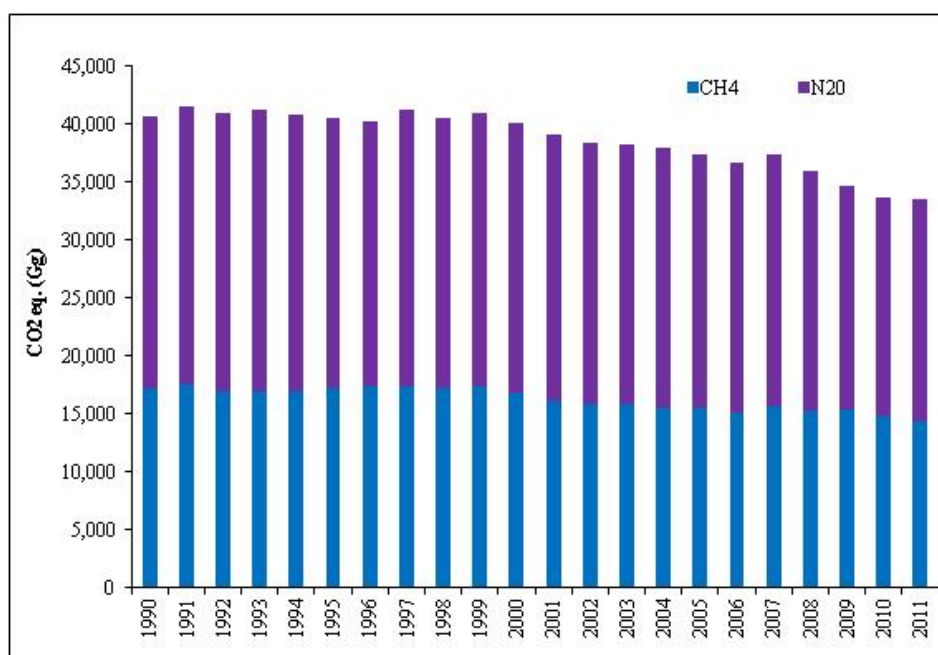
Emission trends per gas

In 2011, 6.9% of the Italian GHG emissions, excluding emissions and removals from LULUCF, (7.8% in 1990) originated from the agriculture sector, which is the second source of emissions, after the energy sector which accounts for 82.7%. For the agriculture sector, the trend of GHGs from 1990 to 2011 shows a decrease of 17.7% due to reduction in activity data, such as the number of animals and cultivated surface/crop production (see Figure 6.1). CH₄ and N₂O emissions have decreased by 16.7% and 18.4%, respectively (see Table 6.1). In 2011, the agriculture sector has been the second source for CH₄, after the waste sector, sharing 39% of national CH₄ levels. As for N₂O, agriculture is the dominant source, accounting for 71% of national N₂O emissions.

² Agricultural Census data are available at the link <http://dati-censimentoagricoltura.istat.it/>

Table 6.1 GHG emissions and trend from 1990 to 2011 for the agriculture sector (Gg CO₂ eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Gg CO₂ eq.										
CH₄	17,330	17,317	16,928	15,549	15,216	15,682	15,357	15,458	14,878	14,438
N₂O	23,409	23,203	23,207	21,813	21,551	21,697	20,659	19,319	18,845	19,092
Total	40,739	40,520	40,135	37,363	36,767	37,380	36,015	34,777	33,723	33,530

**Figure 6.1 Trend of GHG emissions for the agriculture sector from 1990 to 2011 (Gg CO₂ eq.)***Emission trends per sector*

Total GHG emissions and trends by sub category from 1990 to 2011 are presented in Table 6.2 (expressed in Gg. CO₂ eq.). CH₄ emissions from enteric fermentation (4A) and N₂O emissions from direct agriculture soils (4D) are the most relevant categories. In 2011, their individual share in national GHG emissions excluding LULUCF was 2.2% and 3.1 %, respectively.

Table 6.2 Total GHG emissions from 1990 to 2011 for the agriculture sector (Gg CO₂ eq.)

Year	GHG emissions (Gg CO ₂ eq.) by sub category					TOTAL
	4A	4B	4C	4D	4F	
1990	12,278	7,383	1,576	19,484	17	40,739
1995	12,348	7,068	1,671	19,417	17	40,520
2000	12,246	7,140	1,391	19,341	17	40,135
2001	11,423	7,344	1,390	19,029	16	39,202
2002	11,107	7,115	1,439	18,822	18	38,501
2003	11,134	7,075	1,470	18,645	16	38,340
2004	10,908	6,868	1,534	18,705	20	38,034
2005	10,914	6,857	1,472	18,100	18	37,363
2006	10,699	6,629	1,475	17,947	18	36,767
2007	11,099	6,833	1,516	17,914	18	37,380
2008	10,996	6,736	1,386	16,879	19	36,015

Year	GHG emissions (Gg CO ₂ eq.) by sub category					TOTAL
	4A	4B	4C	4D	4F	
2009	11,007	6,685	1,565	15,502	18	34,777
2010	10,732	6,268	1,565	15,139	18	33,723
2011	10,761	5,830	1,550	15,372	18	33,530

6.1.2 Key categories

In 2011, N₂O from agricultural soils, both direct and indirect emissions, CH₄ from enteric fermentation, CH₄ and N₂O from manure management, N₂O Emissions from animal production were ranked among the top-10 level key sources with the Approach 2, including the uncertainty (L2). CH₄ from manure management and N₂O from agricultural soils, both direct and indirect emissions are ranked among the top-10 trend key sources with Approach 2, including the uncertainty (T2). In the following box, key and non-key categories from the agriculture sector are shown, with a level and/or trend assessment (*IPCC Approach 1 and Approach 2*), excluding and including the LULUCF sector in the analysis.

Key-source identification in the agriculture sector with the IPCC Approach 1 and Approach 2 for 2011

			<i>excluding LULUCF</i>	<i>including LULUCF</i>
4A	CH ₄	Emissions from enteric fermentation	Key (L, T2)	Key (L)
4B	CH ₄	Emissions from manure management	Key (L2, T2)	Key (L2, T2)
4B	N ₂ O	Emissions from manure management	Key (L)	Key (L)
4D1	N ₂ O	Direct soil emissions	Key (L, T)	Key (L, T)
4D2	N ₂ O	Emissions from animal production	Key (L2)	Key (L2)
4D3	N ₂ O	Indirect soil emissions	Key (L, T)	Key (L, T2)
4C	CH ₄	Rice cultivation	Non-key	Non-key
4F	CH ₄	Emissions from field burning of agriculture residues	Non-key	Non-key
4F	N ₂ O	Emissions from field burning of agriculture residues	Non-key	Non-key

6.1.3 Activities

Emission factors used for the preparation of the national inventory reflect the characteristics of the Italian agriculture sector. Information from national research studies is considered. Activity data are mainly collected from the National Institute of Statistics (ISTAT, *Istituto Nazionale di Statistica*). Every year, national and international references, and personal communications used for the preparation of the agriculture inventory are kept in the *National References Database*.

Improvements for the Agriculture sector are described in the Italian Quality Assurance/Quality Control plan (ISPRA, 2013). Moreover, an internal report describes the procedure for preparing the agriculture UNFCCC/CLRTAP national emission inventory, and projections (Córdor, 2012).

In the last years, results from different research projects have improved the quality of the agriculture national inventory (MeditAIRaneo project and Convention signed between ISPRA and the Ministry for the Environment, Land and Sea; CRPA, 2006[a], CRPA, 2006[b]). Furthermore, suggestions from the inventory review processes have been considered (UNFCCC, 2009; UNFCCC, 2010[a]; UNFCCC, 2010[b]; ISPRA, 2012[a]). Methodologies for the preparation of agriculture national inventory under the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and the United Nations Framework Convention on Climate Change (UNFCCC) are consistent. Synergies among international conventions and European directives while preparing the agriculture inventory are implemented (Córdor, 2006; Córdor and De Lauretis, 2007; Córdor *et al.*, 2007[b]; Córdor *et al.*, 2008[b]; Córdor and De Lauretis, 2009; Córdor and Vitullo, 2010, 2011; Córdor and Vitullo, 2011).

The national agriculture UNFCCC/CLRTAP emission inventory is used, every 5 years, to prepare a more disaggregated inventory by region and province as requested by CLRTAP (Córdor *et al.*, 2008[c]). A database with the time series for all sectors and pollutants is available (ISPRA, 2008; ISPRA, 2009; ISPRA, 2012[b]). Methodologies used for the inventory, emission scenarios and projections are similar (MATTM, 2007; MATTM, 2009).

6.1.4 Agricultural statistics

The Italian National Statistical System (SISTAN³) revises every year the National Statistical Plan that covers three years and includes, among others, the system of agricultural statistics. In this framework, the Agriculture, Forestry and Fishing Quality Panel has been established under coordination of the Agriculture service of ISTAT where those who produce and use agricultural statistics (mainly public institutions) meet every year in order to monitor and improve national statistics. ISTAT plays a major role in the agricultural sector collecting comprehensive data through different surveys (Greco and Martino, 2001):

- Structural surveys (Farm Structure Survey, survey on economic results of the farm, survey on the production means);
- Conjunctural surveys⁴ (survey on the area and production of the cultivation, livestock number, milk production, slaughter, etc.);
- General Agricultural Census⁵, carried out every 10 years (1990, 2000, 2010).

Detailed information on the agriculture sector is found every two years in the Farm Structure Survey, FSS⁶ (ISTAT, 2008[a]; ISTAT, 2007[a]; ISTAT, 2006[a]). ISTAT has provided quality reports of the FSS 2005 and FSS 2007 (ISTAT, 2008[b]; ISTAT, 2007[d]). The main agricultural statistics used for the agriculture emission inventory are available on-line. Detailed information is provided in 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://agri.istat.it/jsp/Introduzione.jsp
Milk production	Table 6.3	http://agri.istat.it/jsp/Introduzione.jsp
Fertilizers	Table 6.25	http://agri.istat.it/jsp/Introduzione.jsp
Crops production/surface	Table 6.26; 6.27; 6.31; 6.33	http://agri.istat.it/jsp/Introduzione.jsp

Differences in the some animal populations are found between FAOSTAT and national statistics. FAO publishes figures of the $x-1$ year on 1st January of the x year. Each year ISPRA verifies the official statistics directly contacting the experts responsible for each agricultural survey (number of animals, agricultural surface/production, fertilizers, etc). Agricultural statistics reported by ISTAT are also those published in the European statistics database⁷ (EUROSTAT). Whenever outliers are identified, ISTAT and category associations are contacted. The verification of statistics is part of the QA/QC procedures implemented.

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 category, both in terms of level and trend, for approach 2 (and key sources at level assessment with Approach 1). All livestock categories have been estimated except camels and llamas, which are not present in Italy. Methane emissions from poultry do not occur, and emissions from rabbits are estimated and included in “Other” as suggested by the IPCC guidelines.

In 2011, CH₄ emissions from this category were 512.44 Gg which represents 74.5% of CH₄ emissions for the agriculture sector (70.9% in 1990) and 29.4% for national CH₄ emissions excluding LULUCF (28.1% in 1990). Methane emissions from this source consist mainly of cattle emissions: dairy cattle (209.36 Gg) and

³ SISTAN, *Sistema Statistico Nazionale* (<http://www.sistan.it/>)

⁴ <http://agri.istat.it/>

⁵ <http://censagr.istat.it/>; <http://dati-censimentoagricoltura.istat.it/>

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

⁷ <http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database>

non-dairy cattle (188.81 Gg). These two sub-categories represented 40.9% (42.7% in 1990) and 36.8% (39.9% 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 are collected from ISTAT (several years [a], [b], [c], [f]; ISTAT, 1991; 2007[a], [b]; 2013[a]). Livestock categories provided by ISTAT are classified according to the type of production, slaughter or breeding, and the age of animals. In the following box, livestock categories and source of information are provided. Parameters for the livestock categories are shown in Table 6.20. In order to have a consistent time series, it was necessary to reconstruct the number of animals for some categories. The reconstruction used information available from other official sources such as FAO and UNA (FAO, 2013; UNA, 2013).

Activity data for the different livestock categories

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

(a) Reconstruction of a consistent time series; (b) For 1990 data from the census and reconstruction for broilers, hens and other poultry based on meat production (UNA, 2013); (c) For 1990 data from the census and reconstruction based on a production index (ISTAT, 2007[b]; ISTAT, 2013[f])

Dairy cattle

Methane emissions from enteric fermentation for dairy cattle are estimated using a 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 shown 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[a]
Coefficient NE _m (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 (%)	3.59-3.75	ISTAT, several years [a], [b], [d], [e]; ISTAT, 2013[b]
Hours of work per day	0	CRPA, 2006[a]
Portion of cows giving birth	0.90-0.97	AIA, 2012
Milk production (kg head ⁻¹ day ⁻¹)	11.5-18.5	CRPA, 2006[a]; ISTAT, 2013[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[a]
MJ/kg methane	55.65	IPCC, 2000

Milk production national statistics were analysed (Córdoba *et al.*, 2005). Milk used for dairy production and milk used for calf feeding contributes to total milk production. This last value was reconstructed with national and ISTAT publications (ISTAT, 2013[b]). For calculating milk production (kg head⁻¹ d⁻¹), total production is divided by the number of animals and by 365 days, as suggested by the IPCC (IPCC, 2000). Therefore, lactating and non-lactating periods are included in the estimation of the CH₄ 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 shown. Further information on parameters used for dairy cattle estimations is reported in Annex 7.1.

In Table 6.6, the time series of the dairy cattle emission factors (EF) is presented. In 2011, the CH₄ dairy cattle EF was 119.3 kg CH₄ head⁻¹ year⁻¹ with an average milk production of 6,736 kg head⁻¹ year⁻¹ (18.5 kg head⁻¹ day⁻¹). IPCC report a default EF of 109 kg CH₄ head⁻¹ year⁻¹ with a milk production of 6,000 kg head⁻¹ year⁻¹ (IPCC, 2006).

Table 6.3 Parameters used for the estimation of the CH₄ emission factor for dairy cattle

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
1995	2,079,783	3.64	0.95	14.8
2000	2,065,000	3.65	0.93	15.1
2001	2,077,618	3.65	0.91	14.9
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
2006	1,821,370	3.69	0.90	17.4
2007	1,838,783	3.71	0.90	17.3
2008	1,830,711	3.72	0.90	17.7
2009	1,878,421	3.67	0.90	17.4
2010	1,746,140	3.72	0.90	18.7
2011	1,754,981	3.75	0.90	18.5

Non-dairy cattle

For non-dairy cattle, CH₄ emissions from enteric fermentation are estimated with a 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 into gross energy (MJ head⁻¹ day⁻¹) using 18.45 MJ/kg dry matter (IPCC, 2000). Emission factors for each category are calculated with equation 4.14 from IPCC (IPCC, 2000). In Table 6.5, parameters used for the estimation of non-dairy cattle EF are shown. Since the 2006 submission, average weights were updated with information from the Nitrogen Balance Inter-regional Project (CRPA, 2006[a]; Regione Emilia Romagna, 2004). For reporting purposes, some animal categories are aggregated, such as the non-dairy and the swine categories. The non-dairy cattle category is composed of the different sub-categories as shown in Table 6.4. For this reason, the gross energy intake, CH₄ conversion factor and EFs for this category are calculated as a weighted average.

Table 6.4 Non-dairy cattle population (heads) classified by type of production and age

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	
	(heads)										
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
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
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	496,264	1,498,068	25,528	595,029	709,941	181,550	75,365	591,000	46,000	442,525	4,661,270
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
2006	540,223	1,407,401	26,091	608,152	584,680	182,719	78,328	395,066	54,022	419,083	4,295,765
2007	519,034	1,410,357	26,852	625,902	593,369	189,704	79,936	498,091	59,961	440,845	4,444,051
2008	502,391	1,401,501	26,908	627,186	630,194	196,936	74,059	469,074	48,075	372,051	4,348,375
2009	494,463	1,313,146	25,191	587,167	617,494	183,420	83,087	478,782	67,781	373,865	4,224,396
2010	507,452	1,228,696	23,913	557,386	597,733	212,983	70,284	445,370	70,411	372,089	4,086,317
2011	509,904	1,272,903	23,461	546,847	600,769	222,859	70,018	433,336	72,430	390,017	4,142,544

Table 6.5 Main parameters used for non-dairy cattle CH₄ emission factor estimations

Parameters	<1 year	1-2 years Males		1-2 years Females		>2 years Males	>2 years Females		Others
	Others (*)	breeding	for slaughter	breeding	for slaughter	all	breeding	for slaughter	
Average weight (kg)	236	557	557	405	444	700	540	540	557
Percentage weight ingested	2.1	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	197.3	214.8	156.9	171.2	315.5	212.2	212.2	195.3
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 CH₄ emissions, as they are milk fed. Therefore, the average weight for the category "others" of <1 year takes into account fattening male cattle, fattening heifer and heifer for replacement.

National characteristics of Italian breeding are reflected in EFs, and they are also related to the age classification of animals and dry matter intake. In Table 6.6, Implied Emission Factors (IEF) for non-dairy cattle are shown. In 2011, the non dairy-cattle EF was 45.6 kg CH₄ head⁻¹ year⁻¹ while IPCC default EF is 48 kg CH₄ head⁻¹ year⁻¹ (IPCC, 1997). The inter-annual decrease 2005/2006 of the IEF for non-dairy cattle is related to the reduction in the number of animals for some categories and an increase in the number of the '*less than 1 year for the slaughter*' category (no emissions) (see Table 6.4). This last category (calves) has not been considered when estimating methane emissions as they are milk fed. However relevant parameters for this category, used for estimating N₂O emissions from manure management, are the following:

- Average body weight: 157 kg;
- Nitrogen excretion: 75.7 kg N/head/year;
- Average milk period: 4-6 months;
- Average weight at slaughter: less than 300 kg.

Buffalo

Data collected in the framework of the MeditAIRaneo project allowed for the implementation of the Tier2 approach for the buffalo category (IPCC, 2000). Two different country-specific CH₄ EFs, for cow buffalo and other buffaloes, were developed. Detailed description of the methodology is reported in C ndor *et al.* (C ndor *et al.*, 2008[a]). In 2011, the cow buffalo CH₄ EF was 70.4 kg CH₄ head⁻¹ year⁻¹ and for other buffaloes the value was 56.0 kg CH₄ head⁻¹ year⁻¹. The CRF IEF is an average value for the two categories (65.6 kg CH₄ head⁻¹ year⁻¹). Parameters used for the Tier 2 approach are shown in the following boxes.

Parameters for the calculation of CH₄ 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 NE _m , cattle/buffalo (lactating)	0.335	IPCC, 2000
Pasture (%)	2.90	ISTAT, 2003; Zicarelli, 2001; expert judgement
Weight gain (kg day ⁻¹)	0.055	Estimations
Milk fat content (%)	7.73-7.93	ISTAT, several years [a], [b], [d], [e]; ISTAT, 2013[b]
Hours of work per day	0	Our estimation
Proportion of calving cows	0.89-0.84	Barile, 2005; De Rosa and Trabalzi, 2004
Milk production (kg head ⁻¹ day ⁻¹)	1.9-2.6	ISTAT, 2013[b]; OSSLATTE/ISMEA, 2003; ;OSSLATTE, 2001; ISTAT, several years [a], [b], [c] [d], [e], [f]
Digestibility of feed (%)	65	Infascelli, 2003; Masucci <i>et al.</i> , 1997, 1999;
Methane conversion rate (%)	6	CRPA, 2006[a]
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 CH₄ 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 CH₄ 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 (CRPA). Daily dry matter intake for brood-rabbits and other rabbits are 0.13 kg day⁻¹ and 0.11 kg day⁻¹, respectively. Besides, a value of 0.6% has been assumed as CH₄ conversion rate (CRPA, 2004[c]).

Other livestock categories

A Tier 1 approach, with IPCC default EFs, is used to estimate CH₄ emissions from swine, sheep, goats, horses, mules and asses (IPCC, 1997). In Table 6.6, EFs for all livestock categories (dairy cattle, non-dairy cattle, buffalo, swine, sheep, goats, horses, mules and asses, and rabbits) are presented. In Table 6.7, time series of the number of animals are shown.

Table 6.6 Average CH₄ emission factors for enteric fermentation (kg CH₄ head⁻¹ year⁻¹)

Year	Dairy cattle	Non-dairy cattle	Buffalo	Sheep	Goats	Horses	Mules and asses	Sows	Other swine	Rabbits
average CH ₄ EF (kg CH ₄ head ⁻¹ year ⁻¹)										
1990	94.5	45.6	62.9	8.0	5.0	18.0	10.0	1.5	1.5	0.08
1995	106.0	47.4	64.4	8.0	5.0	18.0	10.0	1.5	1.5	0.08
2000	107.0	47.0	66.8	8.0	5.0	18.0	10.0	1.5	1.5	0.08
2001	106.3	46.7	69.7	8.0	5.0	18.0	10.0	1.5	1.5	0.08
2002	110.8	46.5	68.0	8.0	5.0	18.0	10.0	1.5	1.5	0.08
2003	110.8	46.6	67.6	8.0	5.0	18.0	10.0	1.5	1.5	0.08
2004	113.2	46.3	69.7	8.0	5.0	18.0	10.0	1.5	1.5	0.08
2005	114.7	46.4	72.3	8.0	5.0	18.0	10.0	1.5	1.5	0.08
2006	115.0	44.7	70.9	8.0	5.0	18.0	10.0	1.5	1.5	0.08
2007	114.9	46.1	68.3	8.0	5.0	18.0	10.0	1.5	1.5	0.08
2008	116.5	45.5	66.8	8.0	5.0	18.0	10.0	1.5	1.5	0.08
2009	114.8	46.3	65.0	8.0	5.0	18.0	10.0	1.5	1.5	0.08
2010	119.9	45.9	64.7	8.0	5.0	18.0	10.0	1.5	1.5	0.08
2011	119.3	45.6	65.6	8.0	5.0	18.0	10.0	1.5	1.5	0.08

Table 6.7 Time series of number of animals from 1990 to 2011 (heads)

Year	Buffalo	Sheep	Goats	Horses	Mules and asses	Sows	Other swine	Rabbits	Poultry
(heads)									
1990	94,500	8,739,253	1,258,962	287,847	83,853	650,919	7,755,602	14,893,771	173,341,562
1995	148,404	10,667,971	1,372,937	314,778	37,844	689,846	7,370,830	17,110,587	184,202,416
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	193,774	8,311,383	1,024,769	285,000	33,000	697,491	8,068,771	18,494,839	209,187,654
2002	185,438	8,138,309	987,844	277,819	28,913	751,159	8,415,099	18,852,530	205,566,136
2003	222,268	7,950,981	960,994	282,936	28,507	736,637	8,420,087	18,866,643	196,511,409
2004	210,195	8,106,043	977,984	277,767	28,932	724,891	8,247,181	19,654,694	191,315,963
2005	205,093	7,954,167	945,895	278,471	30,254	721,843	8,478,427	20,504,282	188,595,022
2006	230,633	8,227,185	955,316	287,123	31,013	771,751	8,509,352	20,238,089	177,274,561
2007	293,947	8,236,668	920,085	315,725	34,557	753,721	8,519,214	20,964,928	188,871,886
2008	307,149	8,175,196	957,248	332,496	36,239	756,345	8,496,102	19,515,455	197,298,265
2009	344,007	8,012,651	960,950	343,519	40,608	745,508	8,411,572	17,689,669	199,924,644
2010	365,086	7,900,016	982,918	373,324	46,475	717,366	8,603,753	17,957,421	198,346,719
2011	354,402	7,942,641	959,915	373,327	50,966	708,770	8,642,011	18,467,042	200,718,160

6.2.3 Uncertainty and time-series consistency

Uncertainty related to CH₄ emissions from enteric fermentation was 28% for annual emissions, resulting from the combination of 20% of uncertainty for both activity data and emission factors.

In the 2011 submission, Montecarlo analysis was also applied to estimate uncertainty of this category for 2009; an asymmetrical probability density distribution resulted from the analysis, showing uncertainties values equal to -21.8% and 31.7%. Different distributions have been assumed for the parameters; assumptions or

constraints on variables have been appropriately reflected on the choice of type and shape of distributions. A summary of the results is reported in Annex 1.

In 2011, CH₄ emissions from enteric fermentation were 12.4% (512.44 Gg) lower than in 1990 (584.69 Gg). Between 1990 and 2011 cattle livestock has decreased by 23.9% (from 7,752,152 to 5,897,525 heads). Dairy cattle and non-dairy cattle have decreased by 33.6% (from 2,641,755 to 1,754,981) and 18.9% (from 5,110,397 to 4,142,544), respectively. The reduction in number of cattle is the main driving force for the reduction in CH₄ emissions, particularly as emissions per head from cattle are 10 times greater than emissions per head of sheep or goat. In 2011, cattle contribute with 77.7% to total CH₄ emissions from enteric fermentation. In Table 6.8, emission trends from the enteric fermentation category are shown. Emissions from swine, as reported in the CRF submission 2013, are represented by 'other swine' and 'sow' (14.03 Gg).

Table 6.8 Trend of CH₄ emissions from enteric fermentation (Gg)

Year	Dairy cattle	Non-dairy cattle	Buffalo	Sheep	Goats	Horses	Mules and asses	Sows	Other swine	Rabbits	TOTAL
(Gg)											
1990	249.75	233.00	5.95	69.91	6.29	5.18	0.84	0.98	11.63	1.16	584.69
1995	220.53	246.22	9.55	85.34	6.86	5.67	0.38	1.03	11.06	1.33	587.98
2000	221.03	234.48	12.83	88.71	6.88	5.04	0.33	1.06	11.40	1.39	583.14
2001	220.87	217.91	13.51	66.49	5.12	5.13	0.33	1.05	12.10	1.44	543.96
2002	211.81	213.95	12.61	65.11	4.94	5.00	0.29	1.13	12.62	1.46	528.92
2003	212.01	214.17	15.02	63.61	4.80	5.09	0.29	1.10	12.63	1.47	530.19
2004	208.15	206.60	14.64	64.85	4.89	5.00	0.29	1.09	12.37	1.53	519.41
2005	211.19	204.65	14.82	63.63	4.73	5.01	0.30	1.08	12.72	1.59	519.73
2006	209.46	192.10	16.36	65.82	4.78	5.17	0.31	1.16	12.76	1.57	509.48
2007	211.36	205.03	20.06	65.89	4.60	5.68	0.35	1.13	12.78	1.63	528.51
2008	213.21	197.94	20.52	65.40	4.79	5.98	0.36	1.13	12.74	1.52	523.60
2009	215.64	195.53	22.37	64.10	4.80	6.18	0.41	1.12	12.62	1.37	524.14
2010	209.29	187.46	23.62	63.20	4.91	6.72	0.46	1.08	12.91	1.39	511.05
2011	209.36	188.81	23.25	63.54	4.80	6.72	0.51	1.06	12.96	1.43	512.44

6.2.4 Source-specific QA/QC and verification

Since 2006 submission, results from the MeditAIRaneo project focusing on the assessment of critical points of the enteric fermentation category have been incorporated (CRPA, 2006[a]; Valli *et al.*, 2004). In Table 6.9, a list of parameters from the QA/QC plan is reported.

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

Sub category	Parameter	Year of submission 2014	Activities
Dairy cattle		✓	Information coming from 2010 Agricultural census will be analysed and verified

6.2.5 Source-specific recalculations

No recalculations are observed.

6.2.6 Source-specific planned improvements

In the framework of the collaboration between ISPRA and ISTAT (Agriculture Service) we expect to continuously update and improve activity data. Every year agricultural statistics from other sources are also updated (UNA, 2013; AIA, 2012).

6.3 Manure management (4B)

6.3.1 Source category description

In 2011, CH₄ emissions from manure management were 100.67 Gg, which represents 14.6% of CH₄ emissions for the agriculture sector (20.0% in 1990) and 5.8% of national CH₄ emissions (7.9% in 1990). CH₄ emissions from swine were 42.67 Gg and from cattle were 33.71 Gg. These two sub-categories represented 42% and 33%, respectively, of total CH₄ manure management emissions.

In 2011, N₂O emissions from manure management were 11.99 Gg, which represents 19.5% of total N₂O emissions for the agriculture sector (16.8% in 1990) and 13.8% of national N₂O emissions (10.5% in 1990). In 2011, N₂O emissions from this source mainly consist of the solid storage source (10.51 Gg), accounting for 87.7% of the N₂O manure management source.

Since 2006 submission, parameters related to the estimation of CH₄ and N₂O emissions have been updated: average weight, production of slurry and solid manure and the nitrogen excretion rates. The source for updating these parameters was the Nitrogen Balance Inter-regional Project and other national studies (references are provided in this section).

N₂O emissions from manure management are key sources at level, following Approach 1 and Approach 2, and CH₄ emissions from manure management are key sources at level and trend following Approach 2.

6.3.2 Methodological issues

The IPCC Tier 2 approach is used for estimating methane EFs for manure management of cattle, buffalo and swine. For estimating slurry and solid manure EFs and the specific conversion factor, a detailed methodology (*Method 1*) was applied at a regional basis for cattle and buffalo categories. Then, a simplified methodology, for estimating EF time series, was followed (*Method 2*). Livestock population activity data is collected from ISTAT (see Table 6.3; Table 6.4; Table 6.7).

Methane emissions (cattle and buffalo)

Method 1: Regional basis

Methane emission 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). The following factors are used: average regional monthly temperatures (UCEA, 2011), 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 starts with the calculation of the *methane emission rate* (g CH₄ m⁻³ day⁻¹), which is obtained from an equation for slurry (Husted, 1994) and solid manure (Husted, 1993). Then, the *methane emission rate* is transformed to g m⁻³ month⁻¹.

Equations are presented below (CRPA, 2006[a]; CRPA, 1997[a]).

For slurry:

$$\text{CH}_4 \text{ (g m}^{-3} \text{ day}^{-1}\text{)} = e^{(0.68+0.12) * t \text{ (}^\circ\text{C) (average regional monthly temperature)}} \quad \text{Eq. 6.1}$$

For solid manure:

$$\text{CH}_4 \text{ (g m}^{-3} \text{ day}^{-1}\text{)} = e^{(-2.3+0.1) * t \text{ (}^\circ\text{C) (monthly storage temperature)}} \quad \text{Eq. 6.2}$$

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

$$T \text{ solid manure storage} = 6,7086e^{0.1014t \text{ (}^{\circ}\text{C) (average regional monthly temperature)}}$$

For temperatures below 10°C emissions are considered negligible.

The volume of slurry and solid manure produced per livestock category was obtained ($\text{m}^3 \text{ head}^{-1}$) with the average production of slurry and solid manure per livestock category per day ($\text{m}^3 \text{ head}^{-1} \text{ day}^{-1}$) 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 were estimated assuming a distribution of housing systems in Italy, which will be updated with information coming from the 2010 Agricultural Census. Final data from the census have been published at the end of 2012 from Istat and data will be analyzed during 2013. Emission factors for slurry and solid manure ($\text{g CH}_4 \text{ head}^{-1} \text{ month}^{-1}$) are calculated for each month, and were 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 ($\text{kg CH}_4 \text{ head}^{-1} \text{ year}^{-1}$). In order to correlate CH_4 emission production and volatile solid (VS) production, a *specific conversion factor* was estimated. Later, this '*conversion factor*' is used for the simplified methodology (*Method 2*). The *specific conversion factor* values for slurry and solid manure are 15.32 $\text{g CH}_4/\text{kg VS}$ and 4.80 $\text{g CH}_4/\text{kg VS}$, respectively.

Method 2: National basis

A simplified methodology (*Method 2*) for estimating methane EFs from manure management was used for the whole time series. Slurry and solid manure EFs ($\text{kg CH}_4 \text{ head}^{-1} \text{ year}^{-1}$) were calculated with Equations 6.3 and 6.4, respectively. These equations include the *specific conversion factor*, estimated on a regional basis. The production of volatile solids ($\text{kg head}^{-1} \text{ day}^{-1}$) was estimated with the slurry and solid manure production, and factors proposed by Husted: 47 g 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 calculating the methane producing potential (Bo).

In Table 6.10, EF estimations are shown.

$$\text{EF slurry} = 15.32 \text{ gCH}_4/\text{Kg VS} \bullet \text{VS production slurry (kg VS head}^{-1} \text{ day}^{-1}) \bullet 365 \text{ days} \quad \text{Eq. 6.3}$$

$$\text{EF manure} = 4.80 \text{ gCH}_4/\text{Kg VS} \bullet \text{VS production slurry (kg VS head}^{-1} \text{ day}^{-1}) \bullet 365 \text{ days} \quad \text{Eq. 6.4}$$

Table 6.10 Methane manure management EFs for cattle and buffalo in 2011 ($\text{kg CH}_4 \text{ head}^{-1} \text{ yr}^{-1}$)

Livestock category	Slurry ($\text{kg CH}_4 \text{ head}^{-1} \text{ yr}^{-1}$)	Solid manure ($\text{kg CH}_4 \text{ head}^{-1} \text{ yr}^{-1}$)	CH_4 manure management EF ($\text{kg CH}_4 \text{ head}^{-1} \text{ yr}^{-1}$)
Calf	6.22	0.00	6.22
Cattle	5.21	3.59	8.80
Female cattle	2.88	4.08	6.96
Other dairy cattle	4.01	6.65	10.66
Dairy cattle	5.64	9.41	15.04
Cow buffalo	4.93	10.32	15.25
Other buffaloes	3.12	3.17	6.30

Since 2006 submission, the average production of slurry and solid manure per livestock category per day ($\text{m}^3 \text{ head}^{-1} \text{ day}^{-1}$) has been updated with results from the Nitrogen Balance Inter-regional Project (Regione Emilia Romagna, 2004). Based on the type and distribution of housing systems for the different animal categories, and the average weight of animals, a time series of slurry and solid manure production was obtained.

In Table 6.11 the disaggregated manure management EFs for cattle and buffalo are shown. See also Table 6.14 for the average EFs of main categories (dairy, non-dairy, buffalo and swine).

Table 6.11 Methane manure management EFs for cattle and buffalo (kg CH₄ head⁻¹ yr⁻¹)

Year	Calf	Cattle	Female cattle	Other dairy cattle	Dairy cattle	Cow buffalo	Other buffaloes
(kg CH ₄ head ⁻¹ yr ⁻¹)							
1990	6.22	8.11	6.71	10.66	15.04	15.25	6.34
1995	6.22	8.56	6.71	10.66	15.04	15.25	6.33
2000	6.22	8.27	6.80	10.66	15.04	15.25	6.31
2001	6.22	8.48	7.07	10.66	15.04	15.25	6.31
2002	6.22	8.23	6.99	10.66	15.04	15.25	6.30
2003	6.22	8.38	6.94	10.66	15.04	15.25	6.30
2004	6.22	8.34	6.98	10.66	15.04	15.25	6.30
2005	6.22	8.61	6.95	10.66	15.04	15.25	6.30
2006	6.22	8.52	6.87	10.66	15.04	15.25	6.29
2007	6.22	8.56	7.05	10.66	15.04	15.25	6.29
2008	6.22	8.58	6.99	10.66	15.04	15.25	6.29
2009	6.22	8.75	7.03	10.66	15.04	15.25	6.29
2010	6.22	8.81	7.04	10.66	15.04	15.25	6.30
2011	6.22	8.80	6.96	10.66	15.04	15.25	6.30

Since 2006 submission, a reduction of CH₄ emissions has been introduced in the manure management category (4B) in order to consider the biogas production. A national census on biogas production/technology can be found in CRPA and CRPA/AIEL (CRPA, 2008; CRPA/AIEL 2008). Biogas production data are collected every year by the National Electric Network (TERNA, 2013). For further information on biogas activity data see Annex 7.2.

Reductions of CH₄ emissions related to biogas recovery are 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 2011, the CRF IEFs, for dairy cattle and non-dairy cattle, were 8.7 kg CH₄ head⁻¹ year⁻¹, and 4.45 kg CH₄ head⁻¹ year⁻¹, respectively. IPCC default EFs for cool temperature are 14 kg CH₄ head⁻¹ year⁻¹ and 6 kg CH₄ head⁻¹ year⁻¹, respectively (IPCC, 1997).

The IEF for non-dairy cattle and buffalo represents a weighted average. The non-dairy cattle IEF includes: calf, cattle, female cattle and other dairy cattle. The buffalo category includes: cow buffalo and other buffaloes categories. In the following box, EFs and IEFs are shown. Differences, as mentioned before, are related to the amount of CH₄ reductions from biogas recovery. Moreover, interannual decrease of the non-dairy IEFs reflects the strong increase of biogas recovery.

Livestock category	EF (kg CH ₄ head ⁻¹ yr ⁻¹)	IEF(*) (kg CH ₄ head ⁻¹ yr ⁻¹)
Dairy cattle	15.04	8.70
Non-dairy cattle	7.70	4.45
Buffalo	12.27	12.27

(*) IEF as reported in the CRF submission 2013

Emissions from the biogas combustion for energy production are estimated and reported in the energy sector in the 1.A.4.c category, agriculture, forestry and fisheries, biomass fuel.

For reporting purposes, the CH₄ producing potential (Bo) is estimated with Equation 4.17 from IPCC (IPCC, 2000). The average methane conversion factors (MCF), for each manure management system (classified by climate), was estimated with data coming from the Agriculture Census from 1990 and 2000 and the FSS 2005 (ISTAT, 2007[a]). Average MCFs were not used for estimating manure management EF, but they are

useful to verify the EF accuracy. In the following box, estimated country-specific VS and Bo parameters, and IPCC default values are shown. Differences are mainly attributed to country-specific characteristics.

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	2.82	2.68	0.13	0.17
Buffalo	5.31	2.68	0.13	0.10
Swine	0.32	0.50	0.46	0.46

(*) IEF as reported in the CRF submission 2013

Methane emissions (swine)

For the estimation of CH₄ emissions for swine, a country-specific *methane emission rate* was experimentally determined by 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 were considered, such as the livestock population, average weight for fattening swine and sows, and *methane emission rate*. Methane emission rates used are 41 normal litre CH₄/100 kg live weight/day for fattening swine, and 47 normal litre CH₄/100 kg live weight/day for sows including piglets (CRPA, 1997[a]). Then, a reduction of emissions of 8% for covered storage structures is applied to the *methane emission rate*. Characteristics of swine breeding and EFs are shown in Table 6.12. In the 2006 submission, parameters such as: 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.) were updated. The slurry production considered the different swine categories (classified by weight and housing characteristics). Volatile solid content were determined experimentally from 598 measurements carried out by CRPA (CRPA, 2006[a]).

In 2011, the EF from sow was 22.40 kg CH₄ head⁻¹year⁻¹, and for the other swine category was 8.40 kg CH₄ head⁻¹ year⁻¹ (average swine EF is 7.89 kg CH₄ head⁻¹year⁻¹). In Table 6.14 the time series of EFs for the swine category (sow and other swine) are shown. The CRF IEF reported is 4.56 kg CH₄ head⁻¹ year⁻¹. The difference between the EF and the IEF is due to the reduction in CH₄ because of biogas recovery. For reporting purposes, the VS daily excretion and Bo is estimated and is useful to verify the EF accuracy. The VS daily excretion was estimated for each sub-category with the following parameters: animal number, production of slurry (t/y/t live weight) and the volatile solids content in the slurry (g VS/kg slurry w.b.). Methane producing potential (Bo) used Equation 4.17 from the IPCC (IPCC, 2000).

Table 6.12 Methane manure management parameters and emission factors for swine in 2011

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	85	583,308	13,768	8.40
20-50 kg	35	64,993	13,768	3.48
50-80 kg	65	95,860	13,768	6.46
80-110 kg	95	142,477	13,768	9.44
110 kg and more	135	274,971	13,768	13.41
Boar	200	5,007	13,768	19.86
Sow	172.1	139,466	15,783	22.40
Piglets	10	17,487	15,783	1.14
Sow	172.1	121,979	15,783	19.60
			TOTAL	7.89

The fundamental characteristic 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 characteristics are the feeding situation, to obtain high quality meat, and the concentration of Italian pig production, limited to a small area (*Lombardia, Emilia-Romagna, Piemonte and Veneto*), representing 75% of national swine resources (Mordenti *et al.*, 1997). These peculiarities of swine production influence the methane EF for manure management as well as nitrogen excretion factors used for the estimation of N₂O emissions.

Other livestock categories

Methane EFs used for calculating the other livestock categories are those proposed by the IPCC 1996 Guidelines. Since the yearly average temperature in Italy is 13 °C, EFs are characteristic of the "cold" climatic region (IPCC, 1997). A study carried out at national level by CRPA (CRPA, 1997[a]) assessed the specific IPCC default EFs to estimate emissions from this category, and an average figure was calculated for each animal category considering that the manure of some animals occur in Italian provinces where average temperatures are higher than 15° C (temperate). In Table 6.13 the distribution of animals in temperate zone is shown. In Table A.7.3 in the Annex, the percentages of animals in temperate zone based on data from the 2000 Agriculture Census, provided by ISTAT, and the average temperature at provincial level are shown.

Table 6.13 Distribution of animals in temperate zone

Animals in temperate zone based on data from the 2000 agriculture census (ISTAT)	Total	N animals	% animals	Based on temperature non weighted by % animals	
				N animals	% animals
Non-dairy cattle	4,409,921	552,951	12.50%	285,415	6.50%
Dairy cattle	1,842,004	140,747	7.60%	55,975	3.00%
Buffalo	205,093	83,864	40.90%	121	0.10%
Other swine	8,479,430	208,379	2.50%	76,436	0.90%
Sows	721,843	21,948	3.00%	14,775	2.00%
Sheep	7,954,167	2,046,930	25.70%	1,273,110	16.00%
Goats	1,045,898	421,088	40.30%	142,671	13.60%
Horses	278,471	38,047	13.70%	16,695	6.00%
Mules and asses	30,254	6,040	20.00%	2,153	7.10%
Broilers	97,532,025	1,560,813	1.60%	1,269,593	1.30%
hen	52,692,584	3,971,390	7.50%	2,534,710	4.80%
other poultry	38,370,412	567,236	1.50%	555,050	1.40%
Rabbits	21,199,217	1,424,974	6.70%	493,657	2.30%

In Table 6.14, the average methane EFs for cattle, buffalo and swine categories are shown for the whole time series.

For the other categories, the EFs are as follows:

- rabbits, 0.080 kg CH₄ head⁻¹ year⁻¹
- sheep, 0.22 kg CH₄ head⁻¹ year⁻¹
- goats, 0.145 kg CH₄ head⁻¹ year⁻¹
- horses, 1.48 kg CH₄ head⁻¹ year⁻¹
- mules and asses, 0.84 kg CH₄ head⁻¹ year⁻¹
- hens, 0.082 kg CH₄ head⁻¹ year⁻¹
- broilers, 0.079 kg CH₄ head⁻¹ year⁻¹
- other poultry, 0.079 kg CH₄ head⁻¹ year⁻¹

Table 6.14 Average methane EF for manure management (kg CH₄ head⁻¹ year⁻¹)

Year	Dairy cattle	Non-dairy cattle	Buffalo	Sows	Other swine
(kg CH ₄ head ⁻¹ year ⁻¹)					
1990	15.04	7.47	12.17	22.14	8.54
1995	15.04	7.82	11.95	21.96	8.52
2000	15.04	7.67	11.71	21.97	8.43
2001	15.04	7.72	13.74	22.20	8.55
2002	15.04	7.66	14.07	22.27	8.21
2003	15.04	7.69	12.98	22.19	8.20
2004	15.04	7.73	12.87	22.22	8.27
2005	15.04	7.78	12.29	22.30	8.35
2006	15.04	7.67	11.96	22.16	8.35
2007	15.04	7.77	11.97	22.21	8.33
2008	15.04	7.70	11.75	22.14	8.32
2009	15.04	7.75	12.03	22.17	8.40
2010	15.04	7.75	12.30	22.34	8.36
2011	15.04	7.70	12.27	22.40	8.40

(*) These are the EFs used for estimating CH₄ emissions from manure management. CH₄ reductions are not included.

Nitrous oxide emissions

As suggested in the IPCC (IPCC, 2000) N₂O emissions were estimated with equation 4.18 from IPCC. Different parameters were used for the estimation: 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) are considered according to their significance and major distribution in Italy. For these management systems, the following EFs are used: 0.001 kg N₂O-N/kg N excreted, 0.02 kg N₂O-N/kg N excreted and 0.02 kg N₂O-N/kg N excreted, respectively (CRPA, 2000; CRPA, 1997[b]). The chicken-dung drying process system is considered since 1995, since it has become increasingly common (CRPA, 2000; CRPA, 1997[b]).

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). In the 2006 submission, different parameters such as the nitrogen excretion rates (CRPA, 2006[a]; GU, 2006; Xiccato *et al.*, 2005), the slurry and solid manure production, and the average weight (CRPA, 2006[a]; GU, 2006; Regione Emilia Romagna, 2004) were updated. In Table 6.15, nitrogen excretion rates used for the estimation of N₂O are shown. The nitrogen excretion rate for swine is 11.68 kg head⁻¹ yr⁻¹. This last parameter is a weighted average: sow (28.44 kg head⁻¹ yr⁻¹) and other swine (12.92 kg head⁻¹ yr⁻¹).

Table 6.15 Average weight and nitrogen excretion rates in 2011

Livestock category	Average weight (kg)	N excreted Housing (kg head ⁻¹ yr ⁻¹)	N excreted Grazing (kg head ⁻¹ yr ⁻¹)	TOTAL Nitrogen excreted (kg head ⁻¹ yr ⁻¹)
Non-dairy cattle	378	48.18	1.27	49.46
Dairy cattle	603	110.20	5.80	116.00
Buffalo	525	92.05	2.75	94.80
Other swine	85	12.92	-	12.92
Sow	172	28.44	-	28.44
Sheep	48	1.62	14.58	16.20
Goat	47	1.62	14.58	16.20

Livestock category	Average weight (kg)	N excreted Housing (kg head ⁻¹ yr ⁻¹)	N excreted Grazing (kg head ⁻¹ yr ⁻¹)	TOTAL Nitrogen excreted (kg head ⁻¹ yr ⁻¹)
Horses	550	20.00	30.00	50.00
Mules and asses	300	20.00	30.00	50.00
Poultry	1.7	0.52	-	0.52
Rabbit	1.6	1.02	-	1.02

Since 2006 submission, with results obtained from the Nitrogen Balance Inter-regional Project, country-specific annual nitrogen excretion rates have been incorporated. This project involved *Emilia Romagna*, *Lombardia*, *Piemonte* and *Veneto* regions, where animal breeding is concentrated. The nitrogen balance methodology was followed, as suggested by the IPCC. As a result, estimations of nitrogen excretion rates⁸ and net nitrogen arriving to the field⁹ were obtained. In order to get reliable information on feed consumption and characteristics, and composition of the feed ratio, the project considered territorial and dimensional representativeness of Italian breeding. Final annual nitrogen excretion rates used for the UNFCCC/CLRTAP agriculture national inventory are reported in a report from CRPA (CRPA, 2006[a]).

In Table 6.16, nitrogen excretion rates for the main livestock categories are shown for the whole time series. For the other livestock categories nitrogen excretion is the same for the whole time series, as shown below:

- sheep, 16.2 kg head⁻¹ year⁻¹
- goats, 16.2 kg head⁻¹ year⁻¹
- horses, 50.0 kg head⁻¹ year⁻¹
- mules and asses, 50.0 kg head⁻¹ year⁻¹
- hen, 0.66 kg head⁻¹ year⁻¹
- broilers, 0.36 kg head⁻¹ year⁻¹
- other poultry, 0.825 kg head⁻¹ year⁻¹
- rabbits, 1.02 kg head⁻¹ year⁻¹
- fur animals, 4.1 kg head⁻¹ year⁻¹

For the dairy cattle category, the same nitrogen excretion rate is applied for the whole time series. This figure is the result of the Nitrogen Balance Inter-regional Project. Further explanation on the efforts to improve the modelling of nitrogen excretion is given in the following section 6.3.6.

Table 6.16 Nitrogen excretion rates for main livestock categories (kg N head⁻¹ yr⁻¹)

Year	Dairy cattle	Non-dairy cattle	Buffalo	Other swine	Sows
(kg N head ⁻¹ yr ⁻¹)					
1990	116.0	50.00	93.94	13.13	28.10
1995	116.0	49.86	92.42	13.10	27.86
2000	116.0	50.08	90.76	12.96	27.87
2001	116.0	50.69	105.23	13.14	28.17
2002	116.0	50.39	107.58	12.61	28.27
2003	116.0	50.53	99.82	12.60	28.16
2004	116.0	50.04	99.01	12.72	28.20
2005	116.0	49.76	94.91	12.84	28.30
2006	116.0	48.52	92.59	12.84	28.12
2007	116.0	49.84	92.61	12.81	28.18
2008	116.0	49.76	91.05	12.79	28.09
2009	116.0	50.19	93.04	12.92	28.13
2010	116.0	49.83	94.96	12.85	28.36
2011	116.0	49.46	94.80	12.92	28.44

⁸ Nitrogen excretion = N consumed – N retained

⁹ Net nitrogen to field= (N consumed – N retained) – N volatilized

Since 2006 submission, new average weight data have been used for UNFCCC/CLRTAP agriculture national inventory. For verification purpose, a time series reported by ISTAT in the yearbooks (animal weight before slaughter) was collected (CRPA, 2006[a]). For the specific case of sheep and goats, a detailed analysis was applied with information coming from the National Association for Sheep Farming (ASSONAPA, 2006). In order to estimate the average weight for sheep and goats, breed distribution in Italy and consistency for each breed were considered (CRPA, 2006[a]; PROINCARNE, 2005). Slurry and solid manure production parameters were updated in the 2006 submission. These parameters 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 CH₄ and N₂O emissions from manure management has been estimated equal to 102%, as a combination of 20% and 100% for activity data and emission factors, respectively.

In the 2012 submission, Montecarlo analysis was also applied to estimate uncertainty of these two categories. The resulting figures were 22.96% and 10.19% for CH₄ and N₂O emissions from manure management, respectively. Normal and lognormal distributions have been assumed for the parameters; at the same time, whenever assumptions or constraints on variables were known this information has been appropriately reflected on the range of distribution values. A summary of the results is reported in Annex 1.

In 2011, livestock CH₄ emissions from manure management were 39% (100.67 Gg CH₄) lower than in 1990 (164.86 Gg CH₄). From 1990 to 2011, dairy and non-dairy cattle livestock population decreased by 62% and 52%, respectively, while swine decreased by 37%. The reduction of manure management emissions has mainly driven down by the number of cattle and, in the last years, the increasing amount of biogas recovered for energy production. Cattle CH₄ emissions contribute with 33% (in 1990 with 47%) to total CH₄ manure management emissions and swine with 42% (41% in 1990).

In Table 6.17, CH₄ emission trends from manure management are shown. These emissions considered the reduction of CH₄ because of biogas recovery.

Table 6.17 Trend in CH₄ emissions from manure management (Gg)

Year	Dairy cattle	Non-dairy cattle	Buffalo	Sows	Other swine	Sheep	Goats	Horses	Mules and asses	Poultry	Rabbits	TOTAL
(Gg)												
1990	39.74	38.18	1.15	14.41	53.78	1.90	0.18	0.43	0.07	13.82	1.19	164.86
1995	30.85	40.01	1.77	14.94	49.85	2.32	0.20	0.47	0.03	14.67	1.36	156.48
2000	30.80	37.92	2.25	15.42	51.14	2.41	0.20	0.41	0.03	14.09	1.42	156.10
2001	30.78	35.43	2.66	15.25	54.51	1.81	0.15	0.42	0.03	16.68	1.47	159.19
2002	28.17	34.54	2.61	16.40	53.46	1.77	0.14	0.41	0.02	16.39	1.50	155.42
2003	28.11	34.47	2.89	15.96	53.97	1.73	0.14	0.42	0.02	15.68	1.50	154.89
2004	26.73	33.38	2.70	15.57	52.58	1.76	0.14	0.41	0.02	15.27	1.57	150.14
2005	26.44	32.74	2.52	15.36	53.87	1.73	0.14	0.41	0.03	15.05	1.63	149.93
2006	25.21	30.31	2.76	15.73	52.04	1.79	0.14	0.42	0.03	14.15	1.61	144.20
2007	25.05	31.28	3.52	15.16	51.26	1.79	0.13	0.47	0.03	15.07	1.67	145.43
2008	24.11	29.32	3.61	14.66	49.56	1.78	0.14	0.49	0.03	15.74	1.56	140.99
2009	23.79	27.57	4.14	13.91	47.60	1.74	0.14	0.51	0.03	15.95	1.41	136.79
2010	19.61	23.63	4.49	11.96	42.86	1.72	0.14	0.55	0.04	15.82	1.43	122.25
2011	15.26	18.45	4.35	9.18	33.49	1.73	0.14	0.55	0.04	16.01	1.47	100.67

In Table 6.18, N₂O emissions from liquid systems, solid storage and 'other' sources are shown.

Table 6.18 Trend in N₂O emissions due to manure management, (Gg)

Year	Liquid system	Solid storage	Other	TOTAL
(Gg)				
1990	0.62	12.03	-	12.65
1995	0.57	11.54	0.09	12.20
2000	0.54	11.36	0.56	12.46
2001	0.54	11.59	0.78	12.91
2002	0.52	11.05	0.84	12.42
2003	0.52	10.92	0.89	12.33
2004	0.51	10.59	0.89	11.98
2005	0.51	10.49	0.97	11.96
2006	0.50	10.16	0.95	11.61
2007	0.51	10.73	0.94	12.19
2008	0.51	10.71	0.96	12.18
2009	0.51	10.81	0.98	12.30
2010	0.49	10.48	0.97	11.94
2011	0.50	10.51	0.98	11.99

In 2011, N₂O emissions from manure management were 5% (11.99 Gg N₂O) lower than in 1990 (12.65 Gg N₂O). The major contribution is given by the ‘solid storage system’ with 88% (in 1990 with 95%).

6.3.4 Source-specific QA/QC and verification

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

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

Category/sub category	Parameter	Year of submission		Activities
		2014	2015	
Dairy cattle	N excretion	√		Still further efforts on theoretical assessment of N excretion data will be done based on N balance methodology (Gruber and Poesch, 2006).
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 have been analysed. According to experts from CRPA, information collected from SPA 2005 (housing data) needs to be validated with information from the Agricultural Census (CRPA, 2010).
Livestock categories	Slurry and solid manure storage facilities	√		We are analysing and verifying information coming from the Farm and Structure Survey 2007, where a query related to storage facilities for slurry and solid manure was incorporated. Validation will be executed with data coming from the 2010 Agricultural census.
Livestock categories	Production methods	√		Different queries have been incorporated in a specific section of the 2010 Agricultural census. Grazing, housing, storage systems and land spreading information will be collected.
Livestock categories	Average temperature		√	The distribution of animal in the temperate zones will be verified on the basis of animals provincial distribution from the 2010 Agricultural census and updated average temperatures.

6.3.5 Source-specific recalculations

No recalculations are observed.

6.3.6 Source-specific planned improvements

Future agricultural surveys will contribute to the improvement of the national agriculture emission inventory (Córdoba *et al.*, 2005; Córdoba and De Lauretis, 2009). Information from the FSS 2005 and FSS 2007 on

housing and storage systems, respectively, was analysed. Information obtained from these surveys will be validated with information from the Agricultural Census (CRPA, 2010). Furthermore, we expect that in the 2010 Italian Agricultural Census, detailed information on production systems will be obtained with an *ad hoc* survey. Final data from the census have been published at the end of 2012 from Istat and data will be analyzed during 2013. Finally, a specific research on land spreading practices finished at the end of 2009. Results need to be analysed before incorporating them for future submissions (CRPA, 2009). In addition, the distribution of animal in the temperate zones will be verified on the basis of animals provincial distribution from the 2010 Agricultural census and updated average temperatures.

For the dairy cattle category, the suggestions by the review process (UNFCCC, 2009) have been taken into consideration. Nitrogen excretion in Italy has been evaluated through a Nitrogen Balance Inter-regional Project (nitrogen balance in animal farms), funded by the Regional Governments of the most livestock-intensive Italian Regions. The N-balance methodology has been applied in real case farms, monitoring their normal feeding practice, without specific diet adaptation. In the project, the most relevant dairy cattle production systems in Italy have been considered. Contrary to what is normally found in European milk production systems, poor correlation between the N excretion and milk production has been found. Probably there are two reasons for explaining the absence of correlation: a) extreme heterogeneity in the protein content of the forage and in the use of the feed; b) the non optimisation of the protein diet of less productive cattle (De Roest and Speroni, 2005; CRPA, 2010). Still further efforts on theoretical assessment of nitrogen excretion data will be done based on nitrogen balance methodology (Gruber and Pötsch, 2006). An ad-hoc agro-environmental indicator group coordinated by the Ministry of Agriculture is working to determine gross nitrogen balances, therefore N coefficients will be revised. Parameters used for this submission are shown in Table 6.20.

Table 6.20 Parameters used for the different livestock categories in 2013 submission (Year 2011)

Livestock category			Average weight (kg) 2011	N excretion (kg N head ⁻¹ yr ⁻¹) 2011
DAIRY CATTLE			603	116
NON- DAIRY CATTLE				
Less than 1 year (*)			207(**)	24.4 (**)
From 1 year - less than 2 years				
	Male	for reproduction	557	66.8
		for slaughter	557	66.8
	Female	for breeding	405	67.6
		for slaughter	444	53.3
From 2 years and more				
	Male	for reproduction	700	84.0
		for slaughter and work	700	84.0
	Female	Breeding heifer	540	90.2
		Slaughter heifer	540	64.8
		Other dairy cattle	557	54.1
BUFFALO	Cow buffalo		630	116
	Other buffaloes		313	52.2
OTHER SWINE	Weight less than 20 kg		10	
	From 20 kg weight and under 50 kg		35	5.3
	From 50 kg and more			
	Boar		200	30.5
	For slaughter			
		from 50 to 80 kg	65	9.9
		from 80 to 110 kg	95	14.5
		from 110 kg and more	135	20.6
SOW			172.1	28.4 (**)
SHEEP	Sheep		51	16.2
	Other sheep		21	16.2
GOAT	Goat		54	16.2
	Other goat		15	16.2
EQUINE	Horses		550	50.0
	Mules and asses		300	50.0
POULTRY	Broilers		1.2	0.36
	Hen		1.8	0.66
	Other poultry		3.3	0.83
RABBIT	Female rabbits		4	2.5
	Other rabbit		1.3	0.8

(*) Categories included in less than 1 year are: calf, fattening male cattle, fattening heifer and heifer for replacement;

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

6.4 Rice cultivation (4C)

6.4.1 Source category description

For the rice cultivation category, only CH₄ emissions are estimated, other GHGs do not occur; N₂O from fertilisation during cultivation was estimated and reported in “Agricultural soils” under direct soil emissions - synthetic fertilizers. Methane emissions from rice cultivation have not been identified as a key source. In 2011, CH₄ emissions from rice cultivation were 73.8 Gg, which represent 10.7 % of CH₄ emissions for the agriculture sector (9.1% in 1990) and 4.2% for national CH₄ emissions (3.6% in 1990).

In Italy, CH₄ 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 regimes: single aeration (17.6 Gg) and multiple aeration (56.2 Gg).

In response to UNFCCC review processes from 2004 and 2005 (UNFCCC, 2005; UNFCCC, 2004) and in consultation with an expert in CH₄ emissions and rice cultivation (Wassmann, 2005), a detailed methodology was developed. New activity data and parameters are used for the estimation of CH₄ emissions (Córdor *et al.*, 2007[a]). For this purpose, an expert group on rice cultivation together with the C.R.A. – Experimental Institute of Cereal Research – Rice Research Section of Vercelli was established. Different national experts from the rice cultivation sector were also contacted¹⁰.

The quality of the Italian rice emission inventory was verified with the Denitrification Decomposition model (DNDC) model. Initial results have found a high correspondence between the EFs used for the Italian inventory and those simulated with DNDC model (Leip and Bocchi, 2007).

6.4.2 Methodological issues

For the estimation of CH₄ emissions from rice cultivation a detailed methodology was implemented following the IPCC guidelines (IPCC, 2006). We have considered country-specific circumstances. Parameters such as an adjusted integrated emission factor (kg CH₄ m⁻² day⁻¹), cultivation period of rice (days) and annual harvested area (ha) cultivated under specific conditions are considered. Information of the cultivated surface is collected 100% from rice farmers. Every year, data are collected on time by the National Rice Institute (ENR, 2013). Activity data information is shown in the following box.

Parameters used for the calculation of CH₄ emissions from rice cultivation

Parameters	Reference
Cultivated surface with “dry-seeded” technique (%)	ENR, 2012
Cultivated surface – national (ha)	ISTAT, 2013[d],[e]; ISTAT, several years [a],[b]; ENR, 2013
Cultivated surface by rice varieties (ha)	ENR, 2013
Cultivation period of rice varieties (days)	ENR, 2011
Methane emission factor (kg CH ₄ m ⁻² d ⁻¹)	Leip <i>et al.</i> , 2002; Schutz <i>et al.</i> , 1989[a], [b]
Crop production (t yr ⁻¹)	ISTAT, several years [a],[b]; ISTAT, 2013[d],[e]
Yield (t ha ⁻¹)	Estimations based on cultivated surface and crop production data
Straw incorporation (%)	Expert judgement (Tinarelli, 2005; Lupotto <i>et al.</i> , 2005)
Agronomic practices (%)	ISTAT, 2006[b]; Tinarelli, 2005; Lupotto <i>et al.</i> , 2005; Zavattaro <i>et. al.</i> , 2004; Baldoni & Giardini, 1989; Tinarelli, 1973; 1986
Scaling factors (SFw, SFp, SFO)	IPCC, 2006; Yan <i>et. al.</i> , 2005

Rice cultivation practice

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 and Regis, 2002). In Table 6.21, water regimes

¹⁰Stefano 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).

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 and Giardini, 1989). Another water regime system, present in southern Italy, is the sprinkler irrigation, which exists only on experimental plots and could contribute to the diffusion of rice cultivation in areas where water availability is a limiting factor (Spanu et al., 2004; Spanu and Pruneddu, 1996).

Table 6.21 Water regimes in Italy and classification according to IPCC guidelines

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

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

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 planted in dry soil is generally managed as a dry crop until it reaches the 3-4 leaf stage. After this period, the rice is flooded and grows in continuous submersion, as in the conventional system (Ferrero and Nguyen, 2004; Russo, 1994).

During the cultivation period, water is commonly kept at a depth of 4-8 cm, and drained away 2-3 times during the season to improve crop rooting, to reduce algae growth and to allow application of herbicides. Rice fields are drained at the end of August to allow harvesting, once in a year (Ferrero and Nguyen, 2004; Baldoni and 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 and 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 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 CH₄ daily EF (kg CH₄ m⁻² d⁻¹) was done. Different scientific publications related to the CH₄ daily EF measurements in Italian rice fields were revised (Marik *et al.*, 2002; Leip *et al.*, 2002; Dan *et al.*, 2001; Butterbach-Bahl *et al.*, 1997; Schutz *et al.*, 1989[a], [b]; Holzapfel-Pschorn & Seiler, 1986). Other publications indirectly related with CH₄ production were also considered (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 EFs of two cultivation periods (1990 and 1991). In these consecutive years, fields planted with rice cultivar Lido showed a level of CH₄ 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 CH₄ emission factor for years 1998 and 1999; values are similar to those presented in previous publications (Schutz *et al.*, 1989[a], [b]; Holzapfel-Pschorn & Seiler, 1986). Leip *et al.* have published specific CH₄ EF for the so called dry-seeded with delay flooding, as shown in Table 6.21. The dry-seeded technique could bring interesting benefits in emission reduction, since lower emission rates compared with normal agronomic practices were determined experimentally.

The estimation of CH₄ emissions for the rice cultivation category considers an irrigated regime, which includes intermittently flooded with single aeration and multiple aeration regimes. The CH₄ emission factor is 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 (*SF_w*), scaling factor to account for the differences in water regime in the pre-season status (*SF_p*) and scaling factor which varies for both types and amount of amendment applied (*SF_o*). Scaling factor parameters have been updated according to literature (Yan *et al.*, 2005) and the IPCC 2006 Guidelines (IPCC, 2006).

Assumptions of agronomic practices, and parameters used for CH₄ emission estimations are shown in Table 6.21 and Table 6.22, respectively.

Total CH₄ emissions for rice cultivation in 2011 were 73.8 Gg.

Table 6.22 Parameters used for estimating CH₄ emissions from rice cultivation in 2011

Rice cultivation water regimes: Intermittently flooded	Single aeration	Multiple aeration	Multiple aeration
Type of seeding	Dry-seeded	Wet-seeded (<i>classic</i>)	Wet-seeded (<i>red rice control</i>)
Surface (ha)	73,118	78,040	95,383
Daily EF (g CH ₄ m ⁻² d ⁻¹)	0.20	0.28	0.28
<i>SF_w</i>	0.60	0.52	0.52
<i>SF_p</i>	0.68	0.68	0.68
<i>SF_o</i>	2.1	2.1	2.1
Adjusted daily EF (g CH ₄ m ⁻² d ⁻¹)	0.17	0.21	0.21
Days of cultivation (days)	138	155	155
Seasonal EF (g CH ₄ m ⁻² yr ⁻¹)	24.07	32.40	32.40
Methane emissions (Gg)	17.60	25.29	30.91

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 2011, CH₄ emissions from rice cultivation were 1.7% (73.8 Gg CH₄) lower than in 1990 (75.06 Gg CH₄). In Italy, the driving force of CH₄ emissions from rice cultivation is the harvest area and the percentage of single aerated surface (lower CH₄ emission factor). From 1990-2011, the harvest area has increased by 14%, from 215,442 ha year⁻¹ (1990) to 246,541 ha year⁻¹ (2011). The percentage of single aerated surface has increased from 1% (1990) to 29.7% (2011). Water regime trends were estimated together with expert judgement expertise (Tinarelli, 2005; Lupotto *et al.*, 2005) and national available statistics (ENR, 2013). In Table 6.23, CH₄ emissions from rice cultivation and harvested area are shown.

Table 6.23 Harvest area and CH₄ emissions from the rice cultivation sector

Year	Harvested area (10 ⁹ m ² yr ⁻¹)	CH ₄ emissions (Gg) 2013 submission
1990	2.15	75.06
1991	2.06	71.64
1992	2.16	74.39
1993	2.32	78.00
1994	2.36	79.98
1995	2.39	79.56
1996	2.38	78.37
1997	2.33	77.82
1998	2.23	73.50
1999	2.21	72.00
2000	2.20	66.26
2001	2.18	66.19
2002	2.19	68.52
2003	2.20	70.00
2004	2.30	73.04
2005	2.24	70.11
2006	2.29	70.23
2007	2.33	72.18
2008	2.24	65.99
2009	2.38	74.51
2010	2.48	74.54
2011	2.47	73.80

6.4.4 Source-specific QA/QC and verification

In Table 6.24, improvements according to the QA/QC plan are shown.

Table 6.24 Improvements for the rice cultivation category according to the QA/QC plan

Category/sub category	Parameter	Year of submission 2014	Activities
Activity data	Days of cultivation and cultivars	√	
Rice	Emission factor	√	Information on days of cultivation for new varieties will be collected. We have contacted DG Joint Research Centre Institute for Environment and Sustainability - Climate Change Unit, in charge of measuring rice paddy fields in Italy. New measurements have been done since 2007. The use of updated information on EFs is under evaluation.

6.4.5 Source-specific recalculations

No recalculations are observed.

6.4.6 Source-specific planned improvements

Lack of experimental data and knowledge about the occurrence and duration of drainage periods in Italy is the major cause of uncertainty. Moreover, it is not easy to quantify the surface where the traditional or 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 the 2006 submission, a trend in water regime has been calculated together with expert judgement expertise (Tinarelli, 2005; Lupotto *et al.*, 2005) and available statistics (Centro Ricerche sul Riso, 2006). Provincial estimations on the basis of the relation between emissions and temperature would result in further possible improvements, even if enhancement would be limited since the largest Italian rice production is in the Po valley, where monthly temperatures of the rice paddies are similar. In 1990, *Piemonte* and *Lombardia* regions represented 95% of the national surface area of rice cultivation, while in 2011 they represented 92% (ENR, 2013; Confalonieri and Bocchi, 2005).

6.5 Agriculture soils (4D)

6.5.1 Source category description

In 2011, N₂O emissions from agricultural soils were 49.59 Gg, representing 80.5% of N₂O emissions for the agriculture sector (83.2% in 1990) and 57.2% for national N₂O emissions (52.1% in 1990). N₂O emissions from this source consist of direct soil (23.71 Gg), animal production (5 Gg) and indirect soil (20.88 Gg) emissions.

Direct and indirect N₂O emissions from agricultural soils are key sources at level and trend assessment, both with Approach 1 and Approach 2. Animal Production is a key source at level assessment with Approach 2, taking into account the uncertainty.

In Italy, agricultural soil emissions are estimated for direct and indirect soils and animal production. For direct soil emissions the following sources are estimated: synthetic fertilizers, animal waste applied to soil, N-fixing crops, crop residues, cultivation of histosols and sewage sludge applied to soils. For indirect soil emissions, atmospheric deposition and nitrogen leaching and run-off are 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”.

ISPRA is in charge of collecting, elaborating and reporting the UNFCCC/CLRTAP agriculture national emission inventory (APAT, 2005), thus, consistency among methodologies and parameters is verified. Since 2006 submission, the UNFCCC/CLRTAP inventory has updated country-specific nitrogen excretion rates and EFs. The nitrogen balance coming from the CLRTAP emission inventory feeds the UNFCCC inventory, specifically for the estimation of FRAC_{GASM} and FRAC_{GASF} parameters, used for calculating F_{AM} and F_{SN}. Following recommendations from the UNFCCC ERT, direct and indirect N₂O emissions from the use of sewage sludge in agricultural soils have been estimated (UNFCCC, 2010[b]).

6.5.2 Methodological issues

Methodologies used for estimating N₂O emissions from “Agricultural soils” follow the IPCC approach. Emission factors suggested by the IPCC (IPCC, 1997) and by the Research Centre on Animal Production (CRPA, 2000; CRPA, 1997[b]) are used. Activity data used for estimations are shown in the following box.

Data used for estimating agricultural soil emissions

Data	Reference
Fertilizer distributed (t/yr)	ISTAT, 2013[c]; ISTAT, several years [a], [b]
Nitrogen content (%)	ISTAT, 2013[c]; ISTAT, several years [a], [b]
N excretion rates (kg head ⁻¹ yr ⁻¹)	CRPA, 2006[a]; GU, 2006; Xiccato <i>et al.</i> , 2005
Cultivated surface (ha yr ⁻¹)	ISTAT, 2013[d],[e]; ISTAT, several years [a], [b]
Annual crop production (t yr ⁻¹)	ISTAT, 2013[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

Data	Reference
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, 2013[a]; ISTAT, several years [a], [b]

In Table 6.26 and Table 6.27, time series of cultivated surface and crop production used for the preparation of the inventory are shown. In Table 6.25 the time series of the nitrogen content from fertilizers are shown.

For estimating N₂O direct soil emissions, the IPCC approach is followed, and some modifications were included because of country-specific peculiarities (IPCC, 2000; IPCC, 1997). N₂O-N emissions are estimated from the amount of synthetic fertilizers (F_{SN}), animal waste applied to soil (F_{AM}), N-fixing crops (F_{BN}), crop residues (F_{CR}), cultivation of histosols (F_{OS}) and sewage sludge applied to soils (F_{SEWAGE}). Then default IPCC emission factors (IPCC, 2000) are applied. Afterwards, N₂O-N emissions are converted to N₂O emissions, multiplying by the 44/28 coefficient. Animal Production emissions are estimated according to the methodology described in section 6.3.2 for manure management. Indirect emissions are estimated as suggested by IPCC (IPCC, 1997). As requested in a previous review process (UNFCCC, 2005) a review of the FRAC_{LEACH} parameter was done. Italy verified that the IPCC default is similar to the country-specific reference value reported from the main regional basin authority - Po Valley (ADBPO, 2001; ADBPO, 1994).

Direct emissions

Synthetic fertilizers (F_{SN})

The total use of synthetic fertilizer (expressed in t N year⁻¹) is estimated for each type of fertilizer (see Table 6.25). The calculation of synthetic fertilizer use (F_{SN}) is obtained by multiplying the total use of fertilizer by (1- FRAC_{GASF}). FRAC_{GASF} parameter is estimated for the whole time series, following the IPCC definition, where the total N-NH₃ and N-NO_x emissions from fertilizers are divided by the total nitrogen content of fertilizers. N₂O emissions for synthetic fertilizers is obtained multiplying F_{SN} by the emission factor, 0.0125 kg N-N₂O/kg N (IPCC, 1997). In 2008 submission, a specification for “Other nitrogenous fertilizers” was introduced (ENEA, 2006). This improvement was introduced since 1998, because activity data is available from that year.

The time series of nitrogen content of fertilizers is shown in Table 6.31. In 2011, the total use of synthetic fertilizers was 515,966 t N, while F_{SN} parameter was 467,653 t N (see Table 6.28).

Table 6.25 Total use of synthetic fertilizer in 2011 (t N yr⁻¹)

Type of fertilizers	Fertilizers distributed (t yr ⁻¹)	Nitrogen content (%)	Nitrogen content of synthetic fertilizers (t N yr ⁻¹)
Ammonium sulphate	130,645	20.99%	27,418
Calcium cyanamide	23,614	19.80%	4,675
Nitrate (*)	270,850	26.71%	72,334
Urea	478,306	45.79%	219,033
Other nitric nitrogen	116,277	29.36%	3,479
Other ammoniacal nitrogen	-	-	12,993
Other amidic nitrogenous	-	-	17,663
Phosphate nitrogen	270,292	17.49%	47,272
Potassium nitrogen	98,608	18.01%	17,758
NPK nitrogen	535,944	12.21%	65,444
Organic mineral	320,213	8.71%	27,897
TOTAL	2,244,750		515,966

(*) includes ammonim nitrate < 27% and ammonium nitrate > 27% and calcium nitrate

Animal waste applied to soil (F_{AM})

The manure nitrogen corrected for NH_3 and NO_x emissions, excluding manure produced during grazing ($kg\ N\ yr^{-1}$), is calculated with the IPCC methodology (IPCC, 1997). It uses country-specific nitrogen excretion rates (CRPA, 2006[a]; GU, 2006; Xiccato *et al.*, 2005). A country-specific $FRAC_{GASM}$ parameter is estimated and used for the calculation of the animal waste applied to soil. The $FRAC_{GASM}(\text{direct})$ and $FRAC_{GASM}(\text{indirect})$ parameters are reported in Table 6.28. The estimation has followed the IPCC definition; therefore, NH_3 and NO_x emissions from animal manure are divided by the total nitrogen excreted. The F_{AM} ($t\ yr^{-1}$) value is estimated by summing the F_{AM} for each livestock category; then emissions are calculated with emission factor $0.0125\ kg\ N-N_2O/kgN$ (IPCC, 1997). In 2011, F_{AM} parameter was 437,360 t N.

For verification purposes, the $FRAC_{GASM}(\text{direct})$ parameter have been also estimated as a fraction of nitrogen recovered and stored that is emitted as $N-NH_3-NO_x$. This value is equal to 0.392 and 0.358 in 1990 and 2011 respectively.

N-fixing crops (F_{BN})

Nitrogen input from N-fixing crops (F_{BN} , $kg\ N\ yr^{-1}$) is calculated with a country-specific methodology. Peculiarities that are present in Italy were considered: N-fixing crops and legumes forage. F_{BN} is calculated with two parameters: cultivated surface and nitrogen fixed per hectare (Erdam 1959 in Giardini, 1983). Emissions are calculated using the default emission factor $0.0125\ kg\ N-N_2O/kgN$ (IPCC, 1997). In Table 6.26, cultivated surface from N-fixing species ($ha\ yr^{-1}$) and N fixed by each species ($kg\ N\ ha^{-1}\ yr^{-1}$) are shown. In 2011 F_{BN} parameter was 167,385 t N (see Table 6.28).

Table 6.26. Cultivated surface (ha) and nitrogen fixed by each variety ($kg\ N\ ha^{-1}\ yr^{-1}$)

	N fixed	1990	1995	2000	2008	2009	2010	2011
	($kg\ N\ ha^{-1}\ yr^{-1}$)				(ha)			
Bean, fresh seed	40	29,096	23,943	23,448	20,736	20,108	19,027	20,292
Bean, dry seed	40	23,002	14,462	11,046	5,972	6,290	7,001	6,235
Broad bean, fresh seed	40	16,564	14,180	11,998	9,547	8,563	8,487	7,440
Broad bean, dry seed	40	104,045	63,257	47,841	54,310	49,784	52,108	43,477
Pea, fresh seed	50	28,192	21,582	11,403	12,854	15,295	8,691	24,026
Pea, dry seed	72	10,127	6,625	4,498	10,378	10,751	11,692	10,770
Chickpea	40	4,624	3,023	3,996	5,265	5,929	6,813	5,830
Lentil	40	1,048	1,038	1,016	1,821	1,868	2,458	2,156
Tare	80	5,768	6,532	6,500	6,500	6,500	6,500	6,500
Lupin	40	3,303	3,070	3,000	3,000	3,000	3,000	3,000
Soya bean	58	521,169	195,191	256,647	107,795	134,704	159,511	165,955
Alfalfa	194	987,000	823,834	810,866	712,674	720,382	745,244	728,034
Clover grass	103	224,087	125,009	114,844	98,301	100,484	103,241	101,819
TOTAL		1,958,025	1,301,746	1,307,102	1,049,153	1,083,659	1,133,772	1,125,533

Crop residues (F_{CR})

For the estimation of nitrogen input from crop residues (F_{CR}), a country-specific methodology is used. The total amount of crop residues is estimated ($t\ dry\ matter\ yr^{-1}$) by 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) is the available activity data, only the crop residue production ($t\ dry\ matter\ ha^{-1}\ yr^{-1}$) parameter is used to assess total amount of crop residues.

The nitrogen content from cereals, legumes, tubers and roots and legumes forages crop residues ($t\ N\ yr^{-1}$) are estimated by multiplying the total amount of crop residue as dry matter with 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 is obtained

converting protein content in dry matter, dividing by factor 6.25. The F_{CR} parameter is obtained by adding the nitrogen content of cultivars crop residues. In 2011, F_{CR} parameter was 119,362 t N (see Table 6.28). Emissions are calculated with emission factor 0.0125 kg N-N₂O/kg N (IPCC, 1997). The crop residues production is shown in Table 6.27.

Table 6.27 Cultivated surface, crop production and total residue production time series

Year	Cultivated surface^(*) (ha)	Crop production^(*) (t)	Total residue production (dry matter)
1990	2,128,674	82,247,958	20,719,032
1995	1,484,453	81,343,949	20,466,710
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	81,403,175	21,351,753
2005	1,338,663	84,706,239	20,800,493
2006	1,352,385	71,186,530	19,239,493
2007	1,242,481	69,147,007	18,845,035
2008	1,220,887	68,508,147	19,419,500
2009	1,258,535	62,564,634	16,914,244
2010	1,309,926	63,501,859	17,337,605
2011	1,304,417	64,100,854	17,906,847

(*)Cultivated surface and crop production are related to different crops.

Cultivation of histosols (F_{os})

In Italy, the area of organic soils cultivated annually (histosols) is estimated to be 9,000 hectares for the whole time series (CRPA, 1997[b]). This value is multiplied by 8 kg N-N₂O ha⁻¹ yr⁻¹, as suggested by IPCC (IPCC, 2000). The data for surface area, reproduced in the national soil map of the year 1961, were supplied by the Experimental Institute for the study and protection of soil in Florence (ISSDS). These values have been verified with related data for Emilia Romagna region, where this type of soil is most prevalent. The data are consistent with figures used for estimation in the LULUCF sector.

Table 6.28 Parameters used for the estimation of direct and indirect N₂O emissions

Year	F _{SN} (t N)	F _{AM} (t N)	F _{BN} (t N)	F _{CR} (t N)	F _{SEWAGE} (t N)	FRAC _{GASF}	FRAC _{GASM} (direct)	FRAC _{GASM} (indirect) (*)
1990	691,723	473,906	254,654	147,541	4,057	0.087	0.319	0.328
1995	726,343	453,464	191,018	142,216	6,510	0.089	0.298	0.308
2000	715,366	457,677	189,545	144,372	8,763	0.089	0.286	0.296
2001	737,063	467,385	182,928	137,779	12,861	0.089	0.299	0.307
2002	745,286	453,323	177,529	142,457	12,271	0.090	0.297	0.305
2003	750,296	452,988	175,154	119,184	11,718	0.090	0.296	0.304
2004	765,064	440,086	172,532	143,172	6,444	0.091	0.293	0.302
2005	710,888	439,819	176,624	145,247	7,099	0.088	0.293	0.301
2006	713,369	430,481	175,243	128,431	6,222	0.092	0.290	0.299
2007	694,048	446,822	160,575	125,878	6,644	0.093	0.292	0.301
2008	595,641	445,587	160,572	126,173	7,073	0.097	0.291	0.300
2009	469,086	448,007	163,797	113,568	9,092	0.096	0.292	0.301
2010	449,972	435,206	170,215	115,859	8,993	0.094	0.291	0.300
2011	467,653	437,360	167,385	119,362	9,486	0.094	0.291	0.300

(*) FRAC_{GASM} (indirect) is reported in the Table4.Ds2 as “other fractions”

Sewage sludge applied to soils (F_{SEWAGE})

Direct and indirect N₂O emissions from the application of sewage sludge to agricultural soils were calculated using the tier 1 methodology described in the IPCC GPG (IPCC, 2000). Direct emissions were estimated by applying the relevant default IPCC equations, EFs and parameters (see Annex A7.3). From 1995 to 2009 activity data (amount of sewage sludge) and parameters (N content) were collected from the Ministry for the Environment, Land and Sea, which is in charge of collecting and reporting data under the EU Sewage Sludge Directive 86/278/EEC (MATTM, 2010). From 1990 to 1994 AD and parameters were reconstructed, description is available in the Waste Chapter. The amount of sewage N applied was calculated using the amount of sewage sludge (expressed in t dry matter) and the N content of sludge. Emission factor used was 0.0125 kg N-N₂O/kg N and the volatilization factor was 20% for N-NH₃+NO_x emissions (IPCC, 1997).

Animal production

As mentioned in section 6.3.2, when estimating N₂O 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 (kg head⁻¹yr⁻¹) used for estimations are shown. N₂O emissions are estimated with the total nitrogen excreted from grazing (include all livestock categories), number of animals, and an EF of 0.02 kg N₂O-N/kg N excreted (IPCC, 1997).

Indirect emissions

For indirect emissions from agricultural soils the following parameters are estimated:

- Atmospheric deposition
- Nitrogen leaching and run-off

For estimating of N₂O emissions due to atmospheric deposition of NH₃ and NO_x the IPCC approach was followed (IPCC, 1997). Parameters which are used are the: total use of synthetic fertilizer (t N yr⁻¹), FRAC_{GASF} emission factor, total N excreted by livestock (kg head⁻¹yr⁻¹), FRAC_{GASM} emission factor, total use of sewage sludge to agricultural soils (see Table 6.28), FRAC_{SLUDGE} emission factor (the volatilization factor for N-NH₃+NO_x emissions) and emission factor 0.01 kg N₂O-N per kg NH₃-N + NO_x-N emitted (IPCC, 2000; IPCC, 1997). The estimation of N₂O emissions due to nitrogen leaching and run-off has followed the IPCC approach (IPCC, 1997). Parameters which are used are the: total use of synthetic fertilizer, t N yr⁻¹ (see Table 6.25), total N excreted by livestock (kg head⁻¹ yr⁻¹), total use of sewage sludge to agricultural soils, FRAC_{LEACH} emission factor 0.3 N/kg nitrogen of fertilizer or manure and the emission factor 0.025 Kg N₂O-N per kg nitrogen leaching/run-off (IPCC, 2000; IPCC, 1997). As mentioned before, the FRAC_{LEACH} IPCC

default value was compared with the country-specific $FRAC_{LEACH}$ parameter (ADBPO, 2001; ADBPO, 1994). So called, indirect emissions from sewage sludge applied to soils are included in the atmospheric deposition and N leaching estimations.

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) has been estimated to be 102%, as combination of 20% and 100% for activity data and emission factor, respectively.

In the 2012 submission, Montecarlo analysis was also applied to estimate uncertainty of the two key categories *Direct N_2O emissions from agricultural soils* and *Indirect N_2O emissions from nitrogen used in agriculture*. The resulting figures were 21.34% and 21.67% for *Direct and Indirect N_2O emissions*, respectively. Normal and lognormal distributions have been assumed for the parameters; at the same time, whenever assumptions or constraints on variables were known this information has been appropriately reflected on the range of distribution values. A summary of the results is reported in Annex 1.

In Table 6.29, time series of N_2O emissions are reported.

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

Year	Direct Soil Emissions	Animal Production	Indirect Soil emissions	TOTAL
(Gg)				
1990	30.99	5.60	26.26	62.85
1995	29.96	6.44	26.24	62.64
2000	29.89	6.60	25.90	62.39
2001	30.32	5.18	25.88	61.38
2002	30.18	5.03	25.51	60.72
2003	29.76	4.93	25.45	60.15
2004	30.11	4.98	25.24	60.34
2005	29.18	4.90	24.31	58.39
2006	28.67	5.02	24.20	57.89
2007	28.28	5.06	24.44	57.79
2008	26.34	5.06	23.05	54.45
2009	23.75	5.02	21.23	50.01
2010	23.30	4.98	20.56	48.84
2011	23.71	5.00	20.88	49.59

In 2011, N_2O emissions from agricultural soils were 21.1% (49.59 Gg N_2O) lower than in 1990 (62.85 Gg N_2O). Major contributions were given by direct soil (23.71 Gg) and indirect soil emissions (20.88 Gg). Indirect N_2O emissions from nitrogen leaching and run-off sub-category have the highest individual contribution with respect to total 4D N_2O emissions, equal to 32.5% (16.13 Gg N_2O). N_2O 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 N fertilizers and the animal number trends. In 2011, the second individual source with respect to total N_2O emissions was the direct emissions of synthetic fertilizers with 9.19 Gg (18.5%), followed by animal wastes applied to soils, with 8.59 Gg (17.3%). The time series of N_2O emissions from 4D is shown in Table 6.30. Between 1996 and 1997 there was a high increase in the use of nitrogen fertilizers in Italy, thus, emissions could be identified as outlier. Between 2007/2008 (-14%) and 2008/2009 (-21%) N fertiliser distribution has decreased. In 2010 the same trend was observed. According to the Italian Fertilizer Association (AIF) the use of fertilisers is determined by their cost and particularly by the price of agricultural products. In the last years, prices have decreased and, as a result, farmers need to save costs, consequently, less fertilisers is being used (Perelli, 2007; De Corso 2008).

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

Year	Direct N ₂ O emissions						Animal Production	Indirect N ₂ O emissions	
	Synthetic fertilizer	Animal Wastes	N-fixing Crops	Crop Residue	Histosols	Sewage sludge		Atmospheric Deposition	Nitrogen Leaching and Run-off
	Gg						Gg	Gg	
1990	13.59	9.31	5.00	2.90	0.11	0.08	5.60	5.99	20.28
1995	14.27	8.91	3.75	2.79	0.11	0.13	6.44	5.69	20.55
2000	14.05	8.99	3.72	2.84	0.11	0.17	6.60	5.49	20.41
2001	14.48	9.18	3.59	2.71	0.11	0.25	5.18	5.54	20.35
2002	14.64	8.90	3.49	2.80	0.11	0.24	5.03	5.39	20.11
2003	14.74	8.90	3.44	2.34	0.11	0.23	4.93	5.35	20.10
2004	15.03	8.64	3.39	2.81	0.11	0.13	4.98	5.25	20.00
2005	13.96	8.64	3.47	2.85	0.11	0.14	4.90	5.10	19.22
2006	14.01	8.46	3.44	2.52	0.11	0.12	5.02	5.06	19.14
2007	13.63	8.78	3.15	2.47	0.11	0.13	5.06	5.21	19.24
2008	11.70	8.75	3.15	2.48	0.11	0.14	5.06	5.08	17.97
2009	9.21	8.80	3.22	2.23	0.11	0.18	5.02	4.87	16.36
2010	8.84	8.55	3.34	2.28	0.11	0.18	4.98	4.71	15.85
2011	9.19	8.59	3.29	2.34	0.11	0.19	5.00	4.75	16.13

6.5.4 Source-specific QA/QC and verification

Synthetic fertilizers and nitrogen content are compared with the international FAO agriculture database statistics (FAO, 2013). 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 nitrogen content is considered for each substance, while FAO utilises default values. Besides, differences could also derive from different products classification. From a meeting held in July 2011 with the FAO officer in charge of the fertiliser database, ISPRA verified that there are two FAO databases for fertilisers. In Table 6.31 an archive and a new database are presented. Differences between FAO and national statistics will be overcome as soon as the same classification is used.

Table 6.31 Total annual N content in fertilizer applied from 1990 to 2011

Year	National data (t N)	FAO database (Nitrous fertilizer consumption, Mt)	FAO new 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	845,003
2003	824,649	Not available	846,812
2004	841,363	Not available	866,469
2005	779,846	Not available	800,697

Year	National data (t N)	FAO database (Nitrous fertilizer consumption, Mt)	FAO new database (Nitrous fertilizer consumption, Mt)
2006	785,265	Not available	798,807
2007	765,490	Not available	812,480
2008	659,922	Not available	670,261
2009	518,778	Not available	486,728
2010	496,637	Not available	498,605
2011	515,966	Not available	Not available

6.5.5 Source-specific recalculations

N₂O emissions have been recalculated for the whole time series due to the update of N content of sludge (due to a correction of the value of 1999, an update of the estimates for the period 1990-1997 and an update of the amount of sewage sludge applied to soils in 2010), the update of activity data (cultivated surface/crop production of some crops) in 2010 and the update of the FRAC_{GASM} parameter for the sows category (for the period 1998-2005), due to corrections of ammonia emissions from N excreted in housing and an update of emission factor of the storage of N excreted (for the period 2006-2010). New estimates provide a substantial confirmation of previous data, with a maximum increase rate of emissions equal to 0,12% in 1999 and a maximum decrease rate of 0.13% in 2010.

6.5.6 Source-specific planned improvements

In Table 6.32, planned improvements for this category are presented.

Table 6.32 Improvements for the agricultural soils category

Category/sub category	Parameter	Year of submission 2014	Activities
Activity data	Land spreading	√	Figures on land spreading collected in the framework of the 2010 Agricultural Census will be compared with those used in the inventory.

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 a key source. In 2011, CH₄ emissions from this source were 0.64 Gg, representing 0.09% of emissions for the agriculture sector. N₂O emissions were 0.014 Gg, representing 0.02% of emissions for the agriculture sector.

6.6.2 Methodological issues

A country-specific methodology is used for estimating emissions from field burning of agriculture residues. Different IPCC parameters are considered, such as amount of residues produced, amount of dry residues, total biomass burned, and total carbon and nitrogen released. Activity data (agricultural production) used for estimating burning of agriculture residues is summarised in the following box (see Table 6.33).

Data used for estimating field burning of agriculture residues emission

Data	Reference
Annual crop production	ISTAT, 2013[d],[e]; 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

Data	Reference
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 ₂ O)	IPCC, 1997

The same methodology is used to estimate emissions from burning of agriculture residues. Emissions from fixed residues and stubble, burnt on open fields, are reported in this category (4F) while emissions from removable residues burnt off-site, are reported under the waste sector (waste incineration - 6C category).

Table 6.33 Time series of activity data (t) used for 4F estimations

Year	Agricultural production						
	Wheat	Barley	Maize	Oats	Rye	Rice	Sorghum
	(t)						
1990	8,108,500	1,702,500	5,863,900	298,400	20,800	1,290,700	114,200
1995	9,415,700	1,792,900	6,237,700	359,400	18,800	1,235,600	149,500
2000	8,938,400	1,742,087	7,394,100	333,100	22,586	1,271,600	178,700
2001	8,169,800	1,634,200	8,028,900	372,200	22,800	1,305,100	226,800
2002	8,251,401	1,467,378	7,483,438	354,660	20,295	1,360,519	236,060
2003	7,946,081	1,387,069	8,454,164	301,322	19,780	1,320,851	214,802
2004	8,424,492	1,350,494	9,547,541	351,622	20,400	1,359,697	209,191
2005	6,758,351	1,179,575	10,004,700	310,706	19,000	1,442,400	173,570
2006	8,338,301	1,359,076	9,054,600	362,627	20,100	1,407,100	159,872
2007	7,742,782	1,313,323	10,017,178	331,150	12,363	1,427,130	202,370
2008	7,427,660	1,261,560	10,139,639	317,926	10,292	1,245,555	215,200
2009	6,413,329	1,125,720	10,556,185	310,087	8,588	1,272,952	213,992
2010	7,547,763	1,190,326	10,554,423	328,759	9,631	1,378,796	215,072
2011	6,229,454	1,020,838	8,702,289	306,425	6,941	1,448,212	158,217

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

- Amount of “fixed” residues (t), estimated with annual crop production, removable residues/product ratio, and “fixed” residue/removable residues ratio.
- Amount of dry residues in “fixed” residue (t dry matter), calculated with amount of fixed residues and fraction of dry matter.
- Amount of “fixed” dry residues oxidized (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.
- Amount of carbon from stubble burning release in air (t C), calculated with the amount of “fixed” dry residue oxidized and the fraction of carbon from the dry matter of residues.
- C-CH₄ from stubble burning (t C-CH₄), calculated with the amount of carbon from stubble burning release in air and default emissions rate for C-CH₄, equal to 0.005 (IPCC, 1997).

In 2011, final CH₄ emissions from on field burning of agriculture residues (0.64 Gg CH₄) have been estimated multiplying the C-CH₄ value (0.476 Gg C-CH₄) by the coefficient 16/12.

In Table 6.34, parameters used for estimating of CH₄ emissions from on field burning of agriculture residues are shown.

Table 6.34 Parameters used for the estimation of CH₄ emissions from agriculture residues in 2011

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-CH ₄ from stubble burning (t C-CH ₄)
Wheat	6,642	1,146	977	86	42	208
Rye	14	3	2	0	0	0
Barley	951	190	163	15	5	27
Oats	297	52	45	4	2	8
Rice	1,556	261	195	106	44	219
Maize	9,752	975	406	0	0	0
Sorghum	300	105	87	8	3	15
TOTAL	19,512	2,731	1,876	218	95	476

For estimating N₂O emissions, the same amount of “fixed” dry residue oxidized described above were used; further parameters are:

- Amount of nitrogen from stubble burning release in air (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.
- N-N₂O from stubble burning (t N-N₂O), calculated with the amount of nitrogen from stubble burning release in air and the default emissions rate for N- N₂O, equal to 0.007 (IPCC, 1997).

In 2011, final N₂O emissions from on field burning of agriculture residues (0.014 Gg N₂O) are estimated by multiplying the N-N₂O value (0.009 Gg N) with the coefficient 44/28.

Table 6.35 shows the parameters for the estimation of N₂O emissions from field burning of agriculture residues.

Table 6.35 Parameters used for the estimation of nitrous oxide from agriculture residues in 2011

Crop	Amount of “fixed” dry residue oxidized (t 1000 dry matter)	Raw protein content from residues (dry matter fraction)	Fraction of nitrogen from the dry matter of residues	Amount of nitrogen from stubble burning (t 1000 N)	N-N ₂ O from stubble burning (t N-N ₂ O)
Wheat	85.6	0.030	0.005	0.411	2.9
Rye	0.2	0.036	0.006	0.001	0.01
Barley	14.7	0.037	0.006	0.087	0.6
Oats	4.0	0.040	0.006	0.026	0.2
Rice	105.5	0.041	0.007	0.692	4.8
Maize	0		0.007	0.000	0
Sorghum	7.8	0.037	0.006	0.046	0.3
TOTAL	217.9			1.263	8.8

6.6.3 Uncertainty and time-series consistency

Uncertainties for CH₄ and N₂O 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 2011, CH₄ emissions from field burning of agriculture residues were 0.64 Gg emissions of CH₄ and 0.014 Gg emissions of N₂O emissions (see Table 6.36). Variation in emissions trend is related to cereal production trends.

Table 6.36 CH₄ and N₂O emission trends from field burning of agriculture residues (Gg)

Year	CH₄ (Gg)	N₂O (Gg)
1990	0.6232	0.0130
1995	0.6157	0.0129
2000	0.6168	0.0131
2001	0.5741	0.0124
2002	0.6444	0.0138
2003	0.5915	0.0129
2004	0.7164	0.0152
2005	0.6664	0.0143
2006	0.6493	0.0140
2007	0.6600	0.0143
2008	0.6939	0.0145
2009	0.6479	0.0143
2010	0.6433	0.0140
2011	0.6352	0.0139

6.6.4 Source-specific QA/QC and verification

In response to the review process (UNFCCC, 2007) and in order to verify the national assumption, which considered that 10% of the cultivated surface (cereals) is burned in Italy, a specific elaboration of data was done (FSS 2003). ISTAT provided information regarding the regional practise of field burning (cereals). We have confirmed the assumption with data coming from national agricultural statistics (ISTAT, 2007[c]).

6.6.5 Source-specific recalculations

CH₄ and N₂O emissions have been recalculated for the period 1996-2010 due to the update of the fraction of the field where “fixed” residues are burned for the rice production. New values are consistent with the parameters of the rice cultivation category.

6.6.6 Source-specific planned improvements

No specific improvements are planned.

7 Land Use, Land Use Change and Forestry [CRF sector 5]

7.1 Sector overview

CO₂ emissions and removals occur as a result of changes in land-use and from forestry. The sector is responsible for 30.8 Mt of CO₂ removals from the atmosphere in 2011.

The 2003 IPCC Good Practice Guidance for LULUCF has been entirely applied for all the categories of this sector as detailed data were available from national statistics and from research at national and regional level, whereas for category 5A (Forest Land) estimates were supplied by a growth model, applied to national forestry inventory data, with country specific emission factors.

CO₂ emissions from forest fires have been considered 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 2011 are shown in Figure 7.1.

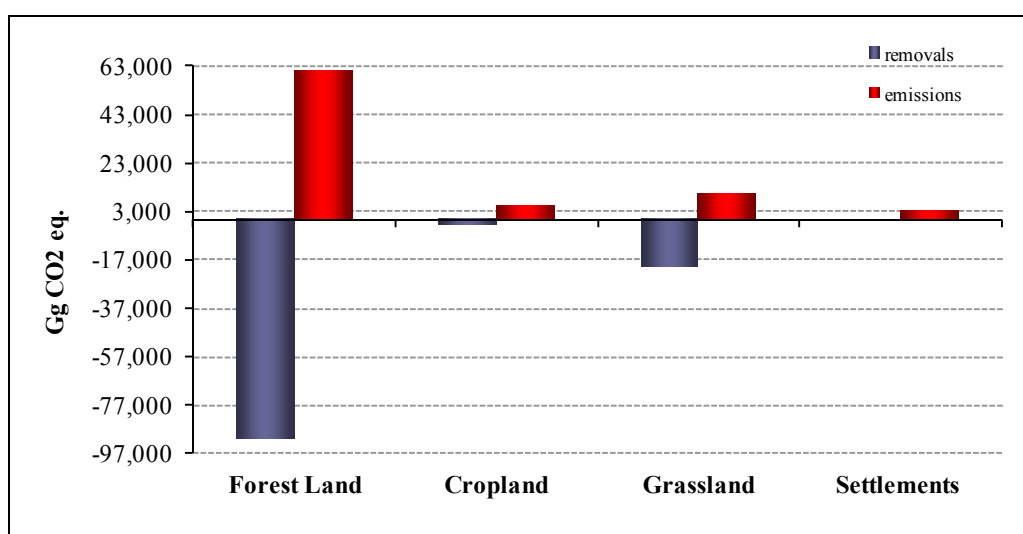


Figure 7.1 Greenhouse gas removals and emissions in LULUCF sector in 2011 [Gg CO₂ eq.]

In Table 7.1 emissions and removals time series is reported.

Table 7.1 Trend in greenhouse gas emissions from the LULUCF sector in the period 1990-2011

GHG Gas Source and Sink Categories	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CO₂	-13,035	-30,688	-26,326	-38,515	-39,379	-18,565	-36,968	-40,290	-43,560	-30,845
A. Forest Land	-17,282	-32,369	-26,989	-36,388	-36,762	-20,645	-33,541	-36,641	-38,247	-29,544
B. Cropland	-1,112	709	-578	-976	-1,047	-851	-1,048	-1,151	-1,185	3,333
C. Grassland	2,843	-1,543	-1,227	-4,501	-4,933	-445	-5,795	-5,930	-7,549	-8,031
D. Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
E. Settlements	2,516	2,514	2,468	3,350	3,363	3,376	3,416	3,432	3,422	3,397
F. Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH₄	598.03	158.87	347.35	160.00	139.06	722.09	212.22	269.40	162.44	188.60
A. Forest Land	182.80	39.37	105.63	48.15	38.27	245.94	57.74	68.64	43.30	63.91
B. Cropland	4.85	1.40	2.82	1.31	1.18	5.56	1.81	1.95	1.04	2.20
C. Grassland	410.38	118.10	238.89	110.55	99.62	470.59	152.68	198.81	118.09	122.49
D. Wetlands	0	0	0	0	0	0	0	0	0	0
E. Settlements	0	0	0	0	0	0	0	0	0	0
F. Other Land	0	0	0	0	0	0	0	0	0	0
G. Other	0	0	0	0	0	0	0	0	0	0
N₂O	283.40	146.57	143.98	83.46	72.22	241.27	85.10	100.57	56.52	66.12
A. Forest Land	0.85	0.18	0.49	0.22	0.18	1.14	0.27	0.32	0.20	0.30
B. Cropland	92.16	91.60	32.65	31.95	25.83	21.80	14.00	8.01	1.53	9.00
C. Grassland	190.39	54.79	110.83	51.29	46.22	218.33	70.84	92.24	54.79	56.83
D. Wetlands	0	0	0	0	0	0	0	0	0	0
E. Settlements	0	0	0	0	0	0	0	0	0	0
F. Other Land	0	0	0	0	0	0	0	0	0	0
G. Other	0	0	0	0	0	0	0	0	0	0
LULUCF (Gg CO₂ equivalent)	-12,154	-30,383	-25,835	-38,271	-39,167	-17,602	-36,670	-39,920	-43,341	-30,590

CO₂ emissions and removals in LULUCF sector, in the period 1990-2011, are shown in Figure 7.2.

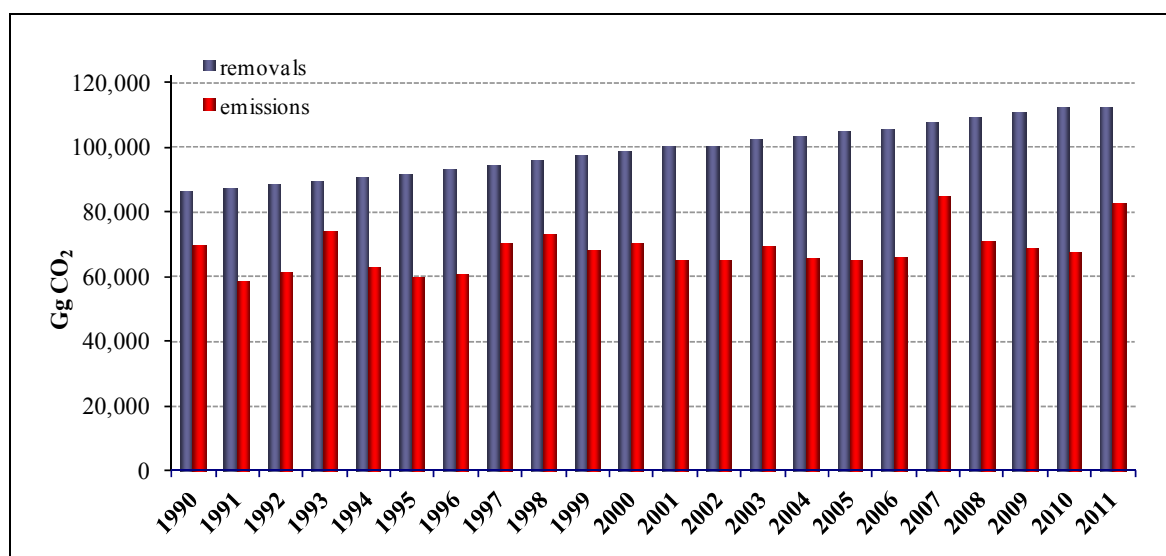


Figure 7.2 CO₂ removals and emissions in LULUCF sector in the period 1990-2011 [Gg CO₂]

The outcome of the key category analysis for 2011, according to level and/or trend assessment (*IPCC Approach 1 and Approach 2*), is listed in Table 7.2. CO₂ emissions and removals from forest land remaining forest land, land converted to forest land, cropland remaining cropland, land converted to grassland and land

converted to settlements have been identified as key categories, both in level and in trend assessment. CO₂ emissions and removals from land converted to cropland have resulted key categories with Approach 2 concerning trend assessment. CO₂ emissions and removals from grassland remaining grassland have resulted key categories concerning trend assessment, either with Approach 1 and Approach 2. Concerning CH₄ or N₂O emissions, no categories have resulted as a key source.

Table 7.2 Key categories identification in the LULUCF sector

	<i>gas</i>	<i>categories</i>	2011
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, T1)
5.B.1	CO ₂	Cropland remaining cropland	key (L, T)
5.B.2	CO ₂	Land converted to cropland	key (T2)
5.C.1	CO ₂	Grassland remaining Grassland	key (T)
5.C.2	CO ₂	Land converted to Grassland	key (L, T)
5.E.2	CO ₂	Land converted to Settlements	key (L, T)
5.D	CO ₂	Wetlands	Non-key
5.E.1	CO ₂	Settlements remaining Settlements	Non-key
5.A.1	CH ₄	Forest land remaining forest land	Non-key
5.A.1	N ₂ O	Forest land remaining forest land	Non-key
5.B.2	N ₂ O	Land converted to cropland	Non-key

For the land use conversion, land use change matrices have been used; the matrices have allowed pointing out the average areas of transition land, separately for each initial and final land use (i.e. forest land, grassland, etc.). 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. A task force has been established among national experts and, in this context, an expert judgment has been made on the basis of known patterns of land-use changes in Italy, also considering local studies and research on land uses transitions.

LUC matrices for each year of the period 1990–2011 have been assembled based on time series of national land use statistics for forest lands, croplands, grasslands, wetlands and settlement areas. More in details the following assumptions have been used: growth in forest land area as detected by the National Forest Inventories is used as the basis. The rule then assumes that new forest land area can only come from grassland; 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. These rules have been set up also on the basis of the relevant normative (i.e. concerning deforestation activities, in Italy land use changes from forest to other land use categories are allowed in very limited circumstances (railways, highways constructions or other public utility projects), as stated in art. 4.2 of the Law Decree n. 227 of 2001; land use changes due to wildfires are not allowed by national legislation (Law Decree 21 November 2000, n. 353, art.10.1)).

Concerning settlements, initial land use may be cropland (annual and perennial), forest land or grassland (see Tables 7.32); in addition a conservative approach was applied, assuming that the total deforested area is converted into settlements.

Regarding wetlands category, there is no occurrence of land transition to and from wetlands, considering that most of them are nature reserves.

In order to determine the lands converting to other land use categories in 20 years, land use change matrices have also been prepared, taking into account the area in conversion over a period of 20 years.

Activities planned in the framework of the ‘National Registry for Carbon sinks’ are expected to be useful to detect the different land uses and land uses changes between 1990 and 2012. Some of these activities (in particular IUTI, inventory of land use) have been completed, resulting in land use classification, for all national territory, for the years 1990, 2000 and 2008. A process of validation and verification of IUTI data is currently ongoing and is going to supply data useful to update and improve the estimations.

Following previous ERT’s recommendation, Italy has decided to use the IPCC default land use transition period of 20 years, in the estimation process of carbon stock changes in mineral soils related to land use

changes. In particular the 20-years transition period has been applied to estimate carbon stock changes from the following land use changes:

LULUCF

- Land converted to Forest land
Grassland to Forest land
- Land converted to Cropland
Grassland to Cropland
- Land converted to Grassland
Cropland to Grassland
- Land converted to Settlements

KP-LULUCF

- Art. 3.3 - Afforestation/Reforestation
- Art. 3.3 – Deforestation

The relevant equations of IPCC GPG for LULUCF (i.e. eq. 3.2.32, eq. 3.3.3, eq. 3.4.8) have been applied; once a land has converted to a land use category, the annual changes in carbon stocks in mineral soils have been reported for 20 years subsequent the conversion. For the Land converted to Settlements and Art. 3.3 – Deforestation, the 20-years transition period has been applied to determine the area in conversion, while the related CO₂ emissions are assumed to happening in the year following the conversion, taking into account the nature of final land use category (Settlements) and assuming that soils organic matter content of previous land use category is lost in the conversion year. Soil Organic Content (SOC) reference value, for Settlements category, has been assumed to be zero.

In the following Table 7.3, the land use matrices for each year of the period 1990–2011 are reported.

Table 7.3 Land use change matrices for the years 1990-2011

		1990						total 1989
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1989	Forest	7,372				0.72		7,373
	Grassland	77.65	9,221	13.95		7.56		9,320
	Cropland		0	11,156		0		11,156
	Wetland				119			119
	Settlements					1,340		1,340
	Other Land						825	825
total 1990		7,450	9,221	11,170	119	1,348	825	30,134
	20 years matrix	1990						total 1971
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1971	Forest	6,815						6,829
	Grassland	635	8,981	207		204		10,027
	Cropland		240	10,963		130		11,333
	Wetland				119			119
	Settlements					1,000		1,000
	Other Land						825	825
Total 1990		7,450	9,221	11,170	119	1,348	825	30,134
Land converted to:		635	240	207	0	348	0	
	20 years matrix	1991						total 1972
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1990	Forest	7,449				0.72		7,450
	Grassland	77.74	9,135	0.48		7.54		9,221
	Cropland		0	11,170		0		11,170
	Wetland				119			119
	Settlements					1,348		1,348
	Other Land						825	825
total 1991		7,527	9,135	11,171	119	1,356	825	30,134
	20 years matrix	1991						total 1972
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1972	Forest	6,845				14.4		6,859
	Grassland	682	8,895	208		198		9,983
	Cropland		240	10,963		119		11,322
	Wetland				119			119
	Settlements					1,025		1,025
	Other Land						825	825
Total 1991		7,527	9,135	11,171	119	1,356	825	30,134
Land converted to:		682	240	208	0	331	0	
	20 years matrix	1992						total 1973
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1991	Forest	7,526				0.72		7,527
	Grassland	77.74	9,049	0.48		7.54		9,135
	Cropland		0	11,171		0		11,171
	Wetland				119			119
	Settlements					1,356		1,356
	Other Land						825	825
total 1992		7,604	9,049	11,171	119	1,365	825	30,134
	20 years matrix	1992						total 1973
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1973	Forest	6,876				14.4		6,890
	Grassland	728	8,810	208		192		9,938
	Cropland		240	10,963		108		11,311
	Wetland				119			119
	Settlements					1,050		1,050
	Other Land						825	825
Total 1992		7,604	9,049	11,171	119	1,365	825	30,134
Land converted to:		728	240	208	0	315	0	
	20 years matrix	1993						total 1974
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1992	Forest	7,603				0.72		7,604
	Grassland	77.74	8,964	0.48		7.54		9,049
	Cropland		0	11,171		0		11,171
	Wetland				119			119
	Settlements					1,365		1,365
	Other Land						825	825
total 1993		7,681	8,964	11,172	119	1,373	825	30,134
	20 years matrix	1993						total 1974
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1974	Forest	6,906				14.4		6,921
	Grassland	775	8,724	208		186		9,893
	Cropland		240	10,963		98		11,301
	Wetland				119			119
	Settlements					1,075		1,075
	Other Land						825	825
Total 1993		7,681	8,964	11,172	119	1,373	825	30,134
Land converted to:		775	240	208	0	298	0	

		1994						total 1993
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1993	Forest	7,680				0.72		7,681
	Grassland	77.74	8,878	0.48		7.54		8,964
	Cropland		0	11,172		0		11,172
	Wetland				119			119
	Settlements					1,373		1,373
	Other Land						825	825
total 1994		7,758	8,878	11,172	119	1,381	825	30,134

		1995						total 1994
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1994	Forest	7,757				0.72		7,758
	Grassland	77.74	8,792	0.48		7.54		8,878
	Cropland		0	11,172		0		11,172
	Wetland				119			119
	Settlements					1,381		1,381
	Other Land						825	825
total 1995		7,835	8,792	11,173	119	1,389	825	30,134

		1996						total 1995
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1995	Forest	7,834				0.72		7,835
	Grassland	77.74	8,714	0		0		8,792
	Cropland		103.37	11,062		7.54		11,173
	Wetland				119			119
	Settlements					1,389		1,389
	Other Land						825	825
total 1996		7,912	8,818	11,062	119	1,398	825	30,134

		1997						total 1996
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1996	Forest	7,911				0.72		7,912
	Grassland	77.74	8,740	0		0		8,818
	Cropland		103.37	10,951		7.54		11,062
	Wetland				119			119
	Settlements					1,398		1,398
	Other Land						825	825
total 1997		7,989	8,843	10,951	119	1,406	825	30,134

		1998						total 1997
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1997	Forest	7,988				0.72		7,989
	Grassland	77.74	8,766	0		0		8,843
	Cropland		103.37	10,840		7.54		10,951
	Wetland				119			119
	Settlements					1,406		1,406
	Other Land						825	825
total 1998		8,066	8,869	10,840	119	1,414	825	30,134

		1999						total 1998
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1998	Forest	8,065				0.72		8,066
	Grassland	77.74	8,791	0		0		8,869
	Cropland		103.37	10,729		7.54		10,840
	Wetland				119			119
	Settlements					1,414		1,414
	Other Land						825	825
total 1999		8,143	8,895	10,729	119	1,422	825	30,134

		2000						total 1999
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1999	Forest	8,142				0.72		8,143
	Grassland	77.74	8,817	0		0		8,895
	Cropland		103.37	10,618		7.54		10,729
	Wetland				119			119
	Settlements					1,422		1,422
	Other Land						825	825
total 2000		8,220	8,920	10,618	119	1,431	825	30,134

		2001						total 2000
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
2000	Forest	8,219				0.72		8,220
	Grassland	77.74	8,843	0		0		8,920
	Cropland		110.74	10,497		10.56		10,618
	Wetland				119			119
	Settlements					1,431		1,431
	Other Land						825	825
total 2001		8,297	8,953	10,497	119	1,442	825	30,134

20 years matrix		1994						total 1975
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1975	Forest	6,937				14.4		6,951
	Grassland	821	8,638	209		180		9,848
	Cropland		240	10,963		87		11,290
	Wetland				119			119
	Settlements					1,100		1,100
	Other Land						825	825
Total 1994		7,758	8,878	11,172	119	1,381	825	30,134
Land converted to:		821	240	209	0	281	0	

20 years matrix		1995						total 1976
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1976	Forest	6,968				14.4		6,982
	Grassland	867	8,552	209		174		9,803
	Cropland		240	10,963		76		11,279
	Wetland				119			119
	Settlements					1,124		1,124
	Other Land						825	825
Total 1995		7,835	8,792	11,173	119	1,389	825	30,134
Land converted to:		867	240	209	0	265	0	

20 years matrix		1996						total 1977
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1977	Forest	6,979				14.4		6,994
	Grassland	933	8,475	182		155		9,744
	Cropland		343	10,880		84		11,307
	Wetland				119			119
	Settlements					1,145		1,145
	Other Land						825	825
Total 1996		7,912	8,818	11,062	119	1,398	825	30,134
Land converted to:		933	343	182	0	253	0	

20 years matrix		1997						total 1978
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1978	Forest	6,991				14.4		7,006
	Grassland	998	8,397	155		135		9,684
	Cropland		447	10,796		91		11,334
	Wetland				119			119
	Settlements					1,165		1,165
	Other Land						825	825
Total 1997		7,989	8,843	10,951	119	1,406	825	30,134
Land converted to:		998	447	155	0	240	0	

20 years matrix		1998						total 1979
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1979	Forest	7,003				14.4		7,017
	Grassland	1,063	8,319	127		115		9,624
	Cropland		550	10,713		99		11,361
	Wetland				119			119
	Settlements					1,186		1,186
	Other Land						825	825
Total 1998		8,066	8,869	10,840	119	1,414	825	30,134
Land converted to:		1,063	550	127	0	228	0	

20 years matrix		1999						total 1980
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1980	Forest	7,015				14.4		7,029
	Grassland	1,128	8,241	100		95		9,564
	Cropland		653	10,629		106		11,389
	Wetland				119			119
	Settlements					1,206		1,206
	Other Land						825	825
Total 1999		8,143	8,895	10,729	119	1,422	825	30,134
Land converted to:		1,128	653	100	0	216	0	

20 years matrix		2000						total 1981
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1981	Forest	7,027				14.4		7,041
	Grassland	1,193	8,164	72		75		9,505
	Cropland		757	10,546		114		11,416
	Wetland				119			119
	Settlements					1,227		1,227
	Other Land						825	825
Total 2000		8,220	8,920	10,618	119	1,431	825	30,134
Land converted to:		1,193	757	72	0	204	0	

20 years matrix		2001						total 1982
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1982	Forest	7,031				14.4		7,046
	Grassland	1,266	8,134	72		75		9,547
	Cropland		819	10,425		109		11,353
	Wetland				119			119
	Settlements					1,243		1,243
	Other Land						825	825
Total 2001		8,297	8,953	10,497	119	1,442	825	30,134
Land converted to:		1,266	819	72	0	199	0	

		2002						total 2001
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
2001	Forest	8,296				0.72		8,297
	Grassland	77.74	8,876	0		0		8,953
	Cropland		110.74	10,375		10.56		10,497
	Wetland				119			119
	Settlements					1,442		1,442
	Other Land						825	825
total 2002		8,374	8,986	10,375	119	1,453	825	30,134
		2003						total 2002
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
2002	Forest	8,373				0.72		8,374
	Grassland	77.74	8,909	0		0		8,986
	Cropland		110.74	10,254		10.56		10,375
	Wetland				119			119
	Settlements					1,453		1,453
	Other Land						825	825
total 2003		8,451	9,019	10,254	119	1,464	825	30,134
		2004						total 2003
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
2003	Forest	8,450				0.72		8,451
	Grassland	77.74	8,942	0		0		9,019
	Cropland		110.74	10,133		10.56		10,254
	Wetland				119			119
	Settlements					1,464		1,464
	Other Land						825	825
total 2004		8,528	9,052	10,133	119	1,476	825	30,134
		2005						total 2004
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
2004	Forest	8,527				0.72		8,528
	Grassland	77.74	8,975	0		0		9,052
	Cropland		110.74	10,012		10.56		10,133
	Wetland				119			119
	Settlements					1,476		1,476
	Other Land						825	825
total 2005		8,605	9,085	10,012	119	1,487	825	30,134
		2006						total 2005
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
2005	Forest	8,604				0.72		8,605
	Grassland	78.63	9,007	0		0		9,085
	Cropland		176.76	9,824		10.56		10,012
	Wetland				119			119
	Settlements					1,487		1,487
	Other Land						825	825
total 2006		8,683	9,183	9,824	119	1,498	825	30,134
		2007						total 2006
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
2006	Forest	8,682				0.72		8,683
	Grassland	78.63	9,105	0		0		9,183
	Cropland		176.76	9,637		10.56		9,824
	Wetland				119			119
	Settlements					1,498		1,498
	Other Land						825	825
total 2007		8,761	9,282	9,637	119	1,510	825	30,134
		2008						total 2007
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
2007	Forest	8,760				0.72		8,761
	Grassland	78.63	9,203	0		0		9,282
	Cropland		176.76	9,450		10.56		9,637
	Wetland				119			119
	Settlements					1,510		1,510
	Other Land						825	825
total 2008		8,839	9,380	9,450	119	1,521	825	30,134
		2009						total 2008
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
2008	Forest	8,838				0.72		8,839
	Grassland	78.63	9,301	0		0		9,380
	Cropland		176.76	9,262		10.56		9,450
	Wetland				119			119
	Settlements					1,521		1,521
	Other Land						825	825
total 2009		8,917	9,478	9,262	119	1,532	825	30,134
20 years matrix		2002						total 1983
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1983	Forest	7,036				14.4		7,051
	Grassland	1,338	8,104	72		75		9,590
	Cropland		882	10,303		105		11,290
	Wetland				119			119
	Settlements					1,259		1,259
	Other Land						825	825
Total 2002		8,374	8,986	10,375	119	1,453	825	30,134
Land converted to:		1,338	882	72	0	194	0	
20 years matrix		2003						total 1984
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1984	Forest	7,041				14.4		7,056
	Grassland	1,410	8,074	72		75		9,632
	Cropland		945	10,182		100		11,227
	Wetland				119			119
	Settlements					1,275		1,275
	Other Land						825	825
Total 2003		8,451	9,019	10,254	119	1,464	825	30,134
Land converted to:		1,410	945	72	0	190	0	
20 years matrix		2004						total 1985
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1985	Forest	7,046				14.4		7,060
	Grassland	1,482	8,045	72		75		9,674
	Cropland		1,008	10,061		95		11,164
	Wetland				119			119
	Settlements					1,291		1,291
	Other Land						825	825
Total 2004		8,528	9,052	10,133	119	1,476	825	30,134
Land converted to:		1,482	1,008	72	0	185	0	
20 years matrix		2005						total 1986
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1986	Forest	7,051				14.4		7,065
	Grassland	1,554	8,015	72		75		9,717
	Cropland		1,071	9,939		90		11,100
	Wetland				119			119
	Settlements					1,307		1,307
	Other Land						825	825
Total 2005		8,605	9,085	10,012	119	1,487	825	30,134
Land converted to:		1,554	1,071	72	0	180	0	
20 years matrix		2006						total 1987
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1987	Forest	7,128				14.4		7,142
	Grassland	1,555	7,936	58		68		9,618
	Cropland		1,247	9,766		101		11,114
	Wetland				119			119
	Settlements					1,315		1,315
	Other Land						825	825
Total 2006		8,683	9,183	9,824	119	1,498	825	30,134
Land converted to:		1,555	1,247	58	0	183	0	
20 years matrix		2007						total 1988
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1988	Forest	7,205				14.4		7,219
	Grassland	1,556	7,858	44		60		9,519
	Cropland		1,424	9,593		112		11,128
	Wetland				119			119
	Settlements					1,323		1,323
	Other Land						825	825
Total 2007		8,761	9,282	9,637	119	1,510	825	30,134
Land converted to:		1,556	1,424	44	0	186	0	
20 years matrix		2008						total 1989
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1989	Forest	7,282				14.4		7,296
	Grassland	1,557	7,779	30		53		9,419
	Cropland		1,601	9,419		122		11,142
	Wetland				119			119
	Settlements					1,331		1,331
	Other Land						825	825
Total 2008		8,839	9,380	9,450	119	1,521	825	30,134
Land converted to:		1,557	1,601	30	0	189	0	
20 years matrix		2009						total 1990
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1990	Forest	7,358				14.4		7,373
	Grassland	1,558	7,700	16		45		9,320
	Cropland		1,778	9,246		133		11,156
	Wetland				119			119
	Settlements					1,340		1,340
	Other Land						825	825
Total 2009		8,917	9,478	9,262	119	1,532	825	30,134
Land converted to:		1,558	1,778	16	0	192	0	

		2010						total 2009
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
2009	Forest	8,916				0.72		8,917
	Grassland	78.63	9,399	0		0		9,478
	Cropland		176.76	9,075		10.56		9,262
	Wetland				119			119
	Settlements					1,532		1,532
	Other Land						825	825
total 2010		8,995	9,576	9,075	119	1,543	825	30,134

		2011						total 2010
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
2010	Forest	8,994				0.72		8,995
	Grassland	79.22	9,470	16.45		10.56		9,576
	Cropland		0	9,075		0		9,075
	Wetland				119			119
	Settlements					1,543		1,543
	Other Land						825	825
total 2011		9,073	9,470	9,091	119	1,555	825	30,134

20 years matrix		2010						total 1991
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1991	Forest	7,435				14.4		7,450
	Grassland	1,559	7,622	2		38		9,221
	Cropland		1,954	9,073		143		11,170
	Wetland				119			119
	Settlements					1,348		1,348
	Other Land						825	825
Total 2010		8,995	9,576	9,075	119	1,543	825	30,134
Land converted to:		1,559	1,954	2	0	195	0	

20 years matrix		2011						total 1992
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1992	Forest	7,512				14.4		7,527
	Grassland	1,561	7,515	18		41		9,135
	Cropland		1,954	9,073		143		11,171
	Wetland				119			119
	Settlements					1,356		1,356
	Other Land						825	825
Total 2011		9,073	9,470	9,091	119	1,555	825	30,134
Land converted to:		1,561	1,954	18	0	198	0	

7.2 Forest Land (5A)

7.2.1 Description

Under this category, CO₂ emissions from living biomass, dead organic matter and soils, from forest land remaining forest land and from land converted to forest land have been reported.

Forest land removals share, in 2011, 66.7% of total CO₂ LULUCF emissions and removals; in particular, the living biomass removals represent 91.4%, while the removals from dead organic matter and soils stand for 5.6% and 2.9% of total 2011 forest land CO₂ removals, respectively, also taking into account that, for forest land remaining forest land, soils pool has been not reported, providing in the relevant paragraph information to demonstrate that this pool is not a source.

CO₂ removals from forest land remaining forest land have been identified as key category (sinks) in level and in trend assessment either with Approach 1 and Approach 2. CO₂ emissions and removals from land converted to forest land have resulted key categories in level and in trend assessment. Concerning CH₄ or N₂O emissions, neither forest land nor land converting to forest land have resulted as a key source.

7.2.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

In 2011 submission, forest definition adopted by Italy in the framework of application of elected 3.4 activity, under Kyoto Protocol, has been fully implemented also in the LULUCF sector of the inventory under the Convention, in order to maintain coherence and congruity between the two forest-related reporting. The forest definition (and the consequent exclusion of plantations) has been set up, and included in the determination of Italy's assigned amount under Article 7, paragraph 4, of the Kyoto Protocol, and the election of the art. 3.3 and 3.4 activities, by a national expert panel set up under the coordination of Ministry of Environment and in cooperation with the Ministry of Agriculture, Food and Forest Policies. The abovementioned panel involves, on a voluntary basis, the relevant national experts, including the forest inventory experts (http://www.sian.it/inventarioforestale/jsp/home_en.jsp), members of the FAO-FRA Italian panel (<http://www.fao.org/docrep/013/al537E/al537E.pdf>) and other national researchers. The national expert panel has considered the Kyoto Protocol rules and requirements, related to reporting and accounting of art. 3.3 and 3.4 activities, and agreed the national forest definition. In the same context, national circumstances (e.g. forest composition, forestry management practices, agroforestry practices, etc.) were examined and it was decided to classify plantations, and in particular poplars, in the cropland category and shrubland in the grassland category because they do not fulfill national forest definition while other plantation typologies, as chestnut and cork oak, have been included in forest.

For the land use conversion, land use change matrices have been used; as abovementioned, LUC matrices for each year of the period 1990–2011 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 First Italian National Forest Inventory (IFN) and the Inventory of Forests and Carbon pools (INFC) was used as the basis. It was assumed that new forest land area can only come from grassland.

The Italian Ministry of Agriculture and Forests (MAF) and the Experimental Institute for Forest Management (ISAFA) carried out the first National Forest Inventory in 1985. As a result of the first IFN based on a regular sampling grid of 3 km by 3 km, the global Italian extent of forest resources was about 8.7 million hectares (MAF/ISAFA, 1988). A second national forest inventory, using a grid of 1 km by 1 km, had been launched in 2001. A first inventory phase, consisting in interpretation of orthophotos, was followed by a ground survey, in order to assess the forest use, and to detect the main attributes of Italian forests. The final result, regarding forest surfaces, has been used (Tabacchi et al., 2007).

The estimation for 1990 was calculated through a linear interpolation between the 1985 and 2005 data. By assuming that the defined trend may well represent the near future, it was possible to extrapolate data for 2006-2011.

Additional source of information was the National Statistics Institute (ISTAT), which had provided annual data on forest area extent, till 2005. In 2006, the National Statistics Institute has officially recognized the INFC data, suspending the annual assessment on forest area extent. ISTAT data on forest were, instead, administrative data underestimating the total forest extension as a consequence of the sample and definition used. Anyway ISTAT data have been used to verify the linear trend assumption of forest areas increase.

7.2.3 *Land-use definitions and the classification systems used and their correspondence to the LULUCF categories*

In the current submission, the forest definition adopted by Italy in the framework of the Kyoto Protocol has been adopted; this definition is in line with the definitions of the Food and Agriculture Organization of the United Nations, therefore the following threshold values for tree crown cover, land area and tree height are applied:

- a. a minimum area of land of 0.5 hectares;
- b. tree crown cover of 10 per cent;
- c. minimum tree height of 5 meters.

7.2.4 *Methodological issues*

Forest Land remaining Forest Land

All the data concerning the growing stock and the related carbon are assessed by the For-est model, 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. Additional information on the methodological aspects may be found in Federici et al., 2008; it has to be noted as in the current submission updated activity data have been used, respect the ones reported in the paper, on the basis of the final outcome of the National Forestry Inventory and the national forest definition. Some specific parameters (i.e. biomass expansion factors, wood basic densities for aboveground biomass estimate, root/shoot ratios) used in the estimation process are the same reported in the above-mentioned article; in other cases (i.e. dead wood or litter pools) different coefficients and relations have been used to deduce the carbon stock changes in the pools. Details are reported in the following relevant sections. The model has been applied at regional scale (NUTS2) because of availability of forest-related statistical data: the First Italian National Forest Inventory (IFN) data and the Inventory of Forests and Carbon pools (INFC) were input data for the forest area, per region and inventory typologies.

The inventory typologies, classified in 4 main categories, 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*

To estimate the growing stock of Italian forest, from 1990 to 2011, 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 [$\text{m}^3 \text{ha}^{-1}$] is computed with the derivative Richards function¹¹, for each forest typology by the Italian yield tables collection;
3. starting from 1986, for each year the growing stock per hectare [$\text{m}^3 \text{ha}^{-1}$] 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. Mortality and rate of drain and grazing are applied, as percentage, directly to the growing stock amount of the previous 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 derivative 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

M_i is the annual rate of mortality

D is the annual rate of drain and grazing for the protective forest

A_i is the total area referred to a specific forest typology for the current year

v_{i-1} is the previous year growing stock volume per hectare

A_{i-1} is the total area referred to a specific forest typology for the previous year

f is the Richards function reported above

The average rate of mortality, the fraction of standing biomass per year, used for the calculation was 0.0116, concerning the evergreen forest, and 0.0117, for deciduous forest, according to the GPG (IPCC, 2003).

The rate of draining and grazing, applied to protective forest, has been set as 3% following an expert judgement (Federici et al., 2008) because of total absence of referable data.

Total commercial harvested wood, for construction and energy purposes, has been obtained from national statistics (ISTAT, several years [a]); data on biomass removed in commercial harvest published by ISTAT (disaggregated at NUTS2 level, in sectoral statistics (ISTAT, several years [a]) or at NUTS1 level for coppices and high forests in national statistics (ISTAT, several years [c])) are underestimating harvested

¹¹ In the followed approach the Richards function is fitted through the data of growing stock [m^3] and increment [$\text{m}^3 \text{y}^{-1}$] obtained by the data of the national forestry inventory and yield tables collection.

$$y = a \cdot \left[1 \pm e^{(\beta - kt)} \right]^{\frac{1}{v}} \quad (\text{Richards function})$$

The independent variable represents the growing stock of the stand, while the dependent variable y is the correspondent increment computed with the Richards function - first derivative.

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

where the general constrain for the parameters are the following:

$$a, k > 0 \quad -1 \leq v \leq \infty \quad \text{and} \quad v \neq 0$$

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

biomass, particularly concerning fuelwood consumption (APAT - ARPA Lombardia, 2007, UNECE – FAO, Timber Committee, 2008, Corona et al., 2007). In particular a specific survey conducted in the framework of the Inventory of Forests and Carbon pools (INFC) has done a regional assessment of the harvested biomass; these data were used to infer a correction factor¹², on regional basis, that was applied to the entire time series of commercial harvested wood. The computed figures have been subtracted, as losses, from growing stock volume, as mentioned above.

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

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

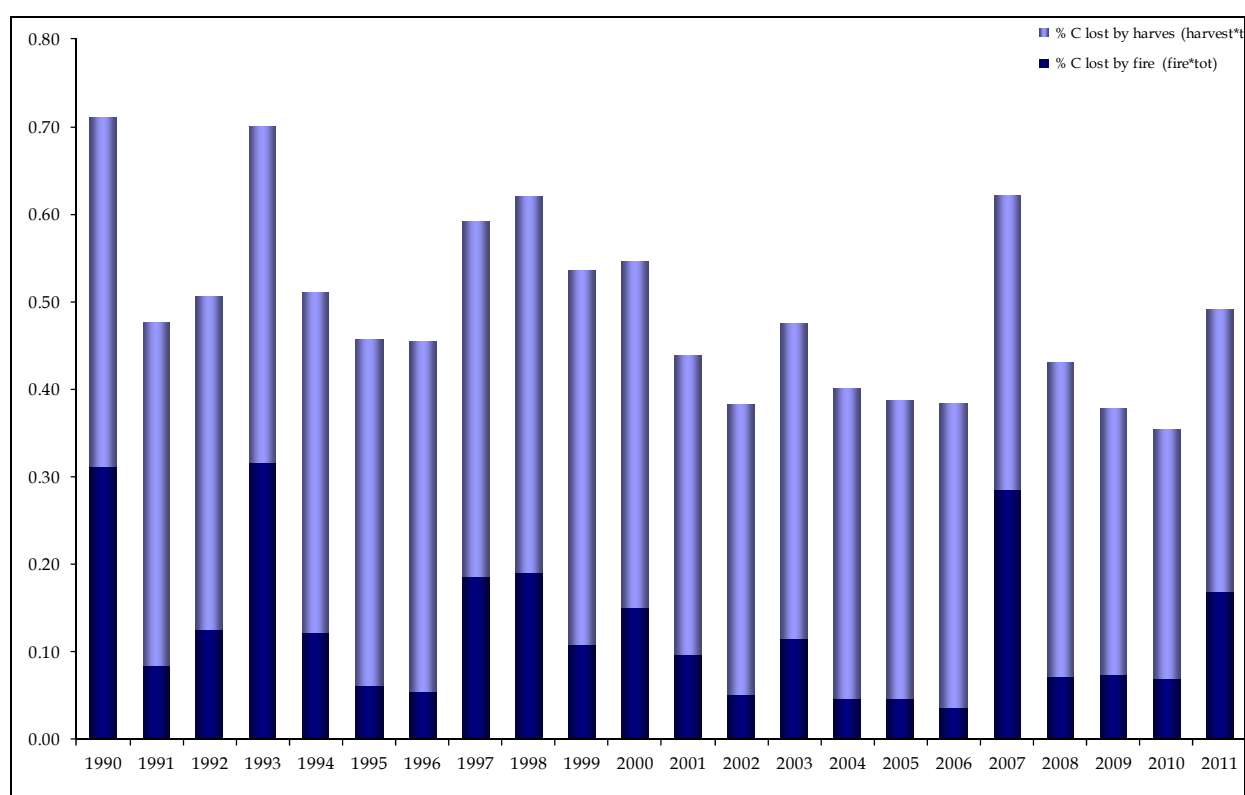


Figure 7.3 Losses by harvest and fires in relation to aboveground carbon

Non CO₂ emissions from fires have been estimated and reported in CRF table 5(V); details on the methodology used to estimate emissions are reported in the paragraph 7.12.2.

Once the growing stock is estimated, the amount of aboveground tree biomass (dry matter), belowground biomass (dry matter) and dead mass (dry matter), can be assessed, from 1990 to 2011. 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:

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

¹² A correction factor for each Italian region (21) has been pointed out. The mean value is 1.57, obtained as ratio of data from official statistics and INFC survey data. The variance is equal to 0.82.

where:

GS = volume of growing stock (MAF/ISAFA, 1988) [$\text{m}^3 \text{ha}^{-1}$]

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] (MAF/ISAFA, 1988)

The BEF were derived for each forest typology and wood basic density (WBD) values were different for the main tree species:

2. starting from 1985, for each year, current increment per hectare [$\text{m}^3 \text{ha}^{-1} \text{y}^{-1}$] is computed with the derivative Richards function, for every specific forest typology by the Italian yield tables collection;
3. starting from 1986, for each year growing stock per hectare [$\text{m}^3 \text{ha}^{-1}$] 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 Table 7.5 biomass expansion factors for the conversions of volume to aboveground tree biomass and wood basic densities are reported.

Table 7.5 Biomass Expansion Factors and Wood Basic Densities

	Inventory typology	BEF	WBD
		<i>aboveground biomass / growing stock</i>	<i>Dry weight t/ fresh volume</i>
<i>stands</i>	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
<i>coppices</i>	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
<i>protective</i>	rupicolous forest	1.44	0.52
	riparian forest	1.39	0.41

Belowground biomass was estimated applying a Root/Shoot ratio to the aboveground biomass. The belowground biomass is computed, as:

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

where:

GS = volume of growing stock [$\text{m}^3 \text{ha}^{-1}$]

R = Root/Shoot ratio which converts growing stock biomass in belowground biomass

BEF = Biomass Expansion Factors which expands growing stock volume to volume of aboveground woody biomass (ISAFA, 2004)

WBD = Wood Basic Density [t d.m. m^{-3}]

A = forest area occupied by specific typology [ha]

Also in this case, the Root/shoot ratios and WBDs were derived for each forest typology, on the basis of different studies conducted at the national and local level in different years and contexts; the derived Root/Shoot ratios have been then included in the JRC-AFOLU database¹³. Description of the database is detailed in Somogyi et al., 2008. The relevant projects taken into account to derive Root/Shoot ratios used in the estimation process are the European projects CANIF¹⁴ (*Carbon and Nitrogen cycling in Forest ecosystems*), CARBODATA¹⁵ (*Carbon Balance Estimates and Resource Management - Support with Data from Project Networks Implemented at European Continental Scale*), CARBOINVENT¹⁶ (*Multi-source inventory methods for quantifying carbon stocks and stock changes in European forests*) and COST¹⁷ Action E21- Contribution of forests and forestry to mitigate greenhouse effects.

In Table 7.6 root/shoot ratio and wood basic densities are reported.

Table 7.6 Root/Shoot ratio and Wood Basic Densities

Inventory typology	R	WBD
	Root/shoot ratio	Dry weight t/ fresh volume
stands	norway spruce	0.29
	silver fir	0.28
	Larches	0.29
	mountain pines	0.36
	mediterranean pines	0.33
	other conifers	0.29
	european beech	0.20
	turkey oak	0.24
	other oaks	0.20
	other broadleaves	0.24
coppices	european beech	0.20
	sweet chestnut	0.28
	Hornbeams	0.26
	other oaks	0.20
	turkey oak	0.24

¹³ European Commission - Joint Research Centre, Institute for Environment and Sustainability, AFOLU DATA clearinghouse: Allometric Biomass and Carbon (ABC) factors database: http://afoludata.jrc.ec.europa.eu/index.php/public_area/data_and_tools

¹⁴ CANIF - Carbon and Nitrogen cycling in Forest ecosystems http://www.bgc-jena.mpg.de/bgc-processes/research/Schulze_Euro_CANIF.html; Scarascia Mugnozza G., Bauer G., Persson H., Matteucci G., Masci A.

(2000). Tree biomass, growth and nutrient pools. In: Schulze E.-D. (edit.) Carbon and Nitrogen Cycling in European forest Ecosystems, Ecological Studies 142, Springer Verlag, Heidelberg. Pp. 49-62. ISBN 3-540-67239-7

¹⁵ CARBODATA - Carbon Balance Estimates and Resource Management - Support with Data from Project Networks Implemented at European Continental Scale: http://afoludata.jrc.it/carbodatat/proj_desc.html

¹⁶ CARBOINVENT - Multi-source inventory methods for quantifying carbon stocks and stock changes in European forests; <http://www.joanneum.at/carboinvent/>

¹⁷ COST Action E21 - Contribution of forests and forestry to mitigate greenhouse effects: http://www.cost.eu/domains_actions/fps/Actions/E21; http://www.afs-journal.org/index.php?option=com_article&access=standard&Itemid=129&url=/articles/forest/pdf/2005/08/F62800f.pdf

Inventory typology	R	WBD
	Root/shoot ratio	Dry weight t/fresh volume
evergreen oaks	1.00	0.72
other broadleaves	0.24	0.53
Conifers	0.29	0.43
protective	rupicolous forest	0.42
	riparian forest	0.23

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

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

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

Following the ERT's recommendation, the dead wood mass has been estimated using coefficients calculated from outcomes of a survey conducted by the Italian national forest inventory, in 2008 and 2009, which specifically intended to investigate the carbon storage of forests. Samples of dead-wood were collected across the country from the plots of the national forest inventory network, and their basic densities measured in order to calculate conversion factors for estimating the dry weight of dead-wood (Di Cosmo et al., 2013). The values used, aggregated at regional level, may be found on the INFC website: http://www.sian.it/inventarioforestale/jsp/dati_carquant_tab.jsp. In Table 7.7 Dead wood coefficients are reported. The dead wood [t] is:

$$\text{Dead wood(d.m.)} = DC \cdot A$$

where:

DC = Dead wood expansion factor (dead wood - dry matter) [t ha⁻¹]

A = forest area occupied by specific typology [ha]

Table 7.7 Dead-wood expansion factor

Inventory typology	dead wood (dry matter)
	t ha ⁻¹
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
protective	rupicolous forest

Inventory typology	dead wood (dry matter) $t\ ha^{-1}$
riparian forest	4.790

The amount of carbon in litter is estimated from the aboveground carbon amount with linear relations, $[C_{\text{litter}} = f(C_{\text{Aboveground}})]$ calculated on data collected within the European project Biosoil¹⁸ (for litter) and a Life+ project FutMon¹⁹ (*Further Development and Implementation of an EU-level Forest Monitoring System*), for the aboveground biomass. BioSoil (2005-2007) was a Demonstration project funded under Regulation (EC) n. 2152/2003 on forest monitoring and environment interactions in the Community (Forest Focus), part of the programme of the International Cooperative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests²⁰). It was composed of a soil module and a biodiversity module. The soil module aimed at assessing soil chemistry and carbon stocks in European forests using the sampling design of ICP level I network with a common field and analytical protocol. In Italy, the BioSoil project was coordinated by the CONECOFOR division of the National Forest Service (CFS), who contracted research institution and university departments (BioSoil, 2011) for the technical work and elaboration. In total 239 forest plots have been surveyed belonging to a national grid of 15 by 18 km. The sites were a subset of the 1985 National Forest Inventory. Soil sampling and laboratory analysis were done in 2006 and 2007. The measurements and analyses performed by the FutMon project were carried out on the same 239 forest plots monitored by Biosoil.

Litter amount was assessed on the basis of weight of the OL horizon. OL horizon is characterised by an accumulation of mainly leaves/needles, twigs and woody materials (including bark), fruits etc. There may be some fragmentation, but most of the original biomass structures are easily discernible. Leaves and/or needles may be discoloured and slightly fragmented. Organic fine substance (in which the original organs are not recognisable with naked eye) amounts to less than 10% by volume. The total litter carbon amount has been estimated from aboveground carbon amount with linear relations differentiated per forestry use: stands (resinous, broadleaves, mixed stands) and coppices. In Table 7.8 the different relations used to obtain litter carbon amount per ha $[t\ C\ ha^{-1}]$ from the aboveground carbon amount per ha $[t\ C\ ha^{-1}]$ have been reported.

Table 7.8 Relations litter - aboveground carbon per ha

	Inventory typology	Relation litter – aboveground C per ha	R ²	Standard error
stands	norway spruce	y = 0.0282x + 2.2494	0.2204	2.63
	silver fir	y = 0.0282x + 2.2494	0.2204	2.63
	larches	y = 0.0282x + 2.2494	0.2204	2.63
	mountain pines	y = 0.0282x + 2.2494	0.2204	2.63
	mediterranean pines	y = 0.0282x + 2.2494	0.2204	2.63
	other conifers	y = 0.0282x + 2.2494	0.2204	2.63
	european beech	y = 0.0197x + 2.4517	0.2037	1.83
	turkey oak	y = 0.0197x + 2.4517	0.2037	1.83
	other oaks	y = 0.0197x + 2.4517	0.2037	1.83
	other broadleaves	y = 0.0197x + 2.4517	0.2037	1.83
coppices	european beech	y = 0.0197x + 2.4517	0.2037	1.83
	sweet chestnut	y = 0.0197x + 2.4517	0.2037	1.83
	hornbeams	y = 0.0197x + 2.4517	0.2037	1.83
	other oaks	y = 0.0197x + 2.4517	0.2037	1.83
	turkey oak	y = 0.0197x + 2.4517	0.2037	1.83

¹⁸ BioSoil-Soil project - http://www3.corpoforestale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/487/UT/systemPrint;http://www.inbo.be/content/page.asp?pid=EN_MON_FSCC_condition_report.

¹⁹ FutMon: Life+ project for the "Further Development and Implementation of an EU-level Forest Monitoring System"; <http://www.futmon.org/>;
<http://www3.corpoforestale.it/flex/cm/pages/ServeAttachment.php/L/IT/D/D.e54313ecaf7ae893e249/P/BLOB%3AID%3D397>

²⁰ International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests operating under the UNECE Convention on Long-range Transboundary Air Pollution – <http://www.icp-forests.org/>

Inventory typology		Relation litter – aboveground C per ha	R ²	Standard error
evergreen oaks		y = 0.0197x + 2.4517	0.2037	1.83
other broadleaves		y = 0.0197x + 2.4517	0.2037	1.83
conifers		y = 0.0282x + 2.2494	0.2204	2.63
<i>protective</i>	rupicolous forest	y = 0.0197x + 2.4517	0.2037	1.83
	riparian forest	y = 0.0197x + 2.4517	0.2037	1.83

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.

Following the main finding of 2011 review process regarding soils pool, Italy has decided to apply the IPCC Tier1, assuming that, for forest land remaining forest land, the carbon stock in soil organic matter does not change, regardless of changes in forest management, types, and disturbance regimes; in other words it has to be assumed that the carbon stock in mineral soil remains constant so long as the land remains forest. Therefore carbon stock changes in soils pool, for forest land remaining forest land, have been not reported. Carbon stock changes in minerals soils, for *Forest land remaining Forest land* have been estimated and detailed in par. 10.3.1.2.

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. 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, using the same For-est model already used in *the forest land remaining forest land* sub-category: a description of the methodology used in the estimation process is provided in par. 7.2.4.

Net carbon stock change in dead organic matter and soil has been calculated as well. Following the main finding of 2011 review process, Italy has decided to use the IPCC default land use transition period of 20 years, to estimate carbon stock changes in mineral soils related to land converted in Forest Land. The relevant equations of IPCC GPG for LULUCF (i.e. eq. 3.2.32, eq. 3.3.3, eq. 3.4.8) have been applied; once a land has converted to a land use category, the annual changes in carbon stocks in mineral soils have been reported for 20 years subsequent the conversion. SOC reference value for grassland has been revised and set to 78.9 t C ha⁻¹, after a review of the latest papers reporting data on soil carbon in mountain meadows, pastures, set-aside lands as well as soil not disturbed since the agricultural abandonment, in Italy (Viaroli and Gardi 2004, CRPA 2009, IPLA 2007, ERSF 2008, Del Gardo *et al* 2003, LaMantia *et al* 2007, Benedetti *et al* 2004, Masciandaro and Ceccanti 1999, Xiloyannis 2007). Concerning forest soils, the SOC reported in the table 7.9 have been used; each SOC reported in the abovementioned table has been used for the years indicated in the first column of the table 7.9. A detailed description of the methodology used in the estimation process of soils pool, and consequently of the SOC, is provided in par. 10.3.1.2, related to the KP-LULUCF.

Table 7.9 Soil Organic Content (SOC) values for forest land remaining forest land

	SOC t C ha ⁻¹
1985-1994	80.406
1995-1999	80.777
2000-2004	81.195
2005-2009	81.660

SOC <i>t C ha⁻¹</i>	
2010-2012	81.952

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

In Table 7.10 carbon stock changes due to conversion to forest land, for the living biomass, dead organic matter and soil pools, have been reported.

Table 7.10 Carbon stock changes in land converting to forest land

Table A10 Carbon stock changes in land converting to forest land							
year	Conversion Area		Carbon stock change in living biomass			Net C stock change in dead organic matter	Net C stock change in mineral soils
	annual change	20 years change	Increase	Decrease	Net change		
	kha		Gg C				
1990	77.65	635	1,659	-1,296	363	33.23	69.82
1991	77.74	682	1,787	-1,091	695	40.92	75.67
1992	77.74	728	1,913	-1,211	702	42.75	81.52
1993	77.74	775	2,038	-1,592	446	39.83	87.37
1994	77.74	821	2,163	-1,382	781	47.30	93.22
1995	77.74	867	2,289	-1,375	915	51.31	100.51
1996	77.74	933	2,465	-1,507	958	54.31	109.69
1997	77.74	998	2,639	-1,887	753	52.88	118.87
1998	77.74	1,063	2,811	-2,068	743	54.71	128.05
1999	77.74	1,128	2,984	-2,002	982	61.34	137.23
2000	77.74	1,193	3,160	-2,177	984	63.57	148.04
2001	77.74	1,266	3,356	-2,074	1,282	71.31	159.55
2002	77.74	1,338	3,550	-2,044	1,506	77.53	171.06
2003	77.74	1,410	3,745	-2,456	1,288	75.91	182.56
2004	77.74	1,482	3,939	-2,379	1,560	83.19	194.07
2005	77.74	1,554	4,133	-2,465	1,668	87.17	207.30
2006	78.63	1,555	4,136	-2,465	1,671	86.65	212.34
2007	78.63	1,556	4,137	-3,248	889	72.74	217.38
2008	78.63	1,557	4,137	-2,647	1,490	82.74	222.42
2009	78.63	1,558	4,139	-2,517	1,622	84.95	227.47
2010	78.63	1,559	4,141	-2,460	1,682	85.86	233.66
2011	79.22	1,561	4,141	-2,874	1,267	77.79	236.94

CO₂ emissions due to wildfires in land remaining forest land are included in CRF Table 5.A.1, carbon stocks change in living biomass - decrease. Non CO₂ emissions from fires have been estimated and reported in CRF table 5(V); details on the methodology used to estimate emissions are reported in the paragraph 7.12.2.

7.2.5 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 1990–2011, Approach 1 of 2006 IPCC Guidelines (IPCC, 2006) has been followed. In Table 7.11, the values of carbon stocks in the five pools, for the 1985, and the abovementioned uncertainties are reported.

Table 7.11 Carbon stocks and uncertainties for year 1985 and current increment related uncertainty

<i>Carbon stocks</i> <i>t CO₂ eq. ha⁻¹</i>	<i>Aboveground biomass</i>	V _{AG}	137.8
	<i>Belowground biomass</i>	V _{BG}	31.5
	<i>Dead mass</i>	V _D	20.8
	<i>Litter</i>	V _L	11.9
	<i>Soil</i>	V _S	293.1
<i>Uncertainty</i>	<i>Growing stock</i>	E _{NFI}	3.2%
	<i>Current increment (Richards)²¹</i>	E _{NFI}	51.6%
	<i>Harvest²²</i>	E _H	30%
	<i>Fire²³</i>	E _F	30%
	<i>Drain and grazing</i>	E _D	30%
	<i>Mortality</i>	E _M	30%
	<i>BEF</i>	E _{BEF1}	30%
	<i>R</i>	E _R	30%
	<i>DCF</i>	E _{DEF}	30%
	<i>Litter (stock + regression)</i>	E _L	102%
	<i>Soil (stock + regression)</i>	E _S	113%
	<i>Basic Density</i>	E _{BD}	30%
	<i>C Conversion Factor</i>	E _{CF}	2%

The uncertainties related to the carbon pools and the overall uncertainty for 1985 has been computed and shown in Table 7.12.

Table 7.12 Uncertainties for the year 1985

<i>Aboveground biomass</i>	E _{AG}	42.59%
<i>Belowground biomass</i>	E _{BG}	42.59%
<i>Dead mass</i>	E _D	52.10%
<i>Litter</i>	E _L	101.62%
<i>Soil</i>	E _S	113.00%
<i>Overall uncertainty</i>	E₁₉₈₅	70.14%

The overall uncertainty related to 1985 (the year of the first National Forest Inventory) has been propagated through the years, till 2011, following Approach 1.

The uncertainties related to the carbon pools and the overall uncertainty for 2011 are shown in Table 7.13.

²¹ The current increment is estimated by the Richards function (first derivative); 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

²² Good Practice Guidance default value (IPCC, 2003)

²³ Good Practice Guidance default value (IPCC, 2003)

Table 7.13 Uncertainties for the year 2011

<i>Aboveground biomass</i>	E _{AG}	79.82%
<i>Belowground biomass</i>	E _{BG}	79.82%
<i>Dead mass</i>	E _D	85.27%
<i>Litter</i>	E _L	101.62%
<i>Soil</i>	E _S	113.00%
Overall uncertainty	E₂₀₁₀	70.44%

Following Approach 1 and the abovementioned methodology, the overall uncertainty in the estimates produced by the described model has been quantified; in Table 7.14 the uncertainties of the 1985-2011 period are reported.

Table 7.14 Overall uncertainties 1985 - 2011

1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
70.1%	72.7%	72.3%	71.8%	71.1%	70.9%	70.9%	70.9%	70.7%	70.5%	70.4%

The overall uncertainty in the model estimates between 1990 and 2011 has been assessed with the following relation:

$$E_{1990-2011} = \frac{\sqrt{(E_{1990} \cdot V_{1990})^2 + (E_{2011} \cdot V_{2011})^2}}{|V_{1990} + V_{2011}|}$$

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 1990–2011 is equal to 50.63%.

A Montecarlo analysis has been carried out to assess uncertainty for Forest Land category (considering both Forest Land remaining Forest Land and Land converted to Forest Land), considering the different reporting pools (*aboveground, belowground, litter, deadwood and soils*), and the subcategories stands, coppices and rupicolous and riparian forests for the reporting year 2009, resulting equal to 49%. As for Land converted to Forest Land, an asymmetrical probability density distribution resulted from the analysis, showing uncertainties values equal to -147.6% and 192.3%. Normal distributions have been assumed for most of the parameters. A more detailed description of the results is reported in Annex 1.

The table reporting the uncertainties referring to all the categories (Forest Land, Cropland, Grassland, Wetlands, Settlements, Other Land) is shown in Annex 1.

A comparison between carbon in the aboveground biomass pool, estimated with the described methodology, and INFC data about 2006 aboveground carbon stock of the whole Italian forest results in 15% difference (Table 7.15).

Table 7.15 Comparison between estimated and INFC 2006 aboveground carbon stock

INFC aboveground carbon stock <i>t C</i>	Estimated aboveground carbon stock <i>t C</i>
486,018,500	412,687,828

A comparison of the model results versus data measured in the framework of Italian National Forest Inventory (INFC) may be carried out on the basis of the outcomes of the soil survey of INFC. In the following Table 7.16 estimated carbon stocks for Soil Organic Matter (SOM) and litter, for 2008, are provided.

Table 7.16 Comparison between estimated and INFC 2008 carbon stocks for SOM and litter

2008	INFC	For-est model	<i>differences</i>	
	<i>t C= Mg</i>	<i>t C= Mg</i>	<i>t C= Mg</i>	%
SOM	703,524,894	730,243,364	26,718,469	-3.80
litter	28,170,660	30,016,553	1,845,893	-6.55

7.2.6 Category-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 database²⁴, ISTAT data²⁵) has been made. 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. An independent verification of reported data was done in the framework of the National Forestry Inventory, resulting in comparison of the model results versus data measured, relating to the year 2005 (Tabacchi et al., 2010). In Figure 7.4 outcome of the comparison is shown.

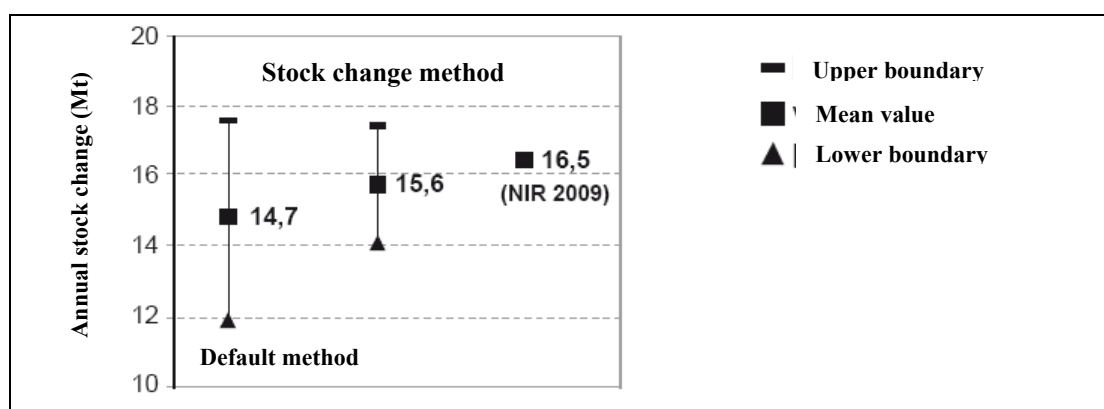


Figure 7.4 Comparison between carbon stock changes, for living biomass pool, by the National Inventory (NIR, 2009) and estimated data on the basis of INFC measurements (modified from Tabacchi et al., 2010)

The INFC classification system, and consequent categories list, has changed respect to the system (and inventory categories) used in the first forest inventory. A transition matrix, between the INFC and first forest inventory classification systems, has been planned, and included in the national registry for forest carbon sinks activities, to be elaborated in order to use all information acquired with INFC. In the meanwhile a comparison among INFC current increment data and For-est model current increment data is possible only for a not exhaustive number of inventory typologies. In the following Figure 7.5 the comparison has been reported.

²⁴ FAO, 2005. FAOSTAT, <http://faostat.fao.org>

²⁵ ISTAT, several years [a], [b], [c]

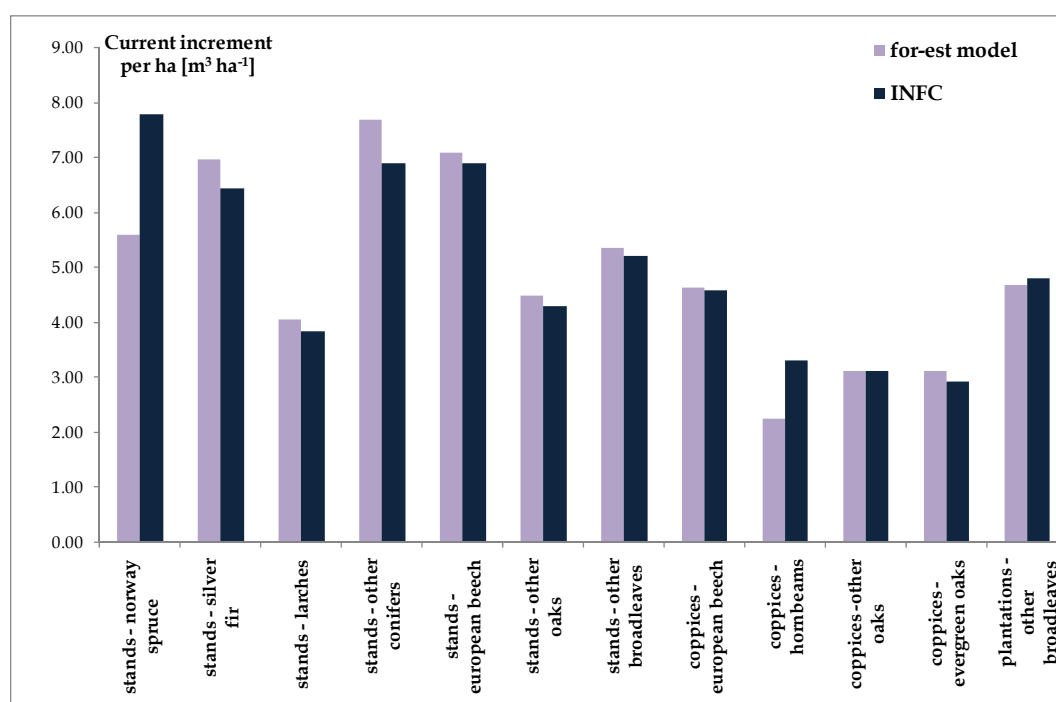


Figure 7.5 Comparison among INFC current increment data and For-est model current increment data

Regarding both soil and litter, a validation of the applied methodology has been done in Piemonte region, comparing results of a regional soil inventory with data obtained with the abovementioned methodology (Petrella and Piazzzi, 2006). Results show a good agreement between the two dataset either in litter and soil. An interregional project, named INEMAR²⁶, developed to carry out atmospheric emission inventories at local scale, has added a module to estimate forest land emission and removals, following the abovementioned methodology. The module has been applied, at local scale with local data, in Lombardia region, for the different pools and for the year 1990, 2000, 2005, 2008. In Figure 7.6 carbon stocks, in the different pools, estimated by the National Inventory (ISPRA) and the correspondent values obtained in the INEMAR framework for the Lombardia region, have showed (ARPA Lombardia - Regione Lombardia, 2011 [a, b]).

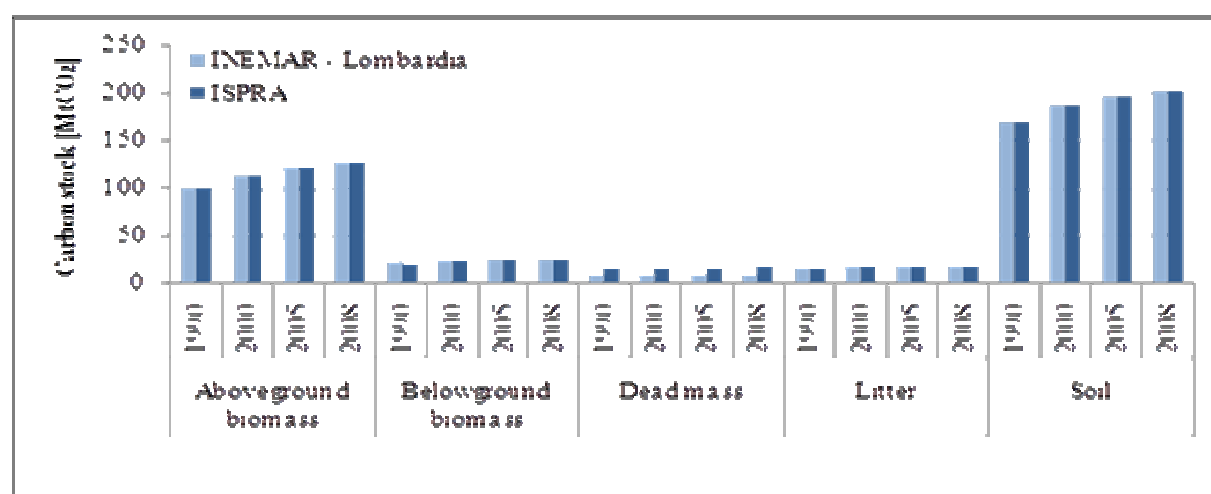


Figure 7.6 Carbon stocks estimates by the National Inventory (ISPRA) and the INEMAR project for Lombardia

In Table 7.17 carbon stocks, in the different pools, estimated by the National Inventory (ISPRA) and the correspondent values obtained in the INEMAR framework for the Lombardia region, are shown.

²⁶ INEMAR: INventario EMissioni Aria: http://www.ambiente.regione.lombardia.it/inemar/e_inemarhome.htm

Table 7.17 Carbon stocks estimates by the National Inventory (ISPRA) and the INEMAR project for Lombardia

	INEMAR - Lombardia	ISPRA	Differences
	<i>Gg CO₂</i>	<i>Gg CO₂</i>	<i>%</i>
1990	311,370	319,203	-2.45
2000	345,886	353,326	-2.11
2005	367,537	375,275	-2.06
2008	379,742	387,673	-2.05

The same module, applied in Lombardia region, will be applied, at local scale with local data, in seven of the 20 Italian regions and the results will constitute a good validation of the used methodology.

Further identification of critical issues and uncertainties in the estimations derived from the participation at workshops and pilot projects (MATT, 2002). Specifically, the European pilot project to harmonise the estimation and reporting of EU Member States, in 2003, led to a comparison among national approaches and problems related to the estimation methodology and basic data needed (JRC, 2004). The estimate methodology has been presented and discussed during several national workshops; findings and comments collected have been used in the refining estimation process.

7.2.7 Category-specific recalculations

Recalculations of emissions and removals have been carried out on the basis of the IPCC Good Practice Guidance for LULUCF (IPCC, 2003).

Deviations from the previous sectoral estimates are equal to an average²⁷ decrease of 10.1%, concerning the whole forest land category; as well regards the different carbon pools, slight decreases of 0.9% and 0.4 in living biomass pool and in soils pool, respectively, are resulting, due to the activity data updating and errors' correction. An average²⁸ decrease of 166.1% respect the previous sectoral estimates is affecting the dead organic matter pool, resulting from the update in the coefficients used in the estimation process, following the 2012 ERT's recommendation. In the Table 7.18 the comparison between the 2013 and 2012 submissions is reported.

Table 7.18 Comparison of the 2013 and 2012 submissions for the Forest land category

	1990	1995	2000	2005	2008	2009	2010
2013 submission	<i>CO₂ eq. - Gg</i>						
Forest land	-17,282	-32,369	-26,989	-36,388	-33,541	-36,641	-38,247
- living biomass	-15,597	-30,301	-24,841	-33,858	-31,004	-34,025	-35,575
- dom	-1,429	-1,699	-1,605	-1,769	-1,722	-1,782	-1,816
- soils	-256	-369	-543	-760	-816	-834	-857
2012 submission							
Forest land	-18,484	-35,403	-29,462	-39,871	-36,619	-40,207	-39,947
- living biomass	-15,563	-30,259	-24,831	-33,849	-30,994	-34,016	-33,816
- dom	-2,666	-4,775	-4,089	-5,262	-4,810	-5,357	-5,275
- soils	-256	-369	-543	-760	-815	-834	-857

7.2.8 Category-specific planned improvements

The INFC data related to the soils survey will definitely constitute a robust database, allowing for refined estimates and lower related uncertainty. The 'National Registry for Carbon sinks', established by a Ministerial Decree on 1st April 2008, is part of National Greenhouse Gas Inventory System in Italy (ISPRA, 2011 [a]) and includes information on units of lands subject of activities under Article 3.3 and activities

²⁷ Average value on the period 1990-2010

²⁸ Average value on the period 1990-2010

elected under Article 3.4 and related carbon stock changes. The National Registry for Carbon sinks is the instrument to estimate, in accordance with the COP/MOP decisions, the IPCC Good Practice Guidance on LULUCF and every relevant IPCC guidelines, the greenhouse gases emissions by sources and removals by sinks in forest land and related land-use changes and to account for the net removals in order to allow the Italian Registry to issue the relevant amount of RMUs. In 2009, a technical group, formed by experts from different institutions (ISPRA; Ministry of the Environment, Land and Sea; Ministry of Agriculture, Food and Forest Policies and University of Tuscia), set up the methodological plan of the activities necessary to implement the registry and defined the relative funding. Some of these activities (in particular IUTI, inventory of land use) has been completed, resulting in land use classification, for all national territory, for the years 1990, 2000 and 2008. A process of validation and verification of IUTI data is currently ongoing and will supply data useful to update and improve the estimations. Activities planned in the framework of the National Registry for Forest Carbon Sinks should also provide data to improve estimate of carbon sequestration due to Afforestation/reforestation activities (with a special focus on soil organic content), and should allow to refine the estimate of forest land category. Specifically, for the LULUCF sector, following the election of 3.4 activities and on account of an in-depth analysis on the information needed to report LULUCF under the Kyoto Protocol, a Scientific Committee, *Comitato di Consultazione Scientifica del Registro dei Serbatoi di Carbonio Forestali*, constituted by the relevant national experts has been established by the Ministry for the Environment, Land and Sea in cooperation with the Ministry of Agriculture, Food and Forest Policies. In addition, in 2013, the joint project “ITALI” (*Integration of Territorial And Land Information*) has started its activities; the project, coordinated by the National Institute of Statistics and promoted by EUROSTAT²⁹, involves ISPRA, the Ministry of Agriculture, Food and Forest Policies, the National Forestry Service and the SIN (*Sistema Informativo Nazionale per lo sviluppo dell’agricoltura*) and is aimed to supply national statistics related to land use and land cover, harmonising and improving the current informative bases already available in the country.

An expert panel on forest fires has been set up, in order to obtain geographically referenced 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 CO₂ emissions due to forest fires, now included in the estimate of the forest land remaining forest land, will be pointed out.

In addition to these expert panels, ISPRA participates in technical working groups, denominated *Circoli di qualità*, within the National Statistical System (Sistan). Concerning the LULUCF sector, this group, coordinated by the National Institute of Statistics, includes both producers and users of statistical information with the aim of improving and monitoring statistical information for the forest sector. These activities should improve the quality and details of basic data, as well as enable a more organized and timely communication.

An update of the for-est model has been done, following the 2012 ERT’s recommendation; the INFC data related to the dead mass, collected in the framework of INFC surveys, have been implemented in the model. The overall upgrade of the used model has been postponed, in order to implement INFC data related to the soils survey and the IUTI results, to achieve the above cited improvements and to obtain more accurate estimates of the carbon stored in the litter and soil pools, using the outcomes of research projects on carbon stocks inventories, with a special focus on the Italian territory. The upgrading of the model will also allow the use of the INFC biomass data, actually not utilized, as classification system, and consequent categories list, has changed from the first forest inventory to INFC. A transition matrix, between the INFC and the first forest inventory classification systems, has been planned to be elaborated in order to use all the information acquired within the INFC.

7.3 Cropland (5B)

7.3.1 Description

Under this category, CO₂ emissions from living biomass, dead organic matter and soils, from cropland remaining cropland and from land converted in cropland have been reported.

²⁹ Eurostat is the statistical office of the European Union:
http://epp.eurostat.ec.europa.eu/portal/page/portal/about_eurostat/introduction

Cropland removals share 7.5% of total CO₂ 2011 LULUCF emissions and removals, in particular the living biomass removals represent 87.1%, while the emissions and removals from soils stand for 12.0% of total cropland CO₂ emissions and removals. The remaining 1.0% is due to dead organic matter pool.

Removals are almost entirely due to cropland remaining cropland, while only land converting to cropland category is responsible for emissions.

CO₂ emissions and removals from cropland remaining cropland have been identified as key category in level and in trend assessment either by Approach 1 and Approach 2. CO₂ emissions and removals from land converting to cropland have been identified as key category in trend assessment (Approach 2). Concerning N₂O emissions, the category land converting to cropland has not resulted as a key source.

7.3.2 *Information on approaches used for representing land areas and on land-use databases used for the inventory preparation*

Coherently with the forest definition adopted by Italy in the framework of application of elected 3.4 activities, under Kyoto Protocol, plantations have been reported into cropland category, as they do not fulfil the national forest definition, which excludes agroforestry systems, predominantly used for agricultural practice; other plantation typologies, such as chestnut and cork oak, have been included in forest land category. Plantations (*eucalyptuses coppices*, *other broadleaves coppices*, *poplar stands*, *other broadleaves stands*, and *conifers stands*) in Italy have to be considered an agroforestry system, characterized by short rotation coppice system. Poplar stands, representing 83% of the total plantation areas in Italy, are typically grown in a short rotation coppice system for two to five years. Once harvested, these crops are usually substituted by annual crops like maize or wheat. For the land use conversion, land use change matrices have been used; as abovementioned, LUC matrices for each year of the period 1990–2011 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. Concerning cropland category, it has been assumed that only transition from grassland to cropland occurs. In response to 2011 ERT's recommendation, Italy has decided to use the IPCC default land use transition period of 20 years, in the estimation process of carbon stock changes in mineral soils related to land converting to cropland; once a land has converted to a land use category, the annual changes in carbon stocks in mineral soils have been reported for 20 years subsequent the conversion.

Furthermore land use changes have been derived, by the way of land use change matrices, smoothing the amount of changes over a 5 year period, harmonizing the whole time series, resulting in a constant amount of C stock change in the 5 year period, following a previous review remark.

7.3.3 *Land-use definitions and the classification systems used and their correspondence to the LULUCF categories*

Cropland areas have been determined on the basis of national statistics (ISTAT, [b], [c]) related to annual crops and perennial woody crops. The subcategory "plantations" has been added; plantation areas have been derived from national forest inventories (IFN, IFNC), through a linear interpolation between the 1985 and 2005 data, extrapolating data for period 2006–2011. National statistics on cropland areas have been used, in order to derive the land in conversion from grassland to cropland, by the way of land use change matrices, following the assumption that transition into cropland category occurs only from grassland category.

7.3.4 *Methodological issues*

Cropland remaining Cropland

Cropland includes all annual and perennial crops; the change in biomass has been estimated only for perennial 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 crops. The perennial crops have been further subdivided into woody crops and plantations. Carbon stock changes due to annual conversion from one cropland subcategory

to another (i.e. annual crops to perennial woody crops) have not been assessed, coherently with the IPCC GPG for LULUCF.

Perennial – woody crops

Concerning woody crops, estimates of carbon stocks changes are applied to aboveground biomass only, according to the GPG (IPCC, 2003), as there is not sufficient information to estimate carbon stocks change in dead organic matter pools. To assess change in carbon in cropland biomass, the Tier 1 based on highly aggregated area estimates for generic perennial woody crops, has been used. The carbon stock change in living biomass has been estimated on the basis of carbon gains and losses, computed applying a value of biomass C stock at maturity. The default factors of aboveground biomass carbon stock at harvest, harvest/maturity cycle, biomass accumulation rate, biomass carbon loss, for the temperate climatic region, are not very representative of the Mediterranean area, where the most common woody crops are crops like olive groves or vineyards that have different harvest/maturity cycles. Therefore, in the absence of country specific values, and following the suggestion of Joint Research Centre (JRC³⁰) experts, in the framework of European Union QA/QC checks of the Member States' inventories for the preparation of EU greenhouse gas inventory, an average value of 10 t C ha⁻¹ (carbon stock at maturity), deduced by the values adopted in Spain, has been chosen (JRC, 2013). A cycle of 20 years has been considered.

Net changes in cropland C stocks obtained are equal to 15 Gg C for 1990, and -1054 Gg C for 2011, as far as living biomass pool is concerned. In Table 7.19 change in carbon stock in living biomass are reported.

Table 7.19 Change in carbon stock in living biomass

<i>year</i>	Area	Gains (Area <30yrs)		Losses		net change in C stock
	<i>kha</i>	<i>kha</i>	<i>GgC</i>	<i>kha</i>	<i>GgC</i>	<i>GgC</i>
1990	2,867	147	74	-6	-58	15
1991	2,831	136	68	-36.6	-366	-298
1992	2,794	124	62	-36.6	-366	-304
1993	2,757	113	56	-36.6	-366	-310
1994	2,721	101	50	-36.6	-366	-316
1995	2,684	89	45	-36.6	-366	-322
1996	2,669	78	39	-15.1	-151	-112
1997	2,654	78	39	-15.1	-151	-113
1998	2,639	78	39	-15.2	-152	-113
1999	2,623	78	39	-15.2	-152	-113
2000	2,608	78	39	-15.2	-152	-113
2001	2,602	78	39	-5.7	-57	-18
2002	2,597	78	39	-5.7	-57	-18
2003	2,591	78	39	-5.7	-57	-18
2004	2,585	78	39	-5.7	-57	-18
2005	2,580	78	39	-5.7	-57	-18
2006	2,586	78	39	0	0	39
2007	2,593	65	32	0	0	32
2008	2,600	52	26	0	0	26
2009	2,607	40	20	0	0	20
2010	2,614	27	14	0	0	14
2011	2,507	34	17	-107.1	-1,071	-1,054

According to the LULUCF GPG (IPCC, 2003), the change in soil C stocks (Equation 3.3.4) is the result of a change in practices or management between the two time periods and concentration of soil carbon is only driven by the change in practice or management. It wasn't possible to point out different sets of relative stock change factors [F_{LU} (land use), F_{MG} (management), F_I (input factor)] for the period 1990-2011 under investigation; therefore, as no management changes can be documented, resulting change in carbon stock has been reported as zero.

³⁰ European Commission's Joint Research Centre (JRC) - Institute for Environment and Sustainability (IES): <http://ies.jrc.ec.europa.eu/>

Perennial – plantations

Regarding plantations, growing stock and the related carbon are assessed by the For-est model, estimating the evolution in time of the different pools and applied at regional scale (NUTS2). A detailed description of the model is reported in the paragraph 7.2.4. Total harvested wood for construction and energy purposes has been obtained from national statistics (ISTAT, several years [a]); these figures have been subtracted, as losses, from growing stock volume, as mentioned above.

The aboveground biomass was calculated, for plantations typologies, through the relation:

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

where:

GS = volume of growing stock (MAF/ISAFA, 1988) [m³ 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 = area occupied by specific typology [ha] (MAF/ISAFA, 1988)

In Table 7.20 the biomass expansion factors for the conversions of volume to aboveground tree biomass and wood basic densities are reported.

Table 7.20 Biomass Expansion Factors and Wood Basic Densities for plantations

	Inventory typology	BEF	WBD
		<i>aboveground biomass / growing stock</i>	<i>Dry weight t/ fresh volume</i>
<i>plantations</i>	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

Belowground biomass was estimated applying a Root/Shoot ratio to the aboveground biomass. The belowground biomass is computed, as:

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

where:

GS = volume of growing stock [m³ ha⁻¹]

BEF = Biomass Expansion Factors which expands growing stock volume to volume of aboveground woody biomass (ISAFA, 2004)

R = Root/Shoot ratio which converts growing stock biomass in belowground biomass

WBD = Wood Basic Density [t d.m. m⁻³]

A = area occupied by specific typology [ha]

The Root/shoot ratios and WBDs were estimated for each typology, on the basis of different studies conducted at the national and local level in different years and contexts and then included in the JRC-AFOLU database³¹. Further details are reported in par. 7.2.4.

In Table 7.21 Root/shoot ratio for the conversion of growing stock biomass in belowground biomass and wood basic densities for plantations typologies are reported.

Table 7.21 Root/shoot ratio and Wood Basic Densities for plantations

³¹ European Commission - Joint Research Centre, Institute for Environment and Sustainability, AFOLU DATA clearinghouse: Allometric Biomass and Carbon (ABC) factors database: http://afoludata.jrc.ec.europa.eu/index.php/public_area/data_and_tools

Inventory typology		R	WBD
		Root/shoot ratio	Dry weight t/ fresh volume
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

Concerning Dead Organic Matter pool, carbon amount contained in litter pool has been estimated, through linear relation established with aboveground carbon, on the basis of the outcomes of European project BioSoil³² (for litter) and a Life+ project FutMon³³, for the aboveground biomass. In Table 7.22 the different relations used to obtain litter carbon amount per ha [t C ha⁻¹] from the aboveground carbon amount per ha [t C ha⁻¹] have been reported.

Table 7.22 Relations litter – aboveground carbon per ha for plantations

Inventory typology		Relation litter – aboveground C per ha	R ²	Standard error
plantations	eucalyptuses coppices	y = 0.0197x + 2.4517	0.2037	1.83
	other broadleaves coppices	y = 0.0197x + 2.4517	0.2037	1.83
	poplars stands	y = 0.0197x + 2.4517	0.2037	1.83
	other broadleaves stands	y = 0.0197x + 2.4517	0.2037	1.83
	conifers stands	y = 0.0282x + 2.2494	0.2204	2.63

Dead wood mass has been estimated using coefficients calculated from outcomes of a survey conducted by the Italian national forest inventory (Di Cosmo et al., 2013). The values used, aggregated at regional level, may be found on the INFC website: http://www.sian.it/inventarioforestale/jsp/dati_carquant_tab.jsp. In Table 7.23 Dead wood coefficients are reported.

The dead wood [t] is:

$$\text{Dead wood(d.m.)} = DC \cdot A$$

where:

DC = Dead-wood expansion factor (dead/live ratio – dry matter) [t ha⁻¹]

A = forest area occupied by specific typology [ha]

Table 7.23 Dead-wood expansion factor

Inventory typology		dead wood (dry matter) t ha ⁻¹
plantations	eucalyptuses coppices	0.670
	other broadleaves coppices	0.670
	poplars stands	0.480
	other broadleaves stands	0.670
	conifers stands	3.040

Regarding soils pool, following the ERT recommendation, Italy has decided to apply the IPCC Tier1, assuming that, the carbon stock in soil organic matter, for plantation, does not change. Therefore carbon stock changes in soils pool, for cropland remaining cropland, have been not reported.

In Table 7.24, plantations areas and net changes in carbon stock, for the different required pools, are reported, for the period 1990-2011.

³² BioSoil project – http://www3.corpoforestale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/487/UT/systemPrint;http://www.inbo.be/content/page.asp?pid=EN_MON_FSCC_condition_report

³³ FutMon: Life+ project for the "Further Development and Implementation of an EU-level Forest Monitoring System"; <http://www.futmon.org/>; <http://www3.corpoforestale.it/flex/cm/pages/ServeAttachment.php/L/IT/D/D.e54313ecaf7ae893e249/P/BLOB%3AID%3D397>

Table 7.24 Change in carbon stock in living biomass, dead organic matter and soil organic matter in plantations

	Area	Living biomass			Dead organic matter	Soil organic matter
		Increase	Decrease	Net Change		
	<i>kha</i>			<i>Gg C</i>		
1990	142	888	-309	578	14.4	0
1991	144	873	-330	542	13.8	0
1992	146	865	-357	507	13.2	0
1993	147	865	-360	505	13.0	0
1994	149	861	-401	460	12.3	0
1995	151	859	-426	433	12.0	0
1996	152	859	-354	505	13.2	0
1997	154	848	-380	467	12.5	0
1998	156	838	-413	425	11.8	0
1999	157	844	-466	378	11.0	0
2000	159	841	-407	433	12.0	0
2001	161	822	-323	499	13.1	0
2002	162	808	-326	483	12.9	0
2003	164	793	-323	470	12.6	0
2004	166	777	-324	453	12.4	0
2005	167	757	-311	446	12.3	0
2006	169	742	-349	394	11.4	0
2007	171	715	-371	344	10.4	0
2008	172	693	-313	380	11.2	0
2009	174	667	-268	399	11.5	0
2010	175	645	-248	397	11.5	0
2011	177	651	-417	234	8.7	0

CO₂ emissions from cultivated organic soils (CRPA, 1997) in cropland remaining cropland have been estimated, using default emission factor for warm temperate, reported in Table 3.3.5 of IPCC GPG; the IPCC default EF for cultivated organic soils is equal to 10 t C ha⁻¹ y⁻¹.

CO₂ emissions from urea application have been estimated, and reported in the following Table 7.25; it has to be noticed that CRF Reporter doesn't allow reporting such a contribution to overall emissions, and therefore these emissions are not included in the current submission.

Table 7.25 CO₂ emissions from urea application

	amount of urea	EF	C emissions	CO ₂ emissions
	<i>Mg</i>	<i>t C⁻¹</i>	<i>Gg C</i>	<i>Gg C</i>
1990	633,873	0.20	127	465
1991	708,148	0.20	142	519
1992	731,357	0.20	146	536
1993	848,043	0.20	170	622
1994	802,345	0.20	160	588
1995	698,251	0.20	140	512
1996	598,943	0.20	120	439
1997	716,463	0.20	143	525
1998	717,711	0.20	144	526
1999	751,223	0.20	150	551
2000	716,412	0.20	143	525
2001	799,064	0.20	160	586
2002	863,113	0.20	173	633
2003	770,412	0.20	154	565

	amount of urea <i>Mg</i>	EF <i>t C⁻¹</i>	C emissions <i>Gg C</i>	CO ₂ emissions <i>Gg C</i>
2004	785,515	0.20	157	576
2005	691,255	0.20	138	507
2006	735,487	0.20	147	539
2007	732,213	0.20	146	537
2008	679,390	0.20	136	498
2009	506,694	0.20	101	372
2010	456,951	0.20	91	335
2011	478,306	0.20	96	351

Land converted to Cropland

In accordance with the GPG methodology, estimates of carbon stock change in living biomass have been provided, since there is not sufficient information to estimate carbon stock change in dead organic matter pool. Concerning soil carbon pool, following the 2011 ERT's recommendation, Italy has decided to use the IPCC default land use transition period of 20 years, to estimate carbon stock changes in mineral soils related to land converted to cropland; once a land has converted to cropland, the annual changes in carbon stocks in mineral soils have been reported for 20 years subsequent the conversion.

N₂O emissions arising from the conversion of land to cropland have been also estimated, and reported in Table 5(III) - N₂O 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 as far as Italy is concerned, to cropland, during each year, from 1990 to 2011, has been estimated through the construction of the land use change matrices, one for each year. The GPG equation 3.3.8 (IPCC, 2003) has been used to estimate the change in carbon stocks resulting from the land use change. The carbon stocks change per area for land converted to cropland is assumed, following the Tier1, equal to loss in carbon stocks in biomass immediately before conversion to cropland.

For the Italian territory, only conversion from grassland to cropland has occurred; therefore the default estimates for standing biomass grassland, as dry matter, reported in Table 3.4.2 of GPG (IPCC, 2003) for warm temperate – dry have been used, equal to 1.6 t d.m. ha⁻¹. Changes in carbon stocks from one year of cropland growth have been obtained by the default biomass carbon stocks reported in Table 3.3.8, for temperate region. In accordance to national expert judgement, it has been assumed that the final crop type, for the areas of transition land, is annual cropland; this assumption has been made on the basis of known patterns of land-use changes in Italy, also considering that most common woody crops are, in Italy, olive groves, orchards or vineyards and that biomass clearing is unusual.

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 1990-2011. C emissions [Gg C] due to change in carbon stocks in living biomass in land converted to cropland are reported in Table 7.26.

Table 7.26 Change in carbon stock in living biomass in land converted to cropland

<i>year</i>	Conversion Area		ΔC converted land <i>Gg C</i>
	<i>annual change</i> <i>kha</i>	<i>20 years change</i> <i>kha</i>	
1990	14.0	207.0	18.1
1991	0.5	207.5	0.6
1992	0.5	208.0	0.6
1993	0.5	208.5	0.6
1994	0.5	209.0	0.6

year	Conversion Area		ΔC converted land Gg C
	annual change kha	20 years change kha	
1995	0.5	209.4	0.6
1996	0	182.0	0
1997	0	154.5	0
1998	0	127.1	0
1999	0	99.6	0
2000	0	72.2	0
2001	0	72.2	0
2002	0	72.2	0
2003	0	72.2	0
2004	0	72.2	0
2005	0	72.2	0
2006	0	58.2	0
2007	0	44.3	0
2008	0	30.3	0
2009	0	16.4	0
2010	0	2.4	0
2011	16.4	18.4	21.4

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, with a land use transition period of 20 years. 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.

SOC reference value for cropland has been set to 56.7 tC/ha on the basis of reviewed references. This value has been drawn up by analysing a collection of the latest papers reporting data on soil carbon under the most common agricultural practices in Italy, including woody cropland cultivations such as vineyards and olive orchards (Triberti *et al* 2008, Ceccanti *et al* 2008, Monaco *et al* 2008, Martiniello 2007, Lugato and Berti 2008, Francaviglia *et al.*, 2006, IPLA 2007, ERSF 2008, Del Gardo *et al* 2003, Puglisi *et al.*, 2008, Lagomarsino *et al* 2009, Perucci *et al* 2008).

Whenever the soil carbon stock was not reported in the papers, it has been calculated at the default depth of 30 cm from the soil carbon content, the bulk density, and the stoniness according to the following formula (Batjes 1996):

$$T_d = \sum_{i=1}^K \rho_i \cdot P_i \cdot D_i \cdot (1 - S_i)$$

where

T_d is the overall soil carbon stock (gcm^{-2}) and, for each K layer of the soil profile, ρ_i is the soil bulk density (gcm^{-3}), P_i is the soil carbon content (gCg^{-1}), D_i is the layer thickness (cm), S_i is the fraction of gravel > 2mm.

If not available in the papers, soil bulk density has been calculated on the basis of the soil organic matter and texture (Adam 1973):

$$\rho = \frac{100}{\left(\frac{X}{\rho_0}\right) + \left(\frac{100 - X}{\rho_m}\right)}$$

where

ρ , soil bulk density (gcm^{-3}); X , percent by weight of organic matter; ρ_0 , average bulk density of organic matter ($0.224 gcm^{-3}$) and ρ_m , bulk density of the mineral matter usually estimated at $1.33 gcm^{-3}$ or determined on the “mineral bulk density chart” (Rawls and Brakensiek, 1985).

Since soil carbon stocks are derived from experimental measurements under some representative cropland management systems, the effect of the practices is intended to be included into the values and consequently no stock change factors (F_{LU} , F_{MG} , F_I) have been applied on the soil carbon stock. Each soil carbon stock was assigned to the geographical area where the relative soil carbon content has been measured and the overall values have been averaged by means of weights resulting from the proportional relevance of the investigated area (ha) over the entire Italian territory.

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). C emissions [Gg C] due to change in carbon stocks in soils in land converted to cropland are reported in Table 7.27.

Table 7.27 Change in carbon stock in soil in land converted to cropland

<i>year</i>	Conversion Area		Carbon stock
	<i>annual change</i>	<i>20 years change</i>	
	<i>kha</i>	<i>kha</i>	<i>Gg C</i>
1990	14.0	207.0	-221.5
1991	0.5	207.5	-222.0
1992	0.5	208.0	-222.5
1993	0.5	208.5	-223.0
1994	0.5	209.0	-223.5
1995	0.5	209.4	-224.0
1996	0	182.0	-194.7
1997	0	154.5	-165.3
1998	0	127.1	-135.9
1999	0	99.6	-106.6
2000	0	72.2	-77.2
2001	0	72.2	-77.2
2002	0	72.2	-77.2
2003	0	72.2	-77.2
2004	0	72.2	-77.2
2005	0	72.2	-77.2
2006	0	58.2	-62.3
2007	0	44.3	-47.4
2008	0	30.3	-32.4
2009	0	16.4	-17.5
2010	0	2.4	-2.6
2011	16.4	18.4	-19.7

7.3.5 Uncertainty and time series consistency

Uncertainty estimates for the period 1990–2011 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). The table reporting the uncertainties referring to the category cropland is shown in Annex 1. Input uncertainties deal with activity data and emission factors have been assessed on the basis of the information provided in the IPCC Good Practice Guidance for LULUCF (IPCC, 2003).

A Montecarlo analysis has been carried out to assess uncertainty for Cropland category (considering both Cropland remaining Cropland and Land converted to Cropland). For Cropland remaining Cropland, an asymmetrical probability density distribution resulted from the analysis, showing uncertainties values equal to -108.5% and 210.2%, taking into account all the carbon pools estimated. As for Land converted to Cropland, an asymmetrical probability density distribution resulted from the analysis, showing uncertainties values equal to -408.2% and 178.5%. Normal distributions have been assumed for most of the parameters. A more detailed description of the results is reported in Annex 1.

7.3.6 Category-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 database³⁴, ISTAT data³⁵) has been made. 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. Several QA activities are carried out in the different phases of the inventory process. In particular the applied methodologies have been presented and discussed during several national workshop and expert meeting, collecting findings and comments to be incorporated in the estimation process. All the LULUCF categories have been embedded in the overall QA/QC-system of the Italian GHG inventory.

7.3.7 Category-specific recalculations

Recalculations of emissions and removals have been carried out on the basis of LULUCF Good Practice Guidance (IPCC, 2003). The comparison with the previous sectoral estimates results in remarkable decrease, as may be noted from the 2013 and 2012 data reported in the Table 7.28. The significant decrease is mainly due to the change in method used to estimate carbon stock changes in perennial crops (living biomass). Deviations from the previous sectoral estimates are equal to an average³⁶ decrease of 3.8%, concerning the dead organic matter pool, resulting from the update in the coefficients used in the estimation process. No deviations from the previous sectoral estimates have to be recorded in soils pool.

Table 7.28 Comparison of the 2013 and 2012 submissions for the Cropland category

	1990	1995	2000	2005	2008	2009	2010
2013 submission							
	<i>CO₂ eq. - Gg</i>						
Cropland	-1,112	709	-578	-976	-1,048	-1,151	-1,185
- living biomass	-2,244	-411	-1,174	-1,569	-1,489	-1,537	-1,505
- dom	-53	-44	-44	-45	-41	-42	-42
- soils	1,142	1,151	613	613	449	394	339
2012 submission							
Cropland	-18,320	-12,850	-13,044	-11,532	-12,141	-12,162	-12,458
- living biomass	-19,411	-13,959	-13,616	-12,116	-12,568	-12,532	-12,778
- dom	-51	-43	-42	-43	-39	-40	-32
- soils	1,142	1,151	613	613	449	394	339

7.3.8 Category-specific planned improvements

Additional research will be carried out 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 disaggregated 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. Activities planned in the framework of the National Registry for Forest Carbon Sinks should also provide

³⁴ FAO, 2005. FAOSTAT, <http://faostat.fao.org>

³⁵ ISTAT, several years [a], [b], [c]

³⁶ Average value on the period 1990-2010

data to improve estimate of carbon sequestration due to Afforestation/reforestation activities (with a special focus on soil organic content), and should allow to refine the estimate of soil organic content in cropland category.

In addition, in 2013, the joint project “ITALI” (*Integration of Territorial And Land Information*) has started its activities; the project, coordinated by the National Institute of Statistics and promoted by EUROSTAT³⁷, involves ISPRA, the Ministry of Agriculture, Food and Forest Policies, the National Forestry Service and the SIN (*Sistema Informativo Nazionale per lo sviluppo dell’agricoltura*) and is aimed to supply national statistics related to land use and land cover, harmonising and improving the current informative bases already available in the country.

7.4 Grassland (5C)

7.4.1 Description

Under this category, CO₂ emissions from living biomass, dead organic matter and soils, from grassland remaining grassland and from land converted in grassland have been reported.

Grassland category is responsible for 8,031 Gg of CO₂ removals in 2011, with 1,213 Gg of CO₂ removals due to living biomass pool, 222 Gg CO₂ removals due to dead organic matter pool and 7,665 Gg of CO₂ removals due the soils pool. In 2011, grassland emissions share 7.6% of absolute CO₂ LULUCF emissions and removals, in particular the living biomass emissions represent 13.3%, while the removals from dead organic matter pool share for 2.4% and removals from soils stand for 84.2% of absolute total grassland CO₂ emissions and removals.

CO₂ emissions and removals from grassland remaining grassland have resulted as key category, concerning trend analysis, either by Approach 1 and Approach 2. CO₂ emissions and removals from land converting to grassland have been identified as key category in level and in trend assessment, either by Approach 1 and Approach 2. Concerning N₂O emissions, the category land converting to cropland has not resulted as a key source.

7.4.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

Coherently with the forest definition adopted by Italy in the framework of application of elected 3.4 activities, under Kyoto Protocol, shrublands have been reported into the grassland category, as they don’t fulfil the national forest definition. For the land use conversion, land use change matrices have been used; as abovementioned, LUC matrices for each year of the period 1990–2011 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. Concerning grassland category, it has been assumed that only transition from cropland to grassland occurs.

In response to ERT recommendation, Italy has decided to use the IPCC default land use transition period of 20 years, in the estimation process of carbon stock changes in mineral soils related to land converting to grassland; once a land has converted to a land use category, the annual changes in carbon stocks in mineral soils have been reported for 20 years subsequent the conversion.

Furthermore land use changes have been derived, by the way of land use change matrices, smoothing the amount of changes over a 5 year period, harmonizing the whole time series, resulting in a constant amount of C stock change in the 5 year period, following a previous review remark.

³⁷ Eurostat is the statistical office of the European Union:
http://epp.eurostat.ec.europa.eu/portal/page/portal/about_eurostat/introduction

7.4.3 *Land-use definitions and the classification systems used and their correspondence to the LULUCF categories*

Grassland areas have been determined on the basis of national statistics (ISTAT, [b], [c]) related to grazing lands, forage crops, permanent pastures, and lands once used for agriculture purposes, but in fact set-aside since 1970. The subcategory “shrublands” has been added; shrublands areas have been derived from national forest inventories (IFN, IFNC), through a linear interpolation between the 1985 and 2005 data, extrapolating data for period 2006-2011. National statistics on cropland areas have been used, in order to derive the land in conversion from cropland to grassland, by the way of LUC matrix, following the assumption that transition into cropland category occurs only from grassland category.

7.4.4 *Methodological issues*

Grassland remaining Grassland

Grassland includes all grazing land and other wood land that do not fulfil the forest definition (as shrublands); the change in biomass has been estimated only for subcategory “other wooded land”, since, for grazing land, 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 grassland remaining grassland have been subdivided into grazing land and other wooded land.

Grazing land

To assess change in carbon in grassland biomass, the Tier 1 has been used; therefore no change in carbon stocks in the living biomass pool has been assumed; in accordance with the GPG no data regarding the dead organic matter pool have been provided, since not enough information is available.

According to the 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 wasn't possible to point out different sets of relative stock change factors [F_{LU} (land use), F_{MG} (management), F_I (input factor)] for the period 1990-2011 under investigation; therefore, as no management changes can be documented, resulting change in carbon stock has been reported as zero.

No CO₂ emissions from organic soils or from application of carbonate containing lime have occurred.

Other wooded land

Regarding shrublands, growing stock and the related carbon are assessed by the For-est model, estimating the evolution in time of the different pools and applied at regional scale (NUTS2). A detailed description of the model is reported in the paragraph 7.2.4.

The aboveground biomass was calculated, for shrublands, through the relation:

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

where:

GS = volume of growing stock (MAF/ISAFA, 1988) [$\text{m}^3 \text{ha}^{-1}$]

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 = area occupied by specific typology [ha] (MAF/ISAFA, 1988)

In Table 7.29 biomass expansion factors for the conversions of volume to aboveground tree biomass and wood basic densities are reported.

Table 7.29 Biomass Expansion Factors and Wood Basic Densities for shrublands

Inventory typology	BEF	WBD
	aboveground biomass / growing stock	Dry weight t/ fresh volume

shrublands	1.49	0.63
------------	------	------

Belowground biomass was estimated applying a Root/Shoot ratio to the aboveground biomass. The belowground biomass is computed, as:

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

where:

GS = volume of growing stock [$\text{m}^3 \text{ha}^{-1}$]

BEF = Biomass Expansion Factors which expands growing stock volume to volume of aboveground woody biomass (ISAF, 2004)

R = Root/Shoot ratio which converts growing stock biomass in belowground biomass

WBD = Wood Basic Density [t d.m. m^{-3}]

A = area occupied by specific typology [ha]

The Root/shoot ratio and WBD were estimated on the basis of different studies conducted at the national and local level in different years and contexts, and then included in the JRC-AFOLU database³⁸. Further details are reported in par. 7.2.4.

In Table 7.30 Root/shoot ratio for the conversion of growing stock biomass in belowground biomass and wood basic density for shrubland are reported.

Table 7.30 Root/Shoot ratio and Wood Basic Densities for shrubland

Inventory typology	R	WBD
	Root/shoot ratio	Dry weight t/ fresh volume
Shrublands	0.62	0.63

Dead wood mass has been estimated using coefficients calculated from outcomes of a survey conducted by the Italian national forest inventory (Di Cosmo et al., 2013). The values used, aggregated at regional level, may be found on the INFC website: http://www.sian.it/inventarioforestale/jsp/dati_carquant_tab.jsp. In Table 7.31 Dead wood coefficients are reported.

The dead wood [t] is:

$$\text{Dead wood(d.m.)} = DC \cdot A$$

where:

DC = Dead-wood expansion factor (dead/live ratio – dry matter) [t ha^{-1}]

A = forest area occupied by specific typology [ha]

Table 7.31 Dead-wood expansion factor

Inventory typology	dead wood (dry matter) t ha^{-1}
Shrublands	1.510

Carbon amount contained in litter pool has been estimated, through linear relation established with aboveground carbon, on the basis of the outcomes of European project Biosoil³⁹ (for litter) and a Life+ project FutMon⁴⁰, for the aboveground biomass. In Table 7.32 the relation used to obtain litter carbon amount per ha [t C ha^{-1}] from the aboveground carbon amount per ha [t C ha^{-1}] has been reported.

³⁸ European Commission - Joint Research Centre, Institute for Environment and Sustainability, AFOLU DATA clearinghouse: Allometric Biomass and Carbon (ABC) factors database: http://afoludata.jrc.ec.europa.eu/index.php/public_area/data_and_tools

³⁹ BioSoil project – http://www3.corpoforestale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/487/UT/systemPrint;http://www.inbo.be/content/page.asp?pid=EN_MON_FSCC_condition_report

⁴⁰ FutMon: Life+ project for the "Further Development and Implementation of an EU-level Forest Monitoring System"; <http://www.futmon.org/>; <http://www3.corpoforestale.it/flex/cm/pages/ServeAttachment.php/L/IT/D/D.e54313ecaf7ae893e249/P/BLOB%3AID%3D397>

Table 7.32 Relations litter - aboveground carbon per ha for shrubland

Inventory typology	Relation litter – aboveground C per ha	R ²	Standard error
shrublands	$y = 0.0249x + 2.6061$	0.191	1.88

As for soils pool, following the ERT recommendation, Italy has decided to apply the IPCC Tier1, assuming that, the carbon stock in soil organic matter, for shrubland, does not change. Therefore carbon stock changes in soils pool, for grassland remaining grassland, have been not reported.

In Table 7.33, other wooded land areas and net changes in carbon stock, for the different required pools, are reported, for the period 1990-2011.

Table 7.33 Change in carbon stock in living biomass, dead organic matter and soil organic matter in other wooded land

	Area	Living biomass			Dead organic matter	Soil organic matter
		Increase	Decrease	Net Change		
	<i>kha</i>			<i>Gg C</i>		
1990	1,561	2,477	-2,584	-106.47	51.68	0
1991	1,578	2,517	-2,356	161.38	56.39	0
1992	1,595	2,560	-2,487	73.01	54.83	0
1993	1,612	2,612	-2,852	-239.95	49.33	0
1994	1,629	2,652	-2,508	144.28	56.09	0
1995	1,646	2,685	-2,300	385.10	60.32	0
1996	1,663	2,718	-2,333	385.30	60.33	0
1997	1,680	2,755	-2,518	236.87	57.72	0
1998	1,697	2,796	-2,692	104.60	55.39	0
1999	1,714	2,829	-2,461	368.44	60.03	0
2000	1,731	2,866	-2,629	237.89	57.73	0
2001	1,748	2,899	-2,514	384.68	60.32	0
2002	1,766	2,930	-2,473	456.94	61.59	0
2003	1,783	2,962	-2,570	391.75	60.44	0
2004	1,800	2,992	-2,521	470.55	61.83	0
2005	1,817	3,021	-2,522	499.25	62.33	0
2006	1,834	3,050	-2,519	530.09	62.87	0
2007	1,851	3,093	-3,084	8.96	54.26	0
2008	1,868	3,122	-2,609	513.05	63.13	0
2009	1,886	3,153	-2,682	471.08	62.68	0
2010	1,903	3,181	-2,651	530.25	63.95	0
2011	1,920	3,215	-2,884	330.91	60.45	0

Land converted to Grassland

The assessment of emissions and removals of carbon due to conversion of other land uses to grassland requires estimates of the carbon stocks prior to and following conversion and the estimates of land converted during the period over which the conversion has an effect.

In accordance with the GPG methodology, estimates of carbon stock change in living biomass has been provided, since there is not sufficient information to estimate carbon stock change in dead organic matter pool. Concerning soil carbon pool, following the 2011 ERT's recommendation, Italy has decided to use the IPCC default land use transition period of 20 years, to estimate carbon stock changes in mineral soils related to land converted to grassland; once a land has converted to grassland, the annual changes in carbon stocks in mineral soils have been reported for 20 years subsequent the conversion. 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 as far as Italy is concerned, to grassland during each year has been pointed out, from 1990 to 2011, for each initial and final land use, through the use of the land use change matrices, one for each year. 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 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 has taken place only in a few years during the period 1990-2011. C emissions [Gg C] due to change in carbon stocks in living biomass in land converted to grassland, are reported in Table 7.34.

Table 7.34 Change in carbon stock in living biomass in land converted to grassland

<i>year</i>	Conversion Area		C_{before}	ΔC_{growth}	ΔC
	<i>annual change</i>	<i>20 years change</i>			
	<i>kha</i>	<i>kha</i>	<i>t C ha⁻¹</i>	<i>t C ha⁻¹</i>	<i>Gg C</i>
1990	0	240	5	3.05	0
1991	0	240	5	3.05	0
1992	0	240	5	3.05	0
1993	0	240	5	3.05	0
1994	0	240	5	3.05	0
1995	0	240	5	3.05	0
1996	103	343	5	3.05	-202
1997	103	447	5	3.05	-202
1998	103	550	5	3.05	-202
1999	103	653	5	3.05	-202
2000	103	757	5	3.05	-202
2001	111	819	5	3.05	-216
2002	111	882	5	3.05	-216
2003	111	945	5	3.05	-216
2004	111	1,008	5	3.05	-216
2005	111	1,071	5	3.05	-216
2006	177	1,247	5	3.05	-345
2007	177	1,424	5	3.05	-345
2008	177	1,601	5	3.05	-345
2009	177	1,778	5	3.05	-345
2010	177	1,954	5	3.05	-345
2011	0	1,954	5	3.05	0

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, with a land use transition period of 20 years. Initial land use soil carbon stock [SOC_(0-T)] and soil carbon stock in the inventory year [SOC₀] for the grassland have been estimated from the reference carbon stocks.

SOC reference value for grassland has been revised and set to 78.9 tC/ha on the basis of reviewed references. It makes the current estimate consistent with the SOC stocks reported for grassland in temperate regions, 60-150 tC/ha (Gardi et al., 2007). This value has been drawn up by analysing a collection of the latest papers reporting data on soil carbon in mountain meadows, pastures, set-aside lands as well as soil not disturbed since the agricultural abandonment in Italy (Viaroli and Gardi 2004, CRPA 2009, IPLA 2007, ERSF 2008,

Del Gardo *et al* 2003, LaMantia *et al* 2007, Benedetti *et al* 2004, Masciandaro and Ceccanti 1999, Xiloyannis 2007).

Whenever the soil carbon stock was not reported in the papers, it has been calculated at the default depth of 30 cm from the soil carbon content, the bulk density, and the stoniness according to the following formula (Batjes 1996):

$$T_d = \sum_{i=1}^K \rho_i \cdot P_i \cdot D_i \cdot (1 - S_i)$$

where T_d is the overall soil carbon stock (gcm^{-2}) and, for each K layer of the soil profile, ρ_i is the soil bulk density (gcm^{-3}), P_i is the soil carbon content (gCg^{-1}), D_i is the layer thickness (cm), S_i is the fraction of gravel > 2mm. If not available in the papers, soil bulk density has been calculated on the basis of the soil organic matter and texture (Adam 1973):

$$\rho = \frac{100}{\left(\frac{X}{\rho_0}\right) + \left(\frac{100-X}{\rho_m}\right)}$$

where ρ , soil bulk density (gcm^{-3}); X , percent by weight of organic matter; ρ_0 , average bulk density of organic matter (0.224 gcm^{-3}) and ρ_m , bulk density of the mineral matter usually estimated at 1.33 gcm^{-3} or determined on the “mineral bulk density chart” (Rawls and Brakensiek, 1985).

Since soil carbon stocks are derived from experimental measurements under some representative cropland managements, the effect of the practices is intended to be included into the values and consequently no stock change factors (F_{LU} , F_{MG} , F_I) have been applied on the soil carbon stock. Each soil carbon stock was assigned to the geographical area where the relative soil carbon content has been measured and the overall values have been averaged by means of weights resulting from the proportional relevance of the investigated area (ha) over the entire Italian territory.

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. C emissions [Gg C] due to change in carbon stocks in soils in land converted to grassland, are reported in Table 7.35.

Table 7.35 Change in carbon stock in soils

year	Conversion Area		Carbon stock
	annual change	20 years change	
	kha	kha	Gg C
1990	0	240	257
1991	0	240	257
1992	0	240	257
1993	0	240	257
1994	0	240	257
1995	0	240	257
1996	103	343	367
1997	103	447	478
1998	103	550	588
1999	103	653	699
2000	103	757	809
2001	111	819	877
2002	111	882	944
2003	111	945	1,011
2004	111	1,008	1,078
2005	111	1,071	1,145
2006	177	1,247	1,334
2007	177	1,424	1,523

year	Conversion Area		Carbon stock
	annual change	20 years change	
	kha	kha	Gg C
2008	177	1,601	1,712
2009	177	1,778	1,901
2010	177	1,954	2,091
2011	0	1,954	2,091

7.4.5 *Uncertainty and time series consistency*

Uncertainty estimates for the period 1990–2011 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). The table reporting the uncertainties referring to the category grassland is shown in Annex 1. Input uncertainties deal with activity data and emission factors have been assessed on the basis of the information provided in the IPCC Good Practice Guidance for LULUCF (IPCC, 2003).

A Montecarlo analysis has been carried out to assess uncertainty for Grassland category (considering both Grassland remaining Grassland and Land converted to Grassland). For Grassland remaining Grassland, an asymmetrical probability density distribution resulted from the analysis, showing uncertainties values equal to -67.7% and 75.0%. An asymmetrical probability density distribution resulted from the analysis also for the subcategory Land converted to Grassland, showing uncertainties values equal to -119.3% and 194.5%. Normal distributions have been assumed for most of the parameters; whenever assumptions or constraints on variables were known this information has been appropriately reflected on the choice of type and shape of distributions. A more detailed description of the results is reported in Annex 1.

7.4.6 *Category-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 database⁴¹, ISTAT data⁴²) has been made. 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. Several QA activities are carried out in the different phases of the inventory process. In particular the applied methodologies have been presented and discussed during several national workshop and expert meeting, collecting findings and comments to be incorporated in the estimation process. All the LULUCF categories have been embedded in the overall QA/QC-system of the Italian GHG inventory.

7.4.7 *Category-specific recalculations*

Recalculations of emissions and removals have been carried out on the basis of LULUCF Good Practice Guidance (IPCC, 2003). The comparison with the previous sectoral estimates results in an average⁴³ decrease of 34.8% in living biomass pool, of 30.5% in deadwood pool and an increase, equal to 11.2%, in soils pool. The deadwood pool deviation is due to the update in the coefficients used in the estimation process, while the remaining deviations are resulting from activity data updating and errors' correction.

⁴¹ FAO, 2005. FAOSTAT, <http://faostat.fao.org>

⁴² ISTAT, several years [a], [b], [c]

⁴³ Average value on the period 1990-2010

7.4.8 *Category-specific planned improvements*

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

Activities planned in the framework of the National Registry for Forest Carbon Sinks should also provide data to improve estimate of carbon sequestration due to Afforestation/reforestation activities (with a special focus on soil organic content), and should allow to refine the estimate of soil organic content in grassland category. In addition, in 2013, the joint project “ITALI” (*Integration of Territorial And Land Information*) has started its activities; the project, coordinated by the National Institute of Statistics and promoted by EUROSTAT⁴⁴, involves ISPRA, the Ministry of Agriculture, Food and Forest Policies, the National Forestry Service and the SIN (*Sistema Informativo Nazionale per lo sviluppo dell'agricoltura*) and is aimed to supply national statistics related to land use and land cover, harmonising and improving the current informative bases already available in the country.

7.5 Wetlands (5D)

7.5.1 *Description*

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

7.5.2 *Information on approaches used for representing land areas and on land-use databases used for the inventory preparation*

For the land use conversion, land use change matrices have been used; as abovementioned, LUC matrices for each year of the period 1990–2011 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 considering the need for the total national area to remain constant. Concerning land converted to wetland, during the period 1990-2011, it has been assumed that no land has been in transition to wetlands.

7.5.3 *Land-use definitions and the classification systems used and their correspondence to the LULUCF categories*

Lands covered or saturated by water, for all or part of the year, 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.

7.5.4 *Methodological issues*

No estimates related to emissions of CO₂, CH₄ and N₂O from flooded lands have been supplied, as very few information on this source is available. Concerning land converted to wetland, no land in transition to wetlands has occurred in 1990-2011.

⁴⁴ Eurostat is the statistical office of the European Union:
http://epp.eurostat.ec.europa.eu/portal/page/portal/about_eurostat/introduction

7.5.5 *Category-specific planned improvements*

Improvements will concern the acquirement of data about flooded lands and the implementation of the GPG method to estimate CO₂, CH₄ and N₂O emissions from flooded lands.

7.6 **Settlements (5E)**

7.6.1 *Description*

Under this category, activity data from settlements and from land converted to settlements are reported; CO₂ emissions, from living biomass and soil, from land converted in settlements have been also reported. In 2011, settlements emissions share 7.7% of absolute CO₂ LULUCF emissions and removals. CO₂ emissions and removals from land converting to settlements have resulted as key category, concerning level an trend analysis, either by Approach 1 and Approach 2.

7.6.2 *Information on approaches used for representing land areas and on land-use databases used for the inventory preparation*

For the land use conversion, land use change matrices have been used; as abovementioned, LUC matrices for each year of the period 1990–2011 have been assembled based on time series of national land use statistics for forest lands, croplands, grasslands, wetlands and settlement areas.

Settlements time series has been developed through a linear interpolation between the 1990, 2000 and 2006 data, obtained by the Corine Land Cover⁴⁵ maps, relatively to the class “*Artificial surfaces*”. By assuming that the defined trend may well represent the near future, it was possible to extrapolate data for the years 2007–2011. The average area of land undergoing a transition from non-settlements to settlements during each year, from 1990 to 2010, has been estimated with the land use change matrices that have also permitted to specify the initial and final land use.

In response to ERT remark in the 2009 review, land use changes have been derived, by the way of LUC matrices, smoothing the amount of changes over a 5 year period, harmonizing the whole time series, resulting in a constant amount of C stock change in the 5 year period.

7.6.3 *Land-use definitions and the classification systems used and their correspondence to the LULUCF categories*

All artificial surfaces, transportation infrastructures (urban and rural), power lines and human settlements of any size, comprising also parks, have been included in this category.

7.6.4 *Methodological issues*

Settlements remaining Settlements

CO₂ estimates on the carbon stocks changes in living biomass, dead organic matter and soil for settlements remaining settlements haven't been submitted, due to the lack of information and data related to urban tree formations. Therefore only activity data have been reported.

Land converted to Settlements

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. A 20-years transition period has been applied to determine the area in conversion to Settlements, while the related CO₂ emissions are assumed to happening in in the year following the conversion, taking into account the nature of final land use category (Settlements) and assuming that soils organic matter content of previous land use category is lost in the conversion year. The

⁴⁵ Corine Land Cover, <http://www.sinanet.isprambiente.it/it/usosuolo> (APAT, 2004)

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, conversions from forest land, grassland and cropland to settlements have occurred in the 1990-2011 period. Carbon stock changes related to forest land converted to settlements have been estimated, for each year and for each pool (living biomass, dead organic matter and soils), on the basis of forest land carbon stocks deduced from the model described in paragraph 7.2.4 and 10.3.1.2, concerning soils pool.

Concerning forest soils, the SOC values reported in the table 7.35 have been used; the time range reported in the first column of the table 7.36 provides the time references for the SOC values' use. A detailed description of the methodology used in the estimation process of soils pool, and consequently of the SOC values, is provided in par. 10.3.1.2, related to the KP-LULUCF.

Table 7.36 Soil Organic Content (SOC) values for forest land remaining forest land

	SOC <i>t C ha⁻¹</i>
1985-1994	80.406
1995-1999	80.777
2000-2004	81.195
2005-2009	81.660
2010-2012	81.952

SOC reference value for grassland has been revised and set to 78.9 t C ha⁻¹, after a review of the latest papers reporting data on soil carbon in mountain meadows, pastures, set-aside lands as well as soil not disturbed since the agricultural abandonment, in Italy (Viaroli and Gardi 2004, CRPA 2009, IPLA 2007, ERSAP 2008, Del Gardo *et al* 2003, LaMantia *et al* 2007, Benedetti *et al* 2004, Masciandaro and Ceccanti 1999, Xiloyannis 2007). SOC reference value for cropland has been set to 56.7 tC/ha on the basis of reviewed references. This value has been drawn up by analysing a collection of the latest papers reporting data on soil carbon (Triberti *et al* 2008, Ceccanti *et al* 2008, Monaco *et al* 2008, Martiniello 2007, Lugato and Berti 2008, Francaviglia *et al.*, 2006, IPLA 2007, ERSAP 2008, Del Gardo *et al* 2003, Puglisi *et al*, 2008, Lagomarsino *et al* 2009, Perucci *et al* 2008).

SOC reference value, for settlements category, has been assumed, using a conservative approach, to be zero. In Table 7.37 C stocks [Gg C] related to change in carbon stocks in living biomass, dead organic matter and soils in forest land converted to settlements are reported.

Table 7.37 Change in carbon stocks in forest land converted to settlements

<i>Year</i>	<i>Conversion Area</i> <i>kha</i>	Forest land to settlements			Total Carbon stock <i>Gg C</i>
		<i>Living biomass</i> <i>Gg C</i>	<i>Dead organic matter</i> <i>Gg C</i>	<i>Soils</i> <i>Gg C</i>	
1990	0.72	-34.03	-3.53	-58.07	-95.63
1991	0.72	-34.34	-3.53	-58.07	-95.94
1992	0.72	-34.60	-3.53	-58.07	-96.20
1993	0.72	-34.60	-3.53	-58.07	-96.21
1994	0.72	-34.86	-3.54	-58.07	-96.47
1995	0.72	-35.19	-3.54	-58.34	-97.08
1996	0.72	-35.52	-3.55	-58.34	-97.40
1997	0.72	-35.67	-3.55	-58.34	-97.56
1998	0.72	-35.77	-3.55	-58.34	-97.66
1999	0.72	-35.99	-3.55	-58.34	-97.89
2000	0.72	-36.19	-3.56	-58.64	-98.38
2001	0.72	-36.50	-3.56	-58.64	-98.71
2002	0.72	-36.89	-3.57	-58.64	-99.10
2003	0.72	-37.15	-3.57	-58.64	-99.36

Year	Forest land to settlements				Total Carbon stock Gg C
	Conversion Area kha	Living biomass	Dead organic matter	Soils	
		Gg C	Gg C	Gg C	
2004	0.72	-37.49	-3.58	-58.64	-99.71
2005	0.72	-37.85	-3.58	-58.98	-100.40
2006	0.72	-38.20	-3.59	-58.98	-100.76
2007	0.72	-38.21	-3.59	-58.98	-100.78
2008	0.72	-38.50	-3.59	-58.98	-101.06
2009	0.72	-38.82	-3.60	-58.98	-101.40
2010	0.72	-39.17	-3.60	-59.19	-101.96
2011	0.72	-39.20	-3.60	-59.19	-101.99

Concerning grassland converted to settlements, change in carbon stocks has been computed only for soil pool, as, in Tier 1 approach, no change in carbon stocks in the grassland living biomass pool has been assumed. For what concerns cropland in transition to settlements, carbon stocks, for each year and for crops type (annual or perennial), have been estimated, using as default coefficients the factors shown in the following Table 7.38.

Table 7.38 Stock change factors for cropland

Biomass carbon stock <i>t C ha⁻¹</i>	
Annual cropland	5
Perennial woody cropland	63

In Table 7.39 C stocks [Gg C] related to change in carbon stocks in living biomass in cropland (annual and perennial) converted to settlements are reported.

Table 7.39 Change in carbon stocks in living biomass in cropland converted to settlements

Year	annual crops to settlements		perennial crops to settlements		Total Carbon stock Gg C
	Conversion Area	Carbon stock	Conversion Area	Carbon stock	
	kha	Gg C	kha	Gg C	
1990	0	0	0	0	0
1991	0	0	0	0	0
1992	0	0	0	0	0
1993	0	0	0	0	0
1994	0	0	0	0	0
1995	0	0	0	0	0
1996	5.66	-28.30	1.88	-118.23	-146.53
1997	5.66	-28.28	1.88	-118.48	-146.76
1998	5.65	-28.26	1.88	-118.74	-147.00
1999	5.65	-28.24	1.89	-119.00	-147.24
2000	5.64	-28.22	1.89	-119.27	-147.49
2001	7.88	-39.41	2.68	-168.71	-208.11
2002	7.85	-39.27	2.70	-170.37	-209.64
2003	7.83	-39.14	2.73	-172.07	-211.20
2004	7.80	-39.00	2.76	-173.81	-212.81
2005	7.77	-38.86	2.79	-175.59	-214.45
2006	7.71	-38.57	2.85	-179.25	-217.82
2007	7.65	-38.27	2.91	-183.05	-221.32
2008	7.59	-37.95	2.97	-187.00	-224.96
2009	7.53	-37.63	3.03	-191.12	-228.75

Year	annual crops to settlements		perennial crops to settlements		Total Carbon stock Gg C
	Conversion Area	Carbon stock	Conversion Area	Carbon stock	
	kha	Gg C	kha	Gg C	
2010	7.46	-37.29	3.10	-195.42	-232.70
2011	0	0	0	0	0

Changes in soil carbon stocks from land converting to settlements have been also estimated. In Table 7.40 soil C stocks [Gg C] of cropland (annual and perennial) and grassland converted to settlements are reported.

Table 7.40 Change in carbon stocks in soil in cropland and grassland converted to settlements

Year	annual crops to settlements		perennial crops to settlements		grassland to settlements	
	Conversion Area	Carbon stock	Conversion Area	Carbon stock	Conversion Area	Carbon stock
	kha	Gg C	kha	Gg C	kha	Gg C
1990	0	0	0	0	7.56	-590.55
1991	0	0	0	0	7.54	-588.60
1992	0	0	0	0	7.54	-588.60
1993	0	0	0	0	7.54	-588.60
1994	0	0	0	0	7.54	-588.60
1995	0	0	0	0	7.54	-588.60
1996	5.66	-320.95	1.88	-106.40	0	0
1997	5.66	-320.72	1.88	-106.63	0	0
1998	5.65	-320.49	1.88	-106.86	0	0
1999	5.65	-320.25	1.89	-107.10	0	0
2000	5.64	-320.01	1.89	-107.34	0	0
2001	7.88	-446.84	2.68	-151.83	0	0
2002	7.85	-445.35	2.70	-153.32	0	0
2003	7.83	-443.82	2.73	-154.85	0	0
2004	7.80	-442.25	2.76	-156.42	0	0
2005	7.77	-440.64	2.79	-158.03	0	0
2006	7.71	-437.35	2.85	-161.32	0	0
2007	7.65	-433.93	2.91	-164.74	0	0
2008	7.59	-437.35	2.97	-168.30	0	0
2009	7.53	-433.93	3.03	-172.01	0	0
2010	7.46	-422.80	3.10	-175.87	0	0
2011	0	0	0	0	10.56	-824.56

7.6.5 Uncertainty and time series consistency

Uncertainty estimates for the period 1990–2011 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). The table reporting the uncertainties referring to the category settlements is shown in Annex 1. Input uncertainties deal with activity data and emission factors have been assessed on the basis of the information provided in the IPCC Good Practice Guidance for LULUCF (IPCC, 2003).

A Montecarlo analysis has been carried out to assess uncertainty for Settlements category, resulting in an asymmetrical probability density distribution, with uncertainties values equal to -100.3% and 49.2%. Normal distributions have been assumed for most of the parameters; whenever assumptions or constraints on variables were known this information has been appropriately reflected on the choice of type and shape of distributions. A more detailed description of the results is reported in Annex 1.

7.6.6 Category-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 database⁴⁶, ISTAT data⁴⁷) has been made. 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. Several QA activities are carried out in the different phases of the inventory process. In particular the applied methodologies have been presented and discussed during several national workshop and expert meeting, collecting findings and comments to be incorporated in the estimation process. All the LULUCF categories have been embedded in the overall QA/QC-system of the Italian GHG inventory.

7.6.7 Category-specific recalculations

Modest deviations from the previous sectoral estimates occurred, essentially due to the update in the coefficients used in the estimation process of forest deadwood pool. The comparison with previous submission results in average⁴⁸ decrease of emissions equal to 1.9% in settlements category, in the period 1990-2010.

7.6.8 Category-specific planned improvements

Further investigation will be made to obtain additional statistics about settlements, comparing the added information to the time series developed from Corine Land Cover data (APAT, 2004). More accurate and resolute data will outcome from the activities, in progress, related to the Kyoto reporting system (National registry for carbon sinks). 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.

In addition, in 2013, the joint project "ITALI" (*Integration of Territorial And Land Information*) has started its activities; the project, coordinated by the National Institute of Statistics and promoted by EUROSTAT⁴⁹, involves ISPRA, the Ministry of Agriculture, Food and Forest Policies, the National Forestry Service and the SIN (*Sistema Informativo Nazionale per lo sviluppo dell'agricoltura*) and is aimed to supply national statistics related to land use and land cover, harmonising and improving the current informative bases already available in the country

7.7 Other Land (5F)

Under this category, CO₂ emissions, from living biomass, dead organic matter and soils, from land converted in other land should be accounted for; no data is reported since the conversion to other land is not occurring.

7.8 Direct N₂O emissions from N fertilization (5(I))

N₂O 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 N₂O emissions from drainage of soils (5(II))

⁴⁶ FAO, 2005. FAOSTAT, <http://faostat.fao.org>

⁴⁷ ISTAT, several years [a], [b], [c]

⁴⁸ Average value on the period 1990-2010

⁴⁹ Eurostat is the statistical office of the European Union: http://epp.eurostat.ec.europa.eu/portal/page/portal/about_eurostat/introduction

As regards N₂O 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 N₂O emissions from disturbance associated with land-use conversion to Cropland (5(III))

7.10.1 Description

Under this category, N₂O emissions from disturbance of soils associated with land-use conversion to cropland are reported, according to the GPG (IPCC, 2003). N₂O emissions from cropland remaining cropland are included in the agriculture sector of the good practice guidance. The good practice guidance provides methodologies only for mineral soils.

7.10.2 Methodological issues

N₂O 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 2011, has been estimated with the land use change matrices; as mentioned above, only conversion from grassland to cropland has occurred in the Italian territory. The GPG equation 3.3.14 has been used to estimate the emissions of N₂O 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 N₂O-N/kg N for the C/N ratio and for calculating N₂O emissions from N in the soil respectively, N₂O emissions have been estimated.

In Table 7.41 N₂O emissions resulting from the disturbance associated with land-use conversion to cropland are reported.

Table 7.41 N₂O emissions from land-use conversion to cropland

year	Conversion Area		Carbon stock	N _{net-min}	N ₂ O _{net-min} -N	N ₂ O emissions
	annual change	annual change				
	kha	kha	Gg C	kt N	kt N ₂ O-N	Gg N ₂ O
1990	13.95	207.04	221.47	15	14.8	0.0125
1991	0.48	207.52	221.98	15	14.8	0.0125
1992	0.48	208.00	222.50	15	14.8	0.0125
1993	0.48	208.48	223.01	15	14.9	0.0125
1994	0.48	208.97	223.53	15	14.9	0.0125
1995	0.48	209.45	224.04	15	14.9	0.0125
1996	0	181.99	194.67	15	13.0	0.0125
1997	0	154.54	165.31	15	11.0	0.0125
1998	0	127.08	135.94	15	9.1	0.0125
1999	0	99.63	106.57	15	7.1	0.0125
2000	0	72.18	77.20	15	5.1	0.0125
2001	0	72.18	77.20	15	5.1	0.0125
2002	0	72.18	77.20	15	5.1	0.0125
2003	0	72.18	77.20	15	5.1	0.0125
2004	0	72.18	77.20	15	5.1	0.0125
2005	0	72.18	77.20	15	5.1	0.0125
2006	0	58.22	62.28	15	4.2	0.0125
2007	0	44.27	47.35	15	3.2	0.0125
2008	0	30.31	32.43	15	2.2	0.0125
2009	0	16.36	17.50	15	1.2	0.0125
2010	0	2.41	2.57	15	0.2	0.0125
2011	16.45	18.37	19.65	15	1.3	0.0125

7.10.3 Category-specific recalculations

No deviations from the previous sectoral estimates occurred, in the period 1990-2010.

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

7.11.1 Description

CO₂ emissions from application of carbonate containing lime and dolomite to agricultural soils have been estimated for the period 1998-2011, since data on agricultural lime application have been made available only for that period; moreover CO₂ emissions from agricultural dolomite application have been included in CO₂ emissions from limestone application, as national statistics on amount of lime applied don't allow to disaggregate the two components (limestone and dolomite). CO₂ emissions from agricultural lime application are reported in the Table5(IV) - CO₂ emissions from agricultural lime application.

7.11.2 Methodological issues

Tier 1 approach, assuming that the total amount of carbonate containing lime is applied annually to cropland soil, has been followed; an overall emission factor of 0.12 t C (t limestone or dolomite)⁻¹ has been used to estimate CO₂ emissions, without differentiating between variable compositions of lime material. The GPG equation 3.3.6 has been used to estimate CO₂ emissions, without disaggregation between calcic limestone and dolomite, as national statistics report an aggregate annual amount of lime.

7.11.3 Category-specific planned improvements

Improvements will concern the acquirement of data about annual amount of lime applied in the period 1990-1997; consideration will be focussed onto the acquisition of disaggregated data on calcic limestone and dolomite agricultural application.

7.12 Biomass Burning (5(V))

7.12.1 Description

Under this source category, CH₄ and N₂O emissions from forest fires are estimated, in accordance with the IPCC method, reporting areas for forest land remaining forest land and land converting to forestland subcategories. CH₄ and N₂O emissions have been also estimated for cropland and grassland categories. Areas affected by fires encompassed in settlements category have been reported, but no emissions are estimated, assuming the carbon losses from the settlements areas affected by fires are irrelevant.

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]). No fires have occurred in plantations, included in subcategory cropland remaining cropland; due to the economic business related to plantations, additional measures are usually undertaken by owners to prevent and avoid fires events. Statistics related to fires occurring in other land use categories (i.e. cropland, grassland and settlements) have been collected in the framework of *ad hoc* expert panel on fires has been set up, formed by experts from different institutions from ISPRA and Ministry of Agriculture, Food and Forest Policies, currently in charge for the official publication related to burned area (<http://www3.corpoforestale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/6358>).

CO₂ emissions due to forest fires in forest land remaining forest land and land converting to forest land are included in Table 5.A.1 of the CRF, under carbon stock change in living biomass - decrease.

Non CO₂ emissions from fires have been estimated and reported in CRF Table 5(V), while NO_x, CO and NMVOC emissions from fires have been reported in CRF Table 5. SO₂ emissions from fires are reported in 5G (Other - SO₂ from fires)

7.12.2 Methodological issues

In Italy, in consideration of national legislation⁵⁰, forest fires do not result in changes in land use; therefore conversion of forest and grassland does not take place. Anyway CO₂ emissions due to forest fires in forest land remaining forest land and land converting to 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 have been estimated following the methodology reported in paragraph 7.2.4.

CH₄, N₂O, CO and NO_x have been estimated following GPG approach (eq. 3.2.19), multiplying the amount of C released from 1990 to 2011, calculated on the basis of regional parameters (Bovio, 1996), by the emission ratios from EMEP/EEA 2009 (table 3.3, chapt. 11.B).

In Table 7.42 CH₄ and N₂O emissions resulting from biomass burning in forest land category are reported.

Table 7.42 CH₄ and N₂O emissions from biomass burning in forest land category

<i>year</i>	<i>Forest land remaining forest land</i>		<i>Land converting to forest land</i>	
	CH₄	N₂O	CH₄	N₂O
	<i>Gg</i>	<i>Gg</i>	<i>Gg</i>	<i>Gg</i>
1990	6.093	0.002	2.611	0.001
1991	1.865	0.001	0.799	0.000
1992	2.763	0.001	1.184	0.000
1993	7.006	0.002	3.003	0.001
1994	2.911	0.001	1.248	0.000
1995	1.312	0.000	0.562	0.000
1996	1.252	0.000	0.536	0.000
1997	3.888	0.001	1.666	0.001
1998	4.466	0.001	1.914	0.001
1999	2.475	0.001	1.061	0.000
2000	3.521	0.001	1.509	0.000
2001	2.310	0.001	0.990	0.000
2002	1.289	0.000	0.552	0.000
2003	2.699	0.001	1.157	0.000
2004	1.594	0.001	0.683	0.000
2005	1.605	0.001	0.688	0.000
2006	1.276	0.000	0.547	0.000
2007	8.198	0.003	3.513	0.001
2008	1.925	0.001	0.825	0.000
2009	2.288	0.001	0.981	0.000
2010	1.443	0.000	0.619	0.000
2011	2.130	0.001	0.913	0.000

In Table 7.43 CO₂, CH₄ and N₂O emissions resulting from biomass burning in cropland and grassland categories are reported.

⁵⁰ Legge 21 novembre 2000, n. 353 - "Legge-quadro in materia di incendi boschivi" art. 10, comma 1 - <http://www.camera.it/parlam/leggi/003531.htm>

Table 7.43 CO₂, CH₄ and N₂O emissions from biomass burning in cropland and grassland categories

<i>year</i>	<i>Cropland</i>			<i>Grassland</i>		
	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O
	<i>Gg</i>	<i>Gg</i>	<i>Gg</i>	<i>Gg</i>	<i>Gg</i>	<i>Gg</i>
1990	42.36	0.23	0.01	3582.67	19.54	0.61
1991	30.46	0.17	0.01	2576.32	14.05	0.44
1992	26.74	0.15	0.00	2261.42	12.34	0.39
1993	38.19	0.21	0.01	3230.05	17.62	0.55
1994	39.01	0.21	0.01	3298.96	17.99	0.57
1995	12.19	0.07	0.00	1031.04	5.62	0.18
1996	16.46	0.09	0.00	1392.23	7.59	0.24
1997	21.18	0.12	0.00	1791.35	9.77	0.31
1998	36.08	0.20	0.01	3051.30	16.64	0.52
1999	13.88	0.08	0.00	1173.96	6.40	0.20
2000	24.66	0.13	0.00	2085.59	11.38	0.36
2001	16.72	0.09	0.00	1413.75	7.71	0.24
2002	8.99	0.05	0.00	760.57	4.15	0.13
2003	20.87	0.11	0.00	1764.96	9.63	0.30
2004	17.18	0.09	0.00	1453.27	7.93	0.25
2005	11.41	0.06	0.00	965.09	5.26	0.17
2006	10.28	0.06	0.00	869.67	4.74	0.15
2007	48.58	0.26	0.01	4108.30	22.41	0.70
2008	15.76	0.09	0.00	1332.93	7.27	0.23
2009	17.05	0.09	0.00	1735.65	9.47	0.30
2010	9.10	0.05	0.00	1030.98	5.62	0.18
2011	19.21	0.10	0.00	1069.37	5.83	0.18

7.12.3 Category-specific planned improvements

An expert panel on forest fires has been set up, in order to obtain geographically referenced data on burned area. Activities planned in the framework of the National Registry for Forest Carbon Sinks should also provide data to improve estimate of emissions by biomass burning.

7.12.4 Uncertainty and time series consistency

Uncertainty estimates for the period 1990–2011 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). Input uncertainties deal with activity data and emission factors have been assessed on the basis of the information provided in the IPCC Good Practice Guidance for LULUCF (IPCC, 2003).

7.12.5 Category-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. Data entries have been checked several times during the compilation of the inventory. Several QA activities are carried out in the different phases of the inventory process. In particular the applied methodologies have been presented and discussed during several national workshop and expert meeting, collecting findings and comments to be incorporated in the estimation process. All the LULUCF categories have been embedded in the overall QA/QC-system of the Italian GHG inventory.

7.12.6 *Category-specific planned improvements*

An expert panel on forest fires has been set up, in order to obtain geographically referenced 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 CO₂ emissions due to forest fires, currently included in the estimate of the forest land remaining forest land, will be pointed out.

In addition an *ad hoc* expert panel on fires has been constituted by experts from different institutions from ISPRA and Ministry of Agriculture, Food and Forest Policies ; the panel is currently working on harmonising the data, related to fires, collected at regional level which are now characterized with different level of disaggregation and details, as:

- burned area, with reference to various land uses
- forest land category, with reference to
 - a. different forest typologies
 - b. specific parameters related to fire's type (crown or grazing fire)
 - c. amount of burned biomass, etc.

The harmonised database will be the informative basis to apply an updated methodology for the emissions estimation from biomass burning, taking into account the real oxidised biomass during fires.

8 WASTE [CRF sector 6]

8.1 Sector overview

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 3.58% (and was 3.79% in the base year 1990).

The trend in greenhouse gas emissions from the waste sector is 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.

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, CH₄ and NMVOC emissions from compost production and NO_x emissions from sludge spreading are reported.

Emissions from methane recovered, used for energy purposes, in landfills and wastewater treatment plants are estimated and reported under category 1A4a.

Table 8.1 Trend in greenhouse gas emissions from the waste sector 1990 – 2011 (Gg)

GAS/SUBSOURCE	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CO₂ (Gg)										
6C. Waste incineration	507.18	453.89	201.57	225.56	238.76	206.76	200.03	242.31	221.55	234.51
CH₄ (Gg)										
6A. Solid waste disposal on land	726.38	757.56	874.15	738.78	707.20	675.89	636.40	630.32	607.95	596.82
6B. Wastewater handling	94.76	105.62	112.73	129.67	130.40	130.77	129.62	129.43	130.51	130.19
6C. Waste incineration	2.09	2.41	2.32	2.56	2.48	2.47	2.57	2.50	2.43	2.42
6D. Other (compost production)	0.01	0.02	0.10	0.20	0.21	0.22	0.21	0.21	0.25	0.26
N₂O (Gg)										
6B. Wastewater handling	5.91	5.73	6.21	6.15	6.15	6.18	6.34	6.32	6.37	6.25
6C. Waste incineration	0.13	0.12	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08

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 category at level and trend assessment calculated with Approach 1 and Approach 2; methane emission from wastewater handling is a key source at level assessment with Approach 1 and Approach 2 in 2011, only with Approach 2 in 1990 and at trend assessment taking into account uncertainty. When including the LULUCF sector in the key source analysis, methane emissions from landfills result as a key source at level and trend with Approach 1 and Approach 2 in 2011, whereas methane emission from wastewater handling is a key category at level assessment with Approach 1 and Approach 2 in 2011, and at trend assessment taking into account uncertainty.

Key-source identification in the waste sector with the IPCC Approach 1 and Approach 2 (without LULUCF) for 2011

6A	CH ₄	Emissions from solid waste disposal sites	Key (L, T)
6B	CH ₄	Emissions from wastewater handling	Key (L, T2)
6B	N ₂ O	Emissions from wastewater handling	Non-key
6C	CO ₂	Emissions from waste incineration	Non-key
6C	CH ₄	Emissions from waste incineration	Non-key
6C	N ₂ O	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*

The source category solid waste disposal on land is a key category for CH₄, both in terms of level and trend. The share of CH₄ emissions is presently 41.9% (and was about 39.5% in the base year 1990) of the CH₄ national total. For this source category, also NMVOC emissions are estimated; it has been assumed that non-methane volatile organic compounds are 1.3 weight per cent of VOC (Gaudioso et al., 1993): this assumption refers to US EPA data (US EPA, 1990).

Methane is emitted from the degradation of waste disposed of in municipal landfills, both managed and unmanaged.

The main parameters that influence the estimation of emissions from landfills are, apart from the amount of waste disposed into managed landfills, 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 waste generation, flow through collection and transportation, separation for resource recovery, treatment for volume reduction, stabilisation, recycling and energy recovery and terminate at landfill sites.

Urban waste disposal in landfill sites is still the main disposal practice: the percentage of waste disposed in landfills dropped from 91.1% in 1990 to 47.8% in 2011. This trend is strictly dependent on policies that have been taken in the last 20 years in waste management. In fact, at the same time, waste incineration as well as composting and mechanical and biological treatment have shown a remarkable rise due to the enforcement of legislation. Also recyclable waste collection, which at the beginning of nineties was a scarce practice and waste were mainly disposed in bulk in landfills or incineration plants, has been increasing: in 2011, the percentage of municipal solid waste separate collection is near 36%, but still far from legislative targets (fixed 50% in 2009).

In particular, in Italy the first legal provision concerning waste management was issued in 1982 (Decree of President of the Republic 10 September 1982, n.915), as a consequence of the transposition of some European Directives on waste (EC, 1975; EC, 1976; EC, 1978). In this decree, uncontrolled waste dumping as well as unmanaged landfills are forbidden, but the enforcement of these measures has been concluded only in 2000. Thus, from 2000 municipal solid wastes are disposed only into managed landfills.

For the year 2011, the non hazardous landfills in Italy disposed 15,644 kt of MSW and 3,469 kt of industrial wastes, as well as 318 kt of sludge from urban wastewater treatment plants.

Since 1999, the number of MSW landfills has decreased by more than 500 plants, despite the decrease of the amount of wastes disposed of is less pronounced. This because both uncontrolled landfills and small controlled landfills have been progressively closed, especially in the south of the country, where the use of modern and larger plants was opted in order to serve large territorial areas.

Concerning the composition of waste which is disposed in municipal landfills, this has been changed over the years, because of the modification of waste production due to changes in the life-style and not to a forceful policy on waste management.

The Landfill European Directive (EC, 1999) has been transposed into national decree only in 2003 by the Legislative Decree 13 January 2003, n. 36 and applied to the Italian landfills since July 2005, but the effectiveness of the policies will be significant in the future. Moreover, a following law decree (Law Decree 30 December 2008, n.208) moved to December 2009 the end of the temporary condition regarding waste acceptance criteria, thus the composition of waste accepted in landfills is expected to change hardly.

Finally, methane emissions are expected especially from non hazardous waste landfills due to biodegradability rate of the wastes disposed of; in the past, provisions by law forced only non hazardous waste landfills to have a collecting gas system. Investigation has been carried out on C&D waste landfills to prove that inert waste does not generate methane emissions. Investigation on industrial sludge disposed into landfills for hazardous waste is ongoing and relates to the 2010 activity data.

8.2.2 *Methodological issues*

Emission estimates from solid waste disposal on land have been carried out using the IPCC Tier 2 methodology, through the application of the First Order Decay Model (FOD).

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).

It has been assumed that all the landfills, both managed and unmanaged, started operations in the same year, and have the same parameters, although characteristics of individual landfill sites can vary substantially.

Moreover, the share of waste disposed of into uncontrolled landfills has gradually decreased, as specified previously, and in the year 2000 it has been assumed equal to 0; nevertheless, emissions still have been occurring due to the waste disposed in the past years. The unmanaged sites have been considered “shallow” according to the IPCC classification.

Municipal solid waste

Basic data on waste production and landfills system are those provided by the national Waste Cadastre. The Waste Cadastre is formed by a national branch, hosted by ISPRA, and by regional and provincial branches. The basic information for the Cadastre is mainly represented by the data reported through the Uniform Statement Format (MUD), complemented by information provided by regional permits, provincial communications and by registrations in the national register of companies involved in waste management activities.

These figures have been elaborated and published by ISPRA yearly since 1999: the yearbooks report waste production data, as well as data concerning landfilling, incineration, composting and generally waste life-cycle data (ANPA-ONR, several years; ISPRA, several years).

For inventory purposes, a database of waste production, waste disposal in managed and unmanaged landfills and sludge disposal in landfills was created and it has been assumed that in Italy 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; ISPRA, 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 estimated, assuming that from 1975 backwards the percentage of waste landfilled is constant and equal to 80%; this percentage has been derived from the analysis of available data. As reported in the Figure 8.1, in the period 1973 – 1991 data are available for specific years (available data are reported in dark blue, whereas estimated data are reported in light blue). From 1973 to 1991 waste disposal has increased, because the most common practice in waste management; from early nineties, thanks to a change in national policies, waste disposal in landfill has started to decrease, in favour of other waste treatments.

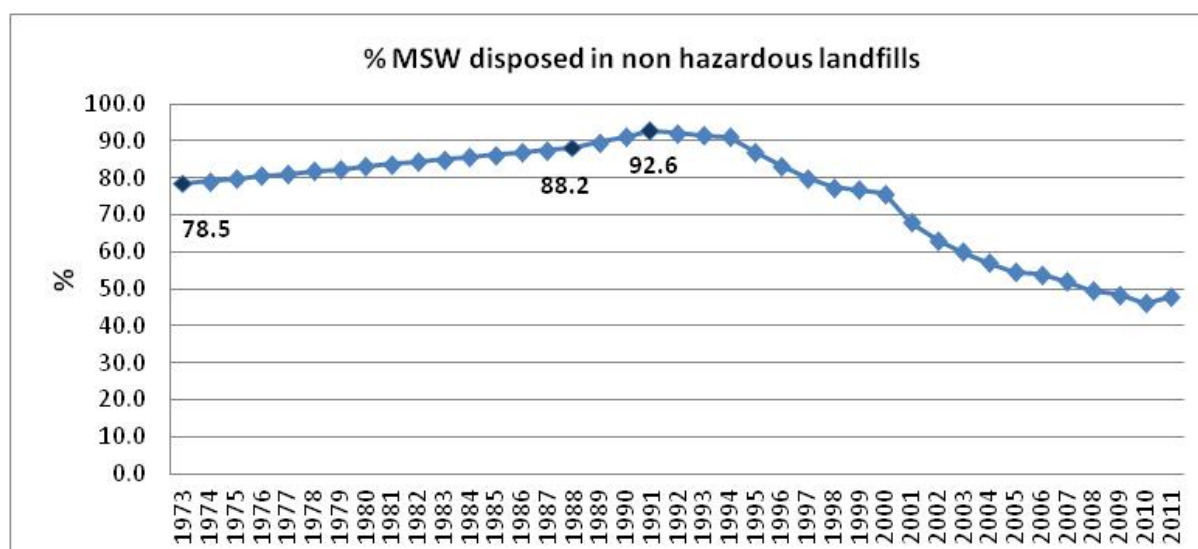


Figure 8.1 Percentage of MSW disposal on land (%)

In the following Table 8.2, the time series of MSW production and MSW disposed of into non hazardous landfills from 1990 is reported. The amount of waste disposed in managed landfills is yearly provided by the national Waste Cadastre since 1995. The time series has been reconstructed backwards on the basis of several studies reporting data available for 1973, 1988, 1991, 1994 (Tecneco, 1972; MATTM, several years). The amount of waste disposed in unmanaged landfills has been estimated as a percentage of the waste disposed in managed landfills. Different studies provided information about the percentage of waste in unmanaged sites for 1973, 1979, 1991 (Tecneco, 1972; ISTAT, 1984, MATTM, several years) and data in other years are extrapolated. These studies show that the share of waste disposed of into uncontrolled landfills has gradually decreased, from 72.8%, in 1973, to 53.4% in 1979 and 26.6% in 1991, which is a consequence of the progressive implementation of the national legislation. Since 2000 the percentage of waste in unmanaged landfills is equal to zero because of legal enforcement described in 8.2.1.

Industrial waste

Industrial wastes assimilated to municipal solid waste (AMSW) could be disposed of in non hazardous landfills. Composition of AMSW must be comparable to municipal solid waste composition.

From 2001, data on industrial waste disposed in municipal landfills are available from Waste Cadastre.

For previous years, assimilated municipal solid waste production has been reconstructed, and the same percentage of MSW disposed in landfill has been applied also to AMSW.

The complete database of AMSW production from 1975 to 2000 has been reconstructed starting from data available for the years 1988 (ISTAT, 1991) and 1991 (MATTM, several years) with a linear interpolation, and with a regression model based on Gross Domestic Product (Colombari et al, 1998). From 1975 back to 1950 AMSW production has been derived as a percentage of MSW production; this percentage has been set equal to 15%, which is approximately the value obtained from the only data available (MSW and AMSW production for the years 1988 and 1991).

In Table 8.2, the time series of AMSW and domestic sludge disposed of into non hazardous landfills from 1990 is reported.

Table 8.2 Trend of MSW production and MSW, AMSW and domestic sludge disposed in landfills, 1990 – 2011

ACTIVITY DATA	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
MSW production (Gg)	22,231	25,780	28,959	31,664	32,511	32,542	32,467	32,110	32,479	32,731
MSW disposed in landfills for non hazardous waste (Gg)	17,432	22,459	21,917	17,226	17,526	16,912	16,069	15,538	15,015	15,644
Assimilated MSW disposed in landfills for non hazardous waste (Gg)	2,828	2,978	2,825	2,914	2,481	2,777	3,703	3,181	3,508	3,469
Sludge disposed in managed landfills for non hazardous waste (Gg)	2,454	1,531	1,326	544	525	407	364	335	331	318
Total Waste to managed landfills for non hazardous waste (Gg)	16,363	21,897	26,069	20,684	20,532	20,095	20,136	19,054	18,855	19,432
Total Waste to unmanaged landfills for non hazardous waste (Gg)	6,351	5,071	0	0	0	0	0	0	0	0
Total Waste to landfills for non hazardous waste (Gg)	22,714	26,968	26,069	20,684	20,532	20,095	20,136	19,054	18,855	19,432

Sludge from urban wastewater plants

Sludge from urban wastewater treatment plants has also been considered, because it can be disposed of at the same landfills as municipal solid waste and assimilated, once it meets specific requirements. The fraction of sludge disposed in landfill sites has been estimated to be 75% in 1990, decreasing to 9% in 2011.

On the basis of their characteristics, sludge from urban wastewater treatment plants is also used in agriculture, sludge spreading on land, and in compost production, or treated in incineration plants.

The percentage of each treatment (landfilling, soil spreading, composting, incinerating and stocking) has been reconstructed within the years starting from 1990: for that year, percentages have been set based on data on tonnes of sludge treated in a given way available from a survey conducted by the National Institute of Statistics on urban wastewater plants for the year 1993 (ISTAT, 1998 [a] and [b]; De Stefanis P. et al., 1998). From 1990 onwards each percentage has been varied on the basis of data available for specific years: in particular, data on sludge use in agriculture have been communicated by the Ministry for the Environment, Land and Sea concerning the reference time period from 1995 (MATTM, 2005; MATTM 2010); data on sludge used in compost production are published from 1999, while data on sludge disposed into landfills are published from 2001 (APAT-ONR, several years; ISPRA, several years).

The total production of sludge from urban wastewater plants is communicated by the Ministry for the Environment, Land and Sea from 1995 (MATTM, 2005; MATTM 2010) in the framework of the reporting commitments established by the European Sewage Sludge Directive (EC, 1986) transposed into the national Legislative Decree 27 January 1992, n. 99.

Moreover, sewage sludge production is available from different sources also for the years 1987, 1991 (MATTM, several years) and 1993 (ISTAT, 1998 [a] and [b]). Thus, for the missing years data have been extrapolated.

As for the waste production, also sludge production time series 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.

To summarize, from 1987 both data on equivalent inhabitants and sludge production are available (published or estimated), thus it is possible to calculate a *per capita* sludge production: the parameter results equal on average to 80 kg inhab.⁻¹ yr⁻¹. Consequently, this value has been multiplied to equivalent inhabitants from 1987 back to 1950.

In Table 8.3, time series of sewage sludge production and landfilling is reported.

Table 8.3 Trend of total sewage sludge production and landfilling, 1990 – 2011

ACTIVITY DATA	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Total sewage sludge production (Gg)	3,272	2,437	3,402	4,299	4,280	3,510	3,041	3,736	3,696	3,717
Sewage sludge landfilled (Gg)	2,454	1,531	1,326	544	525	407	364	335	331	318
Percentage (%)	75.0	62.8	39.0	12.7	12.3	11.6	12.0	9.0	9.0	8.6

Waste composition

One of the most important parameter that influences the estimation of emissions from landfills is the waste composition.

An in-depth survey has been carried out, in order to diversify waste composition over the years.

On the basis of data available on waste composition (Tecneco, 1972; CNR, 1980; Ferrari, 1996), three slots (1950-1970; 1971-1990; 1991- 2005) have been individuated to which different waste composition has been assigned. Waste composition used from 2005 back to 1971 (CNR, 1980; Ferrari, 1996) has been better specified, on the basis of data available from those publications. In particular, screened waste (< 20mm) has been included in emissions estimation, because the 50% of it has been assumed as organic and thus rapidly biodegradable. This assumption has been strengthened by expert judgments and sectoral studies (Regione Piemonte, 2007; Regione Umbria, 2007).

Moreover, a fourth slot (2006-2011) has been individuated on the basis of the analysis of several regional waste composition and the analysis of waste disposed of into non hazardous landfills specified by the European Waste Catalogue (EWC) code for the year 2007, available from Waste Cadastre database (ISPRA, 2010). Data on waste composition refer to recent years and they are representative of the national territory, deriving from the North of Italy (Regione Piemonte, 2007; Regione Veneto, 2006; Regione Emilia Romagna, 2009), the Centre (Regione Umbria, 2007; Provincia di Roma, 2008) and the South (Regione Calabria, 2002; Regione Sicilia 2004). The new waste composition, adopted from 2006, includes compost residues which are disposed into landfills because their parameters are not in compliance with those set by the law: compost residues are reported under garden and park waste component, as they are considered moderately biodegradable. The moisture content and the organic carbon content are from national studies (Andreottola and Cossu, 1988; Muntoni and Poletti, 2002).

In Tables 8.4, 8.5, 8.6 and 8.7 waste composition of each national survey mentioned above and waste composition derived from the analysis of EWC code is reported, together with moisture content, organic carbon content and consequently degradable organic carbon both in waste type *i* and in bulk waste, DOC calculation is described in following paragraphs.

Waste types containing most of the DOC and thus involved in methane emissions are highlighted in bold type.

Since sludge is not included in waste composition, because it usually refers to waste production and not to waste landfilled, it has been added to each waste composition, recalculating the percentage of waste type.

Table 8.4 Waste composition and Degradable Organic Carbon calculation, 1950 - 1970

WASTE COMPONENT	Composition by weight (wet waste)	Moisture content	Organic carbon content (dry matter)	DOC _i (kgC/tMSW)
Organic	32.7%	60%	48%	62.72
Garden and park	3.6%	50%	48%	8.71
Paper, paperboard	29.7%	9%	50%	135.09
Plastic	2.9%	2%	70%	
Inert	26.9%			
Sludge	4.2%	75%	48%	5.07
DOC				211.59

Table 8.5 Waste composition and Degradable Organic Carbon calculation, 1971 – 1990

WASTE COMPONENT	Composition by weight (wet waste)	Moisture content	Organic carbon content (dry matter)	DOC _i (kgC/tMSW)
Organic	33.3%	60%	48%	64.00
Garden and park	3.7%	50%	48%	8.89
Paper, paperboard, textile and wood	19.6%	9%	50%	89.26
Plastic	6.3%	2%	70%	
Inert	6.2%			
Metal	2.6%			
Screened waste (< 2 cm)				
- organic	8.0%	60%	48%	15.45
- non organic	8.0%			
Sludge	12.0%	75%	48%	14.44
DOC				192.04

Table 8.6 Waste composition and Degradable Organic Carbon calculation, 1991 - 2005

WASTE COMPONENT	Composition by weight (wet waste)	Moisture content	Organic carbon content (dry matter)	DOC _i (kgC/tMSW)
Organic	24.7%	60%	48%	47.37
Garden and park	4.2%	50%	48%	10.09
Paper, paperboard	25.5%	8%	44%	103.38
Nappies	2.7%	8%	44%	10.98
Textiles	4.8%	10%	55%	23.98
Leather and rubbers	2.1%	2%	70%	
Light plastics	8.9%	2%	70%	
Rigid plastics	3.0%	2%	70%	
Inert and glasses	5.9%			
Metal	2.9%			
Bulky waste	0.5%			
Various	1.5%			
Screened waste (< 2 cm)				
- organic	3.4%	60%	48%	6.60
- non organic	3.4%			
Sludge	6.3%	75%	48%	7.53
DOC				209.93

Table 8.7 Waste composition and Degradable Organic Carbon calculation, 2006 – 2011

WASTE COMPONENT	Composition by weight (wet waste)	Moisture content	Organic carbon content (dry matter)	DOC _i (kgC/tMSW)
Organic	21.9%	60%	48%	42.07
Garden and park	5.6%	50%	48%	13.53
Wood	1.6%	20%	50%	6.47
Paper, paperboard, nappies	23.9%	8%	44%	96.72
Textiles and leather	3.0%	10%	55%	14.86
Plastics	11.8%	2%	70%	
Metals and Aluminium	2.3%			
Inert and glasses	6.4%			
Bulky waste	2.2%			
Various	6.5%			
Screened waste (< 2 cm)				
- organic	5.4%	60%	48%	10.43
- non organic	5.4%			
Sludge	3.9%	75%	48%	4.68
DOC				188.76

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 8.8. Methane emissions have been estimated separately for each mentioned biodegradability class and the results have been consequently added up.

Table 8.8 Waste biodegradability

Waste biodegradability	Rapidly biodegradable	Moderately biodegradable	Slowly biodegradable
Food	X		
Sewage sludge	X		
Screened waste (organic)	X		
Garden and park		X	
Paper, paperboard			X
Nappies			X
Textiles, leather			X
Wood			X

Degradable organic carbon (DOC) and Methane generation potential (L₀)

Degradable organic carbon (DOC) is the organic carbon in waste that is accessible to biochemical decomposition, and should be expressed as Gg C per Gg waste. The DOC in waste bulk is estimated based on the composition of waste and can be calculated from a weighted average of the degradable carbon content of various components of the waste stream. The following equation estimates DOC using default carbon content values.

$$DOC = \sum_i (DOC_i * W_i)$$

Where:

DOC = fraction of degradable organic carbon in bulk waste, kg C/kg of wet waste

DOC_i = fraction of degradable organic carbon in waste type *i*,

W_i = fraction of waste type *i* by waste category

Degradable organic carbon in waste type i can be calculated as following:

$$DOC_i = C_i * (1 - u_i) * W_i$$

Where:

C_i = organic carbon content in dry waste type i , kg C/ kg of waste type i

u_i = moisture content in waste type i

W_i = fraction of waste type i by waste category

Once known the degradable organic carbon, the methane generation potential value (L_0) is calculated as following:

$$L_0 = MCF * DOC * DOC_F * F * 16/12$$

Where:

MCF = methane correction factor

DOC_F = fraction of DOC dissimilated

F = fraction of methane in landfill gas

Fraction of degradable organic carbon (DOC_F) is an estimate of the fraction of carbon that is ultimately degraded and released from landfill, and reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, under anaerobic conditions in the landfill.

DOC_F value is dependent on many factors like temperature, moisture, pH, composition of waste: the default value 0.5 has been used.

The methane correction factor (MCF) accounts for that unmanaged SWDS (solid waste disposal sites) produce less CH_4 from a given amount of waste than managed SWDS, because a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDS. The MCF should be also interpreted as the 'waste management correction factor' because it reflects the management aspects.

The MCF value used for unmanaged landfill is the default IPCC value reported for uncategorised landfills: in fact, in Italy, before 2000 the existing unmanaged landfills were mostly shallow, because they resulted in uncontrolled waste dumping instead of real deep unmanaged landfills. On the basis of the qualitative information available regarding the national unmanaged landfills, the default IPCC value used has been considered the most appropriate to represent national circumstances also in consideration of the type of waste landfilled and the humidity degree of landfills. It is assumed that landfill gas is 50% VOC. The following Table 8.9 summarizes the methane generation potential values (L_0) generated, distinguished for managed and unmanaged landfills.

Table 8.9 Methane generation potential values by waste composition and landfill typology

L_0 (m^3CH_4 tMSW ⁻¹)	1950 - 1970	1971 - 1990	1991 - 2005	2006 - 2011
Rapidly biodegradable				
- Managed landfill	90.5	86.6	88.1	90.2
- Unmanaged landfill	54.3	52.0	52.9	54.1
Moderately biodegradable				
- Managed landfill	118.2	118.2	118.2	118.2
- Unmanaged landfill	70.9	70.9	70.9	70.9
Slowly biodegradable				
- Managed landfill	224.1	224.1	205.9	204.0
- Unmanaged landfill	134.5	134.5	123.5	122.4

Finally, oxidation factors have been assumed equal to 0.1 for managed landfills and 0 for unmanaged according to the IPCC Good Practice Guidance where 0.1 is suggested for well managed landfills.

Methane generation rate constant (*k*)

The methane generation rate constant *k* in the FOD method is related to the time necessary for DOC in waste to decay to half its initial mass (the ‘half life’ or $t_{1/2}$).

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 8.10. Different *k* values for rapidly, moderately and slowly biodegradable waste are applied to the different parts of the model.

The methane generation rate constant *k* values derive from national and international literature and Italian national experts con (Andreottola and Cossu, 1988; Ham, 1979); these figures are representative of average biogas production conditions with respect to the characteristics of national landfills and waste composition in terms of moisture, density and size.

Table 8.10 Half-life values and related methane generation rate constant

WASTE TYPE	Half life	Methane generation rate constant
Rapidly biodegradable	1 year	0.69
Moderately biodegradable	5 years	0.14
Slowly biodegradable	15 years	0.05

The average *k* is calculated on the basis of the waste composition, and assumes different values during different periods on account of the waste composition changes, as reported in Table 8.11.

Table 8.11 Average *k* values based on waste compositions

	1971 - 1990	1991 - 2005	2006 - 2030
k	0.463	0.362	0.363

Landfill gas recovered (*R*)

Landfill gas recovered data have been reconstructed on the basis of information on extraction plants (De Poli and Pasqualini, 1991; Acaia et al., 2004; Asja, 2003) and electricity production (TERNA, several years).

Only managed landfills have a gas collection system, and the methane extracted can be used for energy production or can be flared.

The amount of methane recovery in landfills has increased as a result of the implementation of the European Directive on the landfill of waste (99/31/EC); the amounts of methane recovered and flared have been estimated taking into account the amount of energy produced, the energy efficiency of the methane recovered, the captation efficiency and the efficiency in recovering methane for energy purposes assuming that the rest of methane captured is flared. The emissions from biogas recovered from landfills and used for energy purposes are reported in the energy sector in “1A4a biomass” category together with wood, the biomass fraction of incinerated waste and biogas from wastewater plants. In Table 8.12 consumptions and low calorific values are reported for the year 2011.

Table 8.12 1A4a biomass detailed activity data. Year 2011

Fuels		Consumption (Gg)	LCV (TJ/Gg)
Wood and similar	Wood	50.18	10.46
	Steam Wood	0.23	31.38
Incinerated waste (biomass)		2967.69	9.20
Biogas from landfills		366.47	50.038
Biogas from wastewater plants		14.99	50.038

The total CH₄ recovered is the sum of methane flared and methane used for energy purposes (see figure 8.2). The methane used for energy production is estimated starting from the electricity produced annually ($E = \text{GWh} \times 3.6 = \text{TJ}$) by landfills (TERNA, several years) assuming an energy conversion efficiency equal to

0.3, typical efficiency value for engines that produce electricity from biogas (Colombo, 2001), and a LCV (Lower Calorific Value) equal to 50.038 TJ/Gg:

$$((E/0.3)/50.038)*1000= \text{CH}_4 \text{ Mg/year}$$

The LCV used for biogas derives from national experts and it is verified with energy and quantitative data about biogas production from waste supplied by TERN (National Independent System Operator). For the years 1987, 1988, 1989 and 1990, the methane flared is supplied by the plants (De Poli and Pasqualini, 1991); from 1991 to 1997 the methane flared has been extrapolated from the previous years; finally, for the following years the methane flared has been estimated using information based on monitored data supplied by the main operators (Asja, 2003 and Acaia, 2004) regarding the efficiency in recovering methane for energy purposes with respect to the total methane collected. This efficiency value increased from 60% of the total, in 1998, to 70% since 2002. Total methane collected is estimated, in 2011, equal to 45% of the total methane produced.

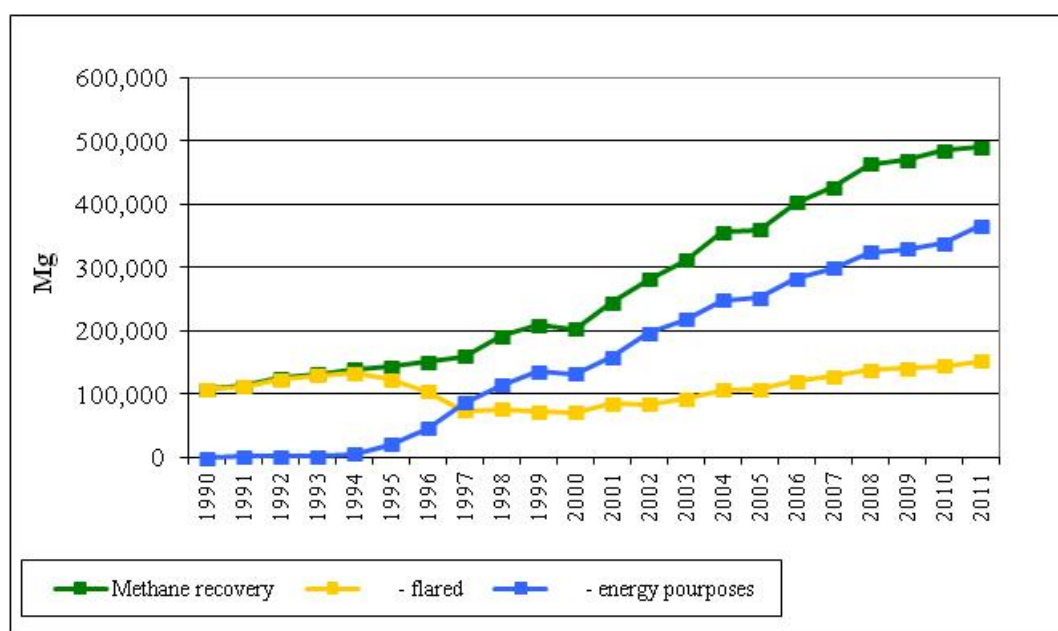


Figure 8.2 Methane recovery distinguished in flared amount and energy purposes (Mg)

CH₄ and NMVOC emission time series

The time series of CH₄ emissions is reported in Table 8.13; emissions from the amount used for energy purposes are estimated and reported under category 1A4a.

Whereas waste production continuously increases, from 2001 solid waste disposal on land has decreased as a consequence of waste management policies, although fluctuations in the amounts of industrial waste and sludge could influence this trend. 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.

Table 8.13 VOC produced, recovered and CH₄ and NMVOC net emissions, 1990 – 2011 (Gg)

EMISSIONS	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Managed Landfills										
VOC produced (Gg)	648.1	755.0	1,028.3	1,084.6	1,097.3	1,091.3	1,088.5	1,092.2	1,085.6	1,082.9
VOC recovered (Gg)	108.9	144.1	203.4	360.5	403.2	427.3	464.3	470.4	484.7	490.6
VOC recovered (%)	16.8	19.1	19.8	33.2	36.7	39.2	42.7	43.1	44.6	45.3
CH ₄ net emissions (Gg)	479.0	542.6	732.8	643.2	616.6	589.8	554.5	552.4	533.8	526.2
NMVOC net emissions (Gg)	6.3	7.1	9.7	8.5	8.1	7.8	7.3	7.3	7.0	6.9

EMISSIONS	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Unmanaged Landfills										
VOC produced (Gg)	250.6	217.7	143.2	96.8	91.8	87.2	83.0	79.0	75.2	71.6
VOC recovered (Gg)	0	0	0	0	0	0	0	0	0	0
CH ₄ net emissions (Gg)	247.3	214.9	141.4	95.6	90.6	86.1	81.9	77.9	74.2	70.7
NMVOC net emissions (Gg)	3.3	2.8	1.9	1.3	1.2	1.1	1.1	1.0	1.0	0.9

8.2.3 *Uncertainty and time-series consistency*

The uncertainty in CH₄ emissions from solid waste disposal sites has been estimated both by Approach 1 and Approach 2 of the IPCC guidelines.

Following Approach 1, the combined uncertainty is estimated to be 36.1%, 20% and 30% for activity data and emission factors, respectively, as suggested by the IPCC Good Practice Guidance (IPCC, 2000).

Applying Montecarlo analysis, the resulting uncertainty is estimated equal to 12.6% in 2009. Normal distributions have been assumed for most of the parameters; whenever assumptions or constraints on variables were known this information has been appropriately reflected on the choice of type and shape of distributions. A summary of the results is reported in Annex 1.

Emissions from landfills (Table 8.13) are influenced, apart from the amount of waste landfilled, also from waste composition, as for each biodegradability class different parameters are used in the model. The total amount of waste disposed into managed landfills increased until 2000 (in 2000 the landfilling of waste in unmanaged landfills has stopped too), then it decreased from 2000 to 2003, while from 2003 it is quite stable. We enhance that the total amount of waste disposed of is the sum of municipal solid wastes (which have decreased due to the enforcement of the legislation), sludge and industrial waste, which are subjected to fluctuation. As previously reported, four waste compositions have been used, changing from 1950 to 2011 as well as the percentage of rapidly, moderately and slowly biodegradable fraction. The combination of the amount of waste landfilled and the waste composition has led to an increase of methane production from 1990 to 2002 and stabilization from 2003 to 2011. At the same time, biogas recovery has increased from 1990 to 2011, but from 2000 the recovery rate is higher: in 2011 the methane recovered is about half of the methane produced.

8.2.4 *Source-specific QA/QC and verification*

The National Waste cadastre is managed by ISPRA and is formed by a national branch hosted by ISPRA and regional and provincial branches hosted by the Regional Agencies for the Protection of the Environment. So the system 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. At central level, ISPRA provides assessment criteria and procedures for data validation, through the definition of uniform standard procedures for all regional branches. The national branch, moreover, ensures spreading of the procedures and training of technicians in each regional branch. Data are validated by ISPRA detecting potential errors and data gaps, comparing among different data sources and asking for further explanation to the regional branches whenever needed. Moreover, ISPRA has started a number of sectoral studies with a view to define specific waste production coefficients related to each production process. So through the definition of such 'production factors' and the knowledge of statistical information on production, it is possible to estimate the amount of waste originated from each sector for the selected territorial grid cell and compare the results to the statistical data on waste production.

For general QC checks on emission estimates and related parameters, each inventory expert fills in, during the inventory compilation process, a format with a list of questions to be answered which helps the compiler avoid potential errors and is also useful to prove the appropriateness of the methodological choices.

Moreover, an in depth analysis of EWC codes of waste disposed of in landfills has been done for the year 2007, thanks to the complete database of Waste Cadastre kindly supplied by ISPRA Waste Office. This accurate analysis has permitted to verify the correctness of waste typology assumptions used for the estimations.

8.2.5 Source-specific recalculations

Recalculations in the sector have been done because the quantity of waste disposed in landfill has been updated since 2009 (ISPRA, several years) producing a recalculation for 2010.

In Table 8.14, municipal and industrial (assimilated to MSW) wastes disposed into non hazardous landfills are reported also for Submission 2012, with differences in percentage.

Table 8.14 MSW disposed into landfills time series, 1990 – 2011 (t), AMSW disposed into landfills time series, 1990 – 2011 (t), and differences in percentage between Submission 2013 and Submission 2012.

Year	Submission 2013			Submission 2012			Δ% MSW	Δ% AMSW	Δ% Total
	MSW to landfill (t)	AMSW to landfill (t)	Total waste (except sludge) to landfill (t)	MSW to landfill (t)	AMSW to landfill (t)	Total waste (except sludge) to landfill (t)			
1990	17,431,760	2,827,867	20,259,627	17,431,760	2,827,867	20,259,627	-	-	-
1995	22,458,880	2,977,672	25,436,552	22,458,880	2,977,672	25,436,552	-	-	-
2000	21,917,417	2,825,340	24,742,757	21,917,417	2,825,340	24,742,757	-	-	-
2005	17,225,728	2,913,697	20,139,425	17,225,728	2,913,697	20,139,425	-	-	-
2006	17,525,881	2,480,830	20,006,711	17,525,881	2,480,830	20,006,711	-	-	-
2007	16,911,545	2,776,637	19,688,182	16,911,545	2,776,637	19,688,182	-	-	-
2008	16,068,760	3,703,220	19,771,980	16,068,760	3,703,220	19,771,980	-	-	-
2009	15,537,822	3,180,904	18,718,726	15,418,152	3,180,904	18,599,056	0.78%	-	0.64%
2010	15,015,119	3,508,400	18,523,519	16,187,282	3,342,705	19,529,988	-7.24%	4.96%	-5.15%
2011	15,644,147	3,468,979	19,113,126						

The amount of VOC recovered has also been updated as reported in Table 8.15.

These updates have influenced methane and NMVOC emissions. In Table 8.15 differences in percentage between emissions from landfills reported in the updated time series and 2012 submission are presented.

Table 8.15 Differences in percentage between emissions from landfills reported in the updated time series and 2012 submission

EMISSIONS	1990	1995	2000	2005	2006	2007	2008	2009	2010
Managed Landfills									
VOC produced (Gg)	-	-	-	-	-	-	-	-	0.13%
VOC recovered (Gg)	-	-	-	-	-	-	-	-	1.70%
CH ₄ net emissions (Gg)	-	-	-	-	-	-	-	-	-1.10%
NMVOC net emissions (Gg)	-	-	-	-	-	-	-	-	-1.10%
Unmanaged Landfills									
VOC produced (Gg)	-	-	-	-	-	-	-	-	-
VOC recovered (Gg)	-	-	-	-	-	-	-	-	-
CH ₄ net emissions (Gg)	-	-	-	-	-	-	-	-	-
NMVOC net emissions (Gg)	-	-	-	-	-	-	-	-	-

8.2.6 Source-specific planned improvements

Currently, more recent data on the fraction of CH₄ in landfill gas and on the amount of landfill gas collected and treated are under investigation. A survey on industrial sludge disposed of into landfills for hazardous waste is ongoing and relates to 2010 activity data.

8.3 Wastewater handling (6B)

8.3.1 Source category description

Under source category 6B, CH₄ and N₂O are estimated both from domestic and commercial wastewater as well as from industrial wastewaters.

In Table 8.16 an emission reporting scheme is shown.

Table 8.16 Emissions reporting scheme

6.B.1 Industrial wastewater	
Wastewater	
Sludge	Emissions from sludge are reported in 6.B.1 Industrial wastewater/wastewater
6.B.2 Domestic and commercial wastewater	
6.B.2.1 Domestic and commercial wastewater	
Wastewater	N ₂ O emissions are reported in 6.B.2.2 Human sewage
Sludge	N ₂ O emissions are reported in 6.B.2.2 Human sewage
6.B.2.2 Human sewage	

The principal by-product of the anaerobic decomposition of the organic matter in wastewater is methane gas. Normally, CH₄ emissions are not encountered in untreated wastewater because even small amounts of oxygen tend to be toxic to the organisms responsible for the production of methane. Occasionally, however, as a result of anaerobic decay in accumulated bottom deposits, methane can be produced. Again, wastewater collected in closed underground sewers is not believed to be a significant source of CH₄ (IPCC, 2006).

In 2005, about 84% of population is served by sewer systems, whereas 74.8% of population is served by wastewater treatment plants (COVIRI, 2005).

In the framework of the Urban Wastewater Treatment Directive (UWWTD, 2011) regarding agglomerations ≥ 2,000 p.e. (population equivalent) and referred to reporting year 2007, Italy reported the following data: 3,246 agglomerations ≥ 2,000 p.e. and 97.8% of all agglomerations have a collecting system in place; 2,942 of these agglomerations (or 90.6% of the total generated load) have installations for secondary treatment in place, while 2,584 agglomerations (or 79.6% of the total generated load) have more stringent treatment installations in place. In unsewered areas, onsite systems, such as Imhoff tanks, are usually used.

On the contrary, in treatment plants, methane is produced from the anaerobic treatment process used to stabilised wastewater sludge.

The plant typology is usually distinguished in ‘primary’ (only physical-chemical unit operations such as sedimentation), ‘secondary’ (biological unit process) or ‘advanced’ treatments, defined as those additional treatments needed to remove suspended and dissolved substances remaining after conventional secondary treatment.

In Italy wastewater handling is managed mainly using a secondary treatment, with aerobic biological units: a wastewater treatment plant standard design consists of bar racks, grit chamber, primary sedimentation, aeration tanks (with return sludge), settling tank, chlorine contact chamber. The stabilization of sludge occurs in aerobic or anaerobic reactors; where anaerobic digestion is used, the reactors are covered and provided of gas recovery.

As a consequence of these considerations, it is assumed that domestic and commercial wastewaters are treated 95% aerobically and 5% anaerobically. The bad management of aerobic process is assumed equal to 5% as a conservative estimation.

For high strength organic waste, such as some industrial wastewater, anaerobic process is recommended also for wastewater besides sludge treatment.

It is assumed that industrial wastewaters are treated 85% aerobically and 15% anaerobically (IRSA-CNR, 1998).

Emissions from methane recovered, used for energy purposes, in wastewater treatment plants are estimated and reported under category 1A4a.

A percentage of 1.8% of domestic and commercial wastewater is currently treated in Imhoff tanks, where the digestion of sludge occurs anaerobically without gas recovery. Therefore, very few emissions from sludge disposal do occur.

8.3.2 Methodological issues

Regarding N₂O emissions from human sewage, 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 (EF₆) 0.01 kg N-N₂O 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) and refers to the Italian value. The estimation procedure checks for consistency with sludge produced and sludge applications, as sludge applied to agriculture soils, sludge incinerated, sludge composting and sludge deposited in solid waste disposal. Sludge spreading is subtracted from human sewage and is not accounted for twice.

N₂O emissions from industrial wastewater have been estimated on the basis of the emission factors equal to 0.25 g N₂O/m³ of wastewater production (EMEP/CORINAIR, 2007). The wastewater production is resulting from the model for the estimation of methane emissions from industrial wastewater.

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. Default emission factors of methane per Chemical Oxygen Demand (COD) equal to 0.25 kg CH₄ kg⁻¹ COD, 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 (m³ t⁻¹) and by the degradable organic component (kg COD (m³)⁻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).

In Table 8.17 detailed references for 2011 are reported: for these national data, slightly differences within the years can occur.

Table 8.17 Wastewater generation and COD values, 2011.

	Wastewater generation (m³/t)	References	COD (g/l)	References
Coke	1.5	IPCC, 2000	0.1	IPCC, 2000
Petroleum Refineries	UNIONE PETROLIFERA supplies Total COD generated per year			
Organic Chemicals	22.33	FEDERCHIMICA, several years	3	IPCC, 2000
Paints	5.5	IPCC, 2000	5.5	IPCC, 2000
Plastics and Resins	0.6	IPCC, 2000	3.7	IPCC, 2000
Soap and Detergents	3	IPCC, 2000	0.9	IPCC, 2000
Vegetables, Fruits and Juices	20	IPCC, 2000	5.2	IPCC, 2000
Sugar Refining	4	ANPA-ONR, 2001	2.5	ANPA-ONR, 2001
Vegetable Oils	3.1	IPCC, 2000	1.2	IPCC, 2000
Dairy Products	3.9	ANPA-ONR, 2001	2.7	ANPA-ONR, 2001
Wine and Vinegar	3.8	ANPA-ONR, 2001	0.2	ANPA-ONR, 2001
Beer and Malt	7	Assobirra, several years	2.9	IPCC, 2000
Alcohol Refining	24	IPCC, 2000	11.0	IPCC, 2000
Meat and Poultry	13	IPCC, 2000	4.1	IPCC, 2000
Fish Processing	13	same value of Meat and Poultry	2.5	IPCC, 2000
Paper	25	Assocarta, several years	0.1	ANPA-FLORYS, 2001; Assocarta, several years
Pulp	25	Assocarta, several years	0.1	ANPA-FLORYS, 2001; Assocarta, several years
Textiles (dyeing)	60	IPCC, 1995	1.0	IPCC, 2000
Textiles (bleaching)	350	IPCC, 1995	1.0	IPCC, 2000
Leather	0.1	UNIC, several years	4.5	UNIC, several years

CH₄ 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). All the anaerobic digestion systems are equipped with systems to collect the methane produced. The methane collected is partly flared and partly used for energy purposes. The total methane recovered is estimated on the basis of the methane production and the efficiency of captation. Where anaerobic digestion of sludge is used, the reactors are covered and provided of gas recovery and the efficiency of captation is equal to 100%; so the methane recovered and reported in the CRFs is equal to the methane production.

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]).

CH₄ emissions have been calculated on the basis of the equivalent inhabitants treated in Imhoff tanks, the organic load in biochemical oxygen demand per person equal to 60 g BOD₅ 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 BOD₅ that readily settles equal to 0.3 (ANPA, 2001; Masotti, 1996), and the IPCC emission factor default value of 0.6 g CH₄ g⁻¹ BOD₅.

CH₄ emissions from wastewater have been estimated assuming that 5% of domestic and commercial wastewater is treated anaerobically. This assumption may correspond to the Italian situation where wastewater is treated in aerobic biological units with the possibility of bad management cases. Both in the case of the sludge and in the case of wastewater Equation 5.5 reported in the IPCC Good Practice Guidance (IPCC, 2000) has been used. The emission factor has been calculated using the Equation 5.7 (IPCC, 2000), whereas MCF has been assumed equal to 1 (0 – 1) and the default value B₀ = 0.6 kgCH₄/kg BOD.

In the case of sludge, most of the CH₄ produced (258,730 Mg in 2011) is recovered and not emitted because the anaerobic digestion of sludge takes place in reactors covered and provided with gas recovery system and

the efficiency of captation is equal to 100%. Only CH₄ produced in Imhoff tanks (7,036 Mg in 2011) is emitted.

In the case of wastewater, the lack of information has led to use the most conservative estimate considering MCF=1 again.

8.3.3 Uncertainty and time-series consistency

The combined uncertainty in CH₄ 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 N₂O 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 8.18; as previously noted only the 15% of industrial flows are treated anaerobically (IRSA-CNR, 1998).

CH₄ emission trend for industrial wastewater handling for different sectors is shown in Table 8.19, whereas the emission trend for N₂O emissions both from industrial wastewater handling and human sewage is shown in Table 8.20.

Concerning CH₄ 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.

The CH₄ emission trend from wastewater and sludge generated by domestic and commercial wastewater treatment is reported in Table 8.21.

Table 8.18 Total industrial wastewater production by sector, 1990 – 2011 (1000 m³)

Wastewater production (1000 m ³)	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Iron and steel	9,534	7,778	6,756	6,861	7,032	7,091	6,728	4,133	6,165	7,182
Oil refinery	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Organic chemicals	210,936	212,317	215,049	214,735	214,972	215,265	214,747	214,064	214,116	213,691
Food and beverage	179,120	177,383	182,736	185,657	182,693	180,401	180,106	184,776	188,823	185,232
Pulp and paper	377,167	402,952	387,285	366,025	365,649	368,979	346,504	225,051	240,061	245,713
Textile industry	108,460	103,047	101,572	75,492	78,272	79,796	68,768	55,751	64,363	57,846
Leather industry	23,623	25,002	27,216	18,315	19,254	18,315	16,804	14,944	14,246	14,512
Total	908,840	928,479	920,614	867,085	867,872	869,847	833,656	698,718	727,774	724,175

Table 8.19 CH₄ emissions from anaerobic industrial wastewater treatment, 1990 – 2011 (Gg)

CH ₄ Emissions (Gg)	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Iron and steel	0.036	0.029	0.025	0.026	0.026	0.027	0.025	0.015	0.023	0.027
Oil refinery	5.850	5.625	4.250	4.750	4.750	4.750	4.750	4.750	4.750	4.750
Organic chemicals	23.794	23.911	24.173	24.177	24.227	24.274	24.180	24.048	24.069	23.999
Food and beverage	22.946	22.112	22.871	23.197	23.220	23.085	22.757	23.513	23.726	23.362
Pulp and paper	0.923	0.986	1.055	0.997	0.996	1.005	0.944	0.613	0.654	0.669
Textile industry	4.067	3.864	3.809	2.831	2.935	2.992	2.579	2.091	2.414	2.169
Leather industry	3.192	3.378	3.677	2.901	3.122	3.100	2.632	2.319	2.517	2.449
Total	60.81	59.91	59.86	58.88	59.28	59.23	57.87	57.35	58.15	57.43

Table 8.20 N₂O emissions from industrial wastewater handling and human sewage, 1990 – 2011 (Gg)

N ₂ O Emissions (Gg)	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Industrial Wastewater	0.227	0.232	0.230	0.217	0.217	0.217	0.208	0.175	0.182	0.181
Human Sewage	5.679	5.500	5.979	5.933	5.932	5.967	6.136	6.141	6.187	6.067
Total	5.91	5.73	6.21	6.15	6.15	6.18	6.34	6.32	6.37	6.25

Table 8.21 CH₄ emissions from sludge generated by domestic and commercial wastewater treatment, 1990 – 2011 (Gg)

Domestic and Commercial Wastewater (5% treated anaerobically)	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Organic loading in wastewater (t year ⁻¹)	49.80	63.75	74.03	105.63	106.25	107.04	107.53	108.25	108.92	109.54
CH ₄ emissions (Gg)	29.88	38.25	44.42	63.38	63.75	64.23	64.52	64.95	65.35	65.73
Sludge (generated by Imhoff tanks)										
Eq. inhabitants treated in Imhoff tanks (10 ³ millions)	1,033	1,893	2,144	1,880	1,870	1,855	1,834	1,808	1,776	1,785
Organic loading in sludge (t year ⁻¹)	6.79	12.43	14.09	12.35	12.29	12.19	12.05	11.88	11.67	11.73
CH ₄ emissions (Gg)	4.07	7.46	8.45	7.41	7.37	7.31	7.23	7.13	7.00	7.04

8.3.4 Source-specific QA/QC and verification

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, in the framework of EPER/E-PRTR registry the methodology used to estimate emissions from wastewater handling can be used by the operators of wastewater treatment plants to check if their emission data exceed the reporting threshold values.

Finally, a Ph.D. thesis on GHG emissions from wastewater handling has been carried out at Environmental, Hydraulic, Infrastructures and Surveying Engineering Department (DIIAR) of Politecnico di Milano (Solini, 2010), where national methodology has been compared with that reported in 2006 IPCC Guidelines (IPCC, 2006) and with a methodology developed in the framework of a previous thesis Ph.D. for the estimation of emissions from wastewater treatment plants located in Regione Lombardia.

8.3.5 Source-specific recalculations

Recalculations in the sector have been done because the activity data about wastewater from organic chemicals industry, food and beverage industry, pulp and paper and textile industry have been updated in 2009 and 2010. Methane emissions from industrial wastewater showed changes reported in Table 8.22.

Table 8.22 Differences in percentages between time series reported in the updated time series and 2011 submission

CH ₄ emissions	1990	1995	2000	2005	2006	2007	2008	2009	2010
Iron and steel	-	-	-	-	-	-	-	-	-
Oil refinery	-	-	-	-	-	-	-	-	-
Organic chemicals	-	-	-	-	-	-	-	0.01%	-0.06%
Food and beverage	-	-	-	-	-	-	-	0.03%	-1.16%
Pulp and paper	-	-	-	-	-	-	-	-26.12%	-26.96%
Textile industry	-	-	-	-	-	-	-	-1.23%	-0.04%
Leather industry	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	-	-	-0.41%	-0.91%

N₂O emissions from industrial wastewater have been recalculated because the activity data on leather industry in 2005 and in 2007 and, more important, the activity data related to pulp and paper industry in 2009 and 2010 have been updated. Regarding human sewage, the activity data related to sludge management have been updated from 1990 to 1997, in 1999 and in 2010. In Table 8.23, differences in percentage between new time series and 2011 submission are reported.

Table 8.23 Differences in percentages between time series reported in the updated time series and 2011 submission

N ₂ O Emissions (Gg)	1990	1995	2000	2005	2006	2007	2008	2009	2010
Industrial Wastewater	-	-	-	-0.11%	-	-0.01%	-	-10.30	-11.16
Human Sewage	-0.05%	-0.09%	-	-	-	-	-	-	0.37%

8.3.6 Source-specific planned improvements

Methane conversion factor from domestic and commercial wastewater will be investigated in the future. Moreover the served population equivalent figures supplied by the National Institute of Statistics will be verified with the results of the next national survey.

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 by the competent authority. Other incineration plants are used exclusively for industrial and sanitary waste, both hazardous and not, and for the combustion of waste oils, whereas there are few plants where treat residual waste from waste treatments, as well as sewage sludge, are treated. Since 2007, the activity of co-incineration in industrial plants, especially to produce wooden furniture, has increased significantly, resulting in an increase of the relevant emissions related to the proportion of waste burned.

Emissions from incineration of human bodies in crematoria have been estimated too.

As mentioned above, emissions from waste incineration facilities with energy recovery are reported under category 1A4a (Combustion activity, commercial/institutional sector) in the “Other fuel” and “Biomass” sub category for the fossil and biomass fraction of wastes, respectively, whereas emissions from other types of waste incineration facilities are reported under category 6C (Waste incineration). For 2011, more than 95% of the total amount of waste incinerated is treated in plants with energy recovery system.

A complete database of the incineration plants is now available, updated with the information reported in the yearly report on waste production and management published by ISPRA (APAT-ONR, several years; ISPRA, 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).

CH₄ emissions from biogenic, plastic and other non-biogenic wastes have been calculated.

8.4.2 Methodological issues

Regarding GHG emissions from incinerators and crematoria, the methodology reported in the IPCC Good Practice Guidance (IPCC, 2000) has been applied, combined with that reported in the CORINAIR Guidebook (EMEP/CORINAIR, 2007; EMEP/EEA, 2009). A single emission factor for each pollutant has been used combined with plant specific waste activity data. Since 2010, NO_x, SO₂ and CO emission factors for urban waste incinerators have been updated on the basis of data provided by plants (ENEA-federAmbiente, 2012; De Stefanis P., 2012)

As regard incineration plants, emissions have been calculated for each type of waste: municipal, industrial, hospital, sewage sludge and waste oils.

A complete database 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 no information was available (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; ENI 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 with 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, except CH₄ emission factor that is derived from EMEP Corinair (EMEP/CORINAIR, 2007).

Specifically:

- 1 for municipal waste, emission data from a large sample of Italian incinerators were used (FEDERAMBIENTE, 1998; ENEA-federAmbiente, 2012);
- 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.

In Table 8.24, emission factors are reported in kg per tons of waste treated, for municipal, industrial, hospital waste, waste oils and sewage sludge.

Table 8.24 Waste incineration emission factors

POLLUTANT/WASTE TYPOLOGY	NMVOC (kg/t)	CO (kg/t)	CO ₂ fossil (kg/t)	N ₂ O (kg/t)	NO _x (kg/t)	SO ₂ (kg/t)	CH ₄ (kg/t)
Municipal waste 1990 - 2009	0.46	0.07	289.26	0.1	1.15	0.39	0.06
Municipal waste since 2010	0.46	0.07	289.26	0.1	0.62	0.02	0.06
Hospital waste	7.4	0.075	1200	0.1	0.604	0.026	0.06
Sewage sludge	0.25	0.6	0	0.227	3	1.8	0.06
Waste oils	7.4	0.075	3000.59	0.1	2	1.28	0.06
Industrial waste	7.4	0.56	1200	0.1	2	1.28	0.06

Here below (Tables 8.25, 8.26, 8.26, 8.28), details about data and calculation of specific emission factors are reported. Emission factors have been estimated on the basis of a study conducted by ENEA (De Stefanis, 1999), based on emission data from a large sample of Italian incinerators (FEDERAMBIENTE, 1998; AMA-Comune di Roma, 1996), legal thresholds (Ministerial Decree 19 November 1997, n. 503 of the Ministry of Environment; Ministerial Decree 12 July 1990), the last study conducted by ENEA and federAmbiente (ENEA-federAmbiente, 2012) and expert judgements.

In details, CO₂ emission factor for municipal waste has been calculated considering a carbon content equal to 23%; moreover, 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 CO₂ from fossil fuels (generally plastics) and CO₂ 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. This fraction is not expected to change significantly because of the energy characteristics required for the waste incinerated.

CO₂ emission factor for industrial, oils and hospital waste has been derived as the average of values of investigated industrial plants. On the other hand, CO₂ 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.

In Table 8.29 activity data are reported by type of waste.

Table 8.25 Municipal waste emission factors

MUNICIPAL WASTE	Average concentration values (mg/Nm ³)		Standard specific flue gas volume (Nm ³ /KgMSW)		E.F. (g/Mg)	
	1990-2009	2010	1990-2009	2010	1990-2009	2010
SO ₂	78.00	2.17	5	6.7	390	18
NO _x	230.00	97.08			1,150	621
CO	14.00	12.30			70	73
N ₂ O					100	100
CH ₄					59.80	59.80
NMVOC					460.46	460.46
C content, % weight	23	23				
CO ₂					826.5 (kg/Mg)	826.5(kg/Mg)

Table 8.26 Industrial waste and oils emission factors

INDUSTRIAL WASTE AND OIL	Average concentration values (mg/Nm ³)	Standard specific flue gas volume (Nm ³ /KgMSW)	E.F. (g/t)
SO ₂	160.00	8	1,280
NO _x	250.00		2,000
CO	70.00		560
N ₂ O			100
CH ₄			59.80
NMVOC			7,400
CO ₂			1,200 (kg/t)

Table 8.27 Hospital waste emission factors

HOSPITAL WASTE	Average concentration values (mg/Nm ³)	Standard specific flue gas volume (Nm ³ /KgMSW)	E.F. (g/t)
SO ₂	3.24	8	26
NO _x	75.45		604
CO	9.43		75
N ₂ O			100
CH ₄			59.80
NMVOC			7,400
CO ₂			1,200 (kg/t)

Table 8.28 Sewage sludge emission factors

SEWAGE SLUDGE	Average concentration values (mg/Nm ³)	Standard specific flue gas volume (Nm ³ /KgMSW)	E.F. (g/t)
SO ₂	300	6	1,800
NO _x	500		3,000
CO	100		600
N ₂ O			100
CH ₄			59.80
NMVOC			251.16
CO ₂			700 (kg/t)

Table 8.29 Amount of waste incinerated by type, 1990 – 2011 (Gg)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Total Waste incinerated	1,656	2,149	3,062	4,964	5,066	6,011	6,065	6,387	6,975	7,383
- with energy recovery	911	1,558	2,752	4,721	4,824	5,791	5,856	6,157	6,742	7,136
- without energy recovery	745	591	310	243	242	220	209	230	233	246
MSW incinerated	1,026	1,437	2,325	3,220	3,269	3,307	3,381	3,863	4,369	4,625
- with energy recovery	626	1,185	2,161	3,168	3,247	3,279	3,357	3,834	4,313	4,566
- without energy recovery	399	251	164	52	23	28	24	29	56	59
Industrial Waste incinerated										
Other waste	473	536	604	1602	1625	2545	2520	2357	2472	2617
- with energy recovery	258	330	510	1,447	1,458	2,407	2,393	2,216	2,355	2,493
- without energy recovery	215	206	94	155	167	137	127	141	117	124
Hospital waste	134	152	110	126	145	132	140	162	128	135
- with energy recovery	25	41	77	106	119	104	106	108	74	78
- without energy recovery	109	111	34	21	26	28	34	54	54	57
Sludge	20.72	23.18	21.50	15.60	25.98	26.06	24.00	5.90	5.90	6.24
- with energy recovery	0.00	0.00	3.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- without energy recovery	20.72	23.18	18.11	15.60	25.98	26.06	24.00	5.90	5.90	6.24
Waste oil	2.66	1.41	0.82	0.67	0.43	0.75	0.29	0.19	0.18	0.18
- with energy recovery	1.77	0.94	0.55	0.54	0.35	0.62	0.29	0.19	0.18	0.18
- without energy recovery	0.89	0.47	0.27	0.12	0.08	0.14	0.00	0.00	0.00	0.00

CH₄ and N₂O 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. Emissions due to stubble burning, which are emissions only from the agriculture residues burned on field, are reported in the agriculture sector, under 4.F. Under the waste sector the burning of removable agriculture residues that are collected and could be managed in different ways (disposed in landfills, used to produce compost or used to produce energy) is reported. Different percentages of the removable agriculture residue burnt for different residues are assumed, varying from 10% to 90%, according to national and international literature. Moreover, these removable wastes are assumed to be all burned in open air (e.g. on field) taking in consideration the higher available CO, NMVOC, PM, PAH and dioxins emission factors. The amount of these wastes treated differently is not supplied, but they are included in the respective sectors (landfill, composting, biogas production for energy purposes, etc.).

The methodology is the same used to calculate emissions from residues burned on fields, in the category 4F, described in details in Chapter 6.

On the basis of carbon and nitrogen content of the residues, CH₄ and N₂O emissions have been calculated, both accounting nearly for 100% of the whole emissions from waste incineration. CO₂ 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).

The amount of biomass from pruning used for domestic heating is reported in the energy sector in the 1A4b category as biomass fuel.

As regard incineration of corpses in crematoria, activity data have been supplied by a specific branch of Federutility, which is the federation of energy and water companies (SEFIT, 2011). Emission factors are from EMEP/EEA Air Pollutant Emission Inventory Guidebook (EMEP/EEA, 2009).

In Table 8.30 time series of cremation as well as annual deaths and crematoria in Italy are reported.

Table 8.30 Cremation time series (activity data), 1990 – 2011

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Cremations (no. of corpses)	5,809	15,436	30,167	48,196	53,013	58,554	63,611	71,898	77,379	87,871
Deaths (no. of corpses)	543,700	555,203	560,241	567,304	557,892	570,801	58,5126	591,663	587,488	593,404
Mortal remains (no.)	1,000	1,750	1,779	9,880	10,101	12,824	15,165	15,819	18,899	23,353
Cremation percentage	1.07	2.78	5.38	8.50	9.50	10.26	10.87	12.15	13.17	14.81
Crematoria (no.)	NA	31	35	43	44	45	45	50	53	56

The major emissions from crematoria are nitrogen oxides, carbon monoxide, sulphur dioxide, particulate matter, mercury, hydrogen fluoride (HF), hydrogen chloride (HCl), NMVOCs, other heavy metals, and some POPs. Here below emission factors used for GHG emissions estimate; all emission factors are from EMEP/EEA, 2009 except for CH₄ and N₂O, assumed equal to MSW emission factor because not available from 2009 Guidebook. CO₂ emissions have been not calculated for the inventory as human body is 'biomass'.

In Table 8.31 emission factors for cremation are reported.

Table 8.31 Cremation emission factors

POLLUTANT/WASTE TYPOLOGY	NMVOC (kg/body)	CO (kg/body)	N₂O (kg/t)	NO_x (kg/body)	SO₂ (kg/body)	CH₄ (kg/t)
Cremation	0.013	0.141	0.1	0.309	0.544	0.06

8.4.3 Uncertainty and time-series consistency

The combined uncertainty in CO₂ emissions from waste incineration is estimated to be about 25.5%, 5% and 25% for activity data and emission factors respectively. For N₂O and CH₄ emissions, the combined uncertainty is estimated to be about 100% and 20.6%.

The time series of activity data, distinguished in Municipal Solid Waste and other (including cremation), is shown in Table 8.32; CO₂ emission trends for each type of waste category are reported in Table 8.33, both for plants without energy recovery, reported under 6C, and plants with energy recovery, reported under

1A4a. In Table 8.34 N₂O and CH₄ emissions are summarized, including those from open burning and cremation.

In the period 1990-2011, total CO₂ emissions have increased by 349%, but whereas emissions from plants with energy recovery have increased by nearly 737%, emissions from plants without energy recovery decreased by 54% (Table 8.32). While CO₂ emission trend reported in 6C is influenced by the amount of waste incinerated in plant without energy recovery, CH₄ and N₂O emission trend are related to the open burning, as already reported above.

Table 8.32 Waste incineration activity data, 1990 – 2011 (Gg)

Activity Data	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
MSW Production (Gg)	22,231	25,780	28,959	31,664	32,511	32,542	32,467	32,110	32,479	32,731
MSW Incinerated (%)	4.6%	5.6%	8.0%	10.2%	10.1%	10.2%	10.4%	12.0%	13.5%	14.1%
- in energy recovery plants	2.8%	4.6%	7.5%	10.0%	10.0%	10.1%	10.3%	11.9%	13.3%	13.9%
MSW to incineration (Gg)	1,026	1,437	2,325	3,220	3,269	3,307	3,381	3,863	4,369	4,625
Industrial, Sanitary, Sewage Sludge and Waste Oil to incineration (Gg)	631	712	737	1,744	1,797	2,703	2,684	2,525	2,606	2,758
Cremation (no. of corpses)	5,809	15,436	30,167	48,196	53,013	58,554	63,611	71,898	77,379	87,871
Total Waste to incineration, excluding cremation (6C and 1A4a) (Gg)	1,656	2,149	3,062	4,964	5,066	6,011	6,065	6,387	6,975	7,383

Table 8.33 CO₂ emissions from waste incineration (without and with energy recovery), 1990 – 2011 (Gg)

CO ₂ Emissions	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Incineration of domestic or municipal wastes (Gg)	115.47	72.64	47.30	15.02	6.61	8.19	7.04	8.44	16.11	17.05
Incineration of industrial wastes (except flaring) (Gg)	257.99	247.11	113.09	185.57	200.30	164.81	152.68	169.07	140.72	148.96
Incineration of hospital wastes (Gg)	131.07	132.73	40.36	24.61	31.62	33.34	40.31	64.79	64.71	68.50
Incineration of waste oil (Gg)	2.66	1.41	0.82	0.36	0.24	0.41	0.00	0.00	0.00	0.00
Incineration of corpses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Waste incineration (6C) (Gg)	507	454	202	226	239	207	200	242	222	235
Waste incineration reported under 1A4a (Gg) – not biomass	526	791	1,331	2,781	2,833	3,964	3,970	3,898	4,162	4,406
Waste incineration reported under 1A4a (Gg) - biomass	337	637	1161	1,702	1,744	1,762	1,803	2,059	2,317	2,453
Total waste incineration (Gg)	1,033	1,245	1,532	3,007	3,072	4,171	4,170	4,140	4,384	4,640

Table 8.34 N₂O and CH₄ emissions from waste incineration (cremation and open burning included), 1990 – 2011 (Gg)

GAS/SUBSOURCE	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
N₂O (Gg)										
Waste incineration (6C)	0.13	0.12	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08
MSW incineration reported under 1A4a – not biomass	0.05	0.08	0.13	0.27	0.27	0.37	0.37	0.37	0.39	0.42
MSW incineration reported under 1A4a – biomass	0.04	0.08	0.14	0.21	0.21	0.21	0.22	0.25	0.28	0.30

GAS/SUBSOURCE	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CH₄ (Gg)										
Waste incineration (6C)	2.09	2.41	2.32	2.56	2.48	2.47	2.57	2.50	2.43	2.42
MSW incineration reported under 1A4a	0.03	0.05	0.08	0.16	0.16	0.22	0.22	0.22	0.24	0.25
MSW incineration reported under 1A4a – biomass	0.02	0.05	0.08	0.12	0.13	0.13	0.13	0.15	0.17	0.18

8.4.4 Source-specific QA/QC and verification

Several verification were carried out which led to some recalculations as described in the following paragraph 8.4.5.

8.4.5 Source-specific recalculations

As planned in the previous submissions a rearrangement of incinerators database has been made. During this process an in depth analysis about all incineration plants has been carried out with the target to eliminate double counting and to add eventual not counted plants.

Table 8.35 Differences in percentages between time series reported in the updated time series and 2012 submission

GAS/SUBSOURCE	1990	1995	2000	2005	2006	2007	2008	2009	2010
CO₂ (Gg)									
Waste incineration (6C)	-	-	-	-	-	-	-	10.96%	-3.72%
MSW incineration reported under 1A4a	-	-	-	-	-	-0.09%	-0.05%	-4.85%	-10.51%
N₂O (Gg)									
Waste incineration (6C)	-55.4%	-71.5%	-75.6%	-79.0%	-78.1%	-77.7%	-78.5%	-78.9%	-77.5%
MSW incineration reported under 1A4a	-	-	-	-	-	-0.08%	-0.05%	-4.26%	-9.40%
CH₄ (Gg)									
Waste incineration (6C)	-72.6%	-81.3%	-80.6%	-81.9%	-81.6%	-80.8%	-80.9%	-81.6%	-80.5%
MSW incineration reported under 1A4a	-	-	-	-	-	-0.08%	-0.05%	-4.26%	-9.40%

The analysis regarding incineration plants has been conducted through verifications and comparisons with data reported in E-PRTR registry, Emissions Trading Scheme and updated data of waste amount and pollutants emissions (ENEA-federAmbiente, 2012) and it results in some recalculations since 2007. These investigations have shown that some plants have been erroneously reported as incinerators whilst boilers and cement kiln facility already considered in the energy sector. Other plants were erroneously classified without energy recovery system whereas they were already equipped. On the other hand, since 2007 co-incinerators have been identified and considered during the estimation process in 1A4a because modern plants with energy recovery.

Recalculations in N₂O and CH₄ emissions occurred for the whole time series because of the updating of open burning activity data as a consequence of a reallocation of biomass pruning used for domestic heating, and relevant emissions, in the energy sector in the 1A4b biomass fuel subcategory.

8.4.6 Source-specific planned improvements

No further improvements are planned.

8.5 Other waste (6D)

8.5.1 Source category description

Under this source category CH₄ emissions from compost production have been reported. The amount of waste treated in composting plants has shown a great increase from 1990 to 2011 (from 363,319 tons to 8,857,122 Mg).

Information on input waste to composting plants are published yearly by ISPRA since 1996, including data for 1993 and 1994 (ANPA, 1998; APAT-ONR, several years; ISPRA, 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: plants that treat a selected waste (food, market, garden waste, sewage sludge and other organic waste, mainly from the agro-food industry); and mechanical-biological treatment plants, where the unselected waste is treated to produce compost, refuse derived fuel (RDF), and a waste with selected characteristics suitable for landfilling or incinerating systems.

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).

For these emissions, literature data (Hogg, 2001) have been used for the emission factor, 0.029 g CH₄ kg⁻¹ treated waste, which is the same as the compost production emission factor. The paper referred to considers also national experimental measurements from the Scuola Agraria del Parco di Monza, and reports that methane emissions are expected to be zero where the facility is well operated.

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 8.36, activity data, CH₄ and NMVOC emissions are reported. Moreover, NO_x emissions from sludge spreading are reported.

Table 8.36 CH₄ and NMVOC emissions from compost production, 1990 – 2011 (Gg)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
<u>Waste treated in composting plants (t)</u>										
<u>CH₄ (Gg)</u>										
Compost production (6D)	0.011	0.023	0.097	0.200	0.213	0.220	0.210	0.210	0.246	0.260
<u>NMVOC (Gg)</u>										
Compost production (6D)	0.018	0.040	0.168	0.346	0.369	0.380	0.364	0.364	0.425	0.450
<u>NO_x (Gg)</u>										
Sludge spreading (6D)	0.667	1.069	1.440	1.166	1.022	1.092	1.162	1.494	1.477	1.558

8.5.3 Uncertainty and time-series consistency

The uncertainty in CH₄ emissions from compost production is estimated to be about 100% in annual emissions, 10% and 100% concerning activity data and emission factors respectively.

8.5.4 Source-specific QA/QC and verification

This source category is covered by the general QA/QC procedures.

8.5.5 *Source-specific recalculations*

Negligible recalculations due to the 2009 compost activity data update.

8.5.6 *Source-specific planned improvements*

No specific activities are planned.

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 2010 have been submitted as well as the CRF for the year 2011 and recalculation tables of the CRF have been filled in. Explanatory information on the major recalculations between the 2012 and 2013 submissions for the year 2010 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 2012 submission and the actual one (2013 submission) are summarised in Table 9.2 by gas; differences in emission levels due to recalculations are also reported.

Improvements in the calculation of emission estimates have led to a recalculation of the entire time series of the national inventory. Considering total GHG emissions without LULUCF, estimates show a decrease in comparison with the last year submission, equal to -0.05% for the base year and -0.20% for 2010. Considering the national total with the LULUCF sector, the base year has increased by 4.55% and the 2010 emission levels by 2.74%.

Detailed explanations of these recalculations are provided in the sectoral chapters.

Changes in the base year levels are related, primarily, to the energy sector due to a revision of CO₂ from ferroalloys production which have been excluded from the iron and steel category because already accounted for in the industrial processes; N₂O and CH₄ emissions from road transport due to the update of the COPERT model, the reallocation of N₂O and CH₄ emissions from biomass pruning from the waste to the energy sector. The LULUCF sector was also affected by an update in methodology to calculate emission and removal from cropland, the coefficients used to estimate the carbon stock changes in the deadwood pool and the availability of new information on fires areas in cropland and grassland which have been estimated and included in the inventory.

For 2010, changes regarded the energy sector, due to the update of CO₂ emission factors for different fuel on account of information derive from operators under the European emissions trading scheme, in particular coal derived gases and natural gas; the amount of waste incinerated for energy purposes have been updated; N₂O and CH₄ emissions from road transport due to the update of the COPERT model. In the industrial and in the agriculture sectors, there have been minor recalculations on account of the update of different activity data and parameters. The LULUCF sector was also affected by the same revisions, as for 1990. In the waste sector, the main revision regarded the update of waste incineration emissions on the basis of data collected at plant level.

Table 9.1 Explanations of the main recalculations in the 2013 submission

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please tick where the latest NIR includes major changes in methodological descriptions compared to the previous year NIR	Please tick where this is also reflected in recalculations compared to the previous year CRF	If ticked please provide some more detailed information for example related to sub-category, gas, reference to pages in the NIR, etc
Total (Net Emissions)	√	√	CO2 from 1A2. CO2 emission from ferroalloys production reported under the industrial processes sector have been removed for the whole timeseries from the energy sector because of double counting. CH4 and N2O from 1A4 and 6C. Pruning biomass burnt for residential heating has been reallocated from the waste sector to the energy sector for the whole timeseries. CO2 from 6C. Update of data from incineration plants in 2009 and 2010 CO2 from 1A. Update of CO2 emission factor for natural gas for 2009-2010 and for coal derived gases from 2005 CO2 from 5B. Update in methodology to estimate C stock changes in perennial crops CO2, CH4 and N2O from 5B and 5C. Emissions from fires in Cropland and Grassland categories have been added and estimated for the whole time series
1. Energy	√	√	CO2 from 1A2. CO2 emission from ferroalloys production reported under the industrial processes sector have been removed for the whole time series from the energy sector because of double counting. CO2 from 6C. Update of data from incineration plants in 2009 and 2010 CH4 and N2O from 1A4. Pruning biomass burnt for residential heating has been reallocated from the waste sector to the energy sector for the whole timeseries.
A. Fuel Combustion (Sectoral Approach)	√	√	CO2 from 1A2. CO2 emission from ferroalloys production reported under the industrial processes sector have been removed from the energy sector because of double counting for the whole timeseries. CH4 and N2O from 1A4. Pruning biomass combustion for residential heating have been reallocated from the waste sector to the energy sector for the whole timeseries.
1. Energy Industries		√	CO2 from 1A1. Update of CO2 emission factor for natural gas for 2009 and 2010 and coal derived gases from 2005. CH4 and N2O from 1A1. Addition of bioliquid fuel consumption.
2. Manufacturing Industries and Construction	√	√	CO2 from 1A2. CO2 emission from ferroalloys production reported under the industrial processes sector have been removed from the energy sector because of double counting, for the whole time series. Update of CO2 natural gas emission factor for 2009 and 2010.
3. Transport	√	√	CO2, CH4 and N2O from 1A3b. Use of the updated COPERT 4 model version.
4. Other Sectors	√	√	CO2 from 1A4. Update of urban waste activity data in incineration with energy recovery for 2008-2010. CH4 and N2O from 1A4. Emission from combustion of pruning biomass have been reallocated from the waste sector to the energy sector.
5. Other			
B. Fugitive Emissions from Fuels			
1. Solid Fuels	√	√	CO2 from 1B1. Emissions from mining and post mining activities have been added. CH4 from 1B1. Emissions from post mining activities in surface mines have been added
2. Oil and Natural Gas	√	√	CO2, CH4 and N2O from 1B2. Emissions from gas and

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please tick where the latest NIR includes major changes in methodological descriptions compared to the previous year NIR	Please tick where this is also reflected in recalculations compared to the previous year CRF	If ticked please provide some more detailed information for example related to sub-category, gas, reference to pages in the NIR, etc
			oil exploration have been added CH4 from 1B2. Update of CH4 emission factor for gas distribution. N2O from 1B2. Update of the emission factor for oil flaring.
2. Industrial Processes		√	
A. Mineral Products		√	CO2 from 2A. Update of CO2 emission factor and activity data for soda ash production
B. Chemical Industry			
C. Metal Production			
D. Other Production			
E. Production of Halocarbons and SF6			
F. Consumption of Halocarbons and SF6		√	HFCs from 2F. Update of activity data of Mobile Air Conditioning for 2010
G. Other			
3. Solvent and Other Product Use		√	CO2 from 3. update of EF for paint application for manufacture of automobiles, car repairing and wood. update of AD for manufacture of automobiles, glues and adhesives, and fat edible and non edible oil extraction. revision of emission estimates from domestic solvent use for double counting of pharmaceutical products
4. Agriculture		√	
A. Enteric Fermentation			
B. Manure Management			
C. Rice Cultivation			
D. Agricultural Soils		√	N2O from 4D. Update of N content of sludge applied to soil; update of emissions from sows
E. Prescribed Burning of Savannas			
F. Field Burning of Agricultural Residues		√	CH4 and N2O from 4F. Update of fraction burned of rice residues and some crop production
G. Other			
5. Land Use, Land-Use Change and Forestry	√	√	CO2, CH4 and N2O from 5B and 5C. Emissions from fires in Cropland and Grassland categories have been estimated for the whole time series. Update in deadwood coefficients. Update in methodology to estimate C stock changes in perennial crops.
A. Forest Land	√	√	CO2 from 5A. Update in deadwood coefficients. Update in activity data.
B. Cropland	√	√	CO2 from 5B. Update in methodology to estimate C stock changes in perennial crops. Update in deadwood coefficients. Emissions from organic soils was reallocated, fixing a previous allocation's error. CO2, CH4 and N2O from 5B. Emissions from fires in Cropland and Grassland categories have been estimated
C. Grassland	√	√	CO2, CH4 and N2O from 5C. Emissions from fires in Cropland and Grassland categories have been estimated
D. Wetlands			
E. Settlements		√	CO2 from 5E. Update in activity data.
F. Other Land			
G. Other			
6. Waste	√	√	CO2 from 6C. Update of data from incineration plants in 2009 and 2010. CH4 and N2O from 6C. Emission from combustion of pruning biomass have been reallocated from the waste sector to the energy sector for the whole time series
A. Solid Waste Disposal on Land		√	CH4 from 6A. Update of urban waste activity data.
B. Waste-water Handling		√	N2O from 6B. Update of human sewage activity data from 1990 to 1997 and in 1999. N2O from 6B. Update of

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please tick where the latest NIR includes major changes in methodological descriptions compared to the previous year NIR	Please tick where this is also reflected in recalculations compared to the previous year CRF	If ticked please provide some more detailed information for example related to sub-category, gas, reference to pages in the NIR, etc
			industrial wastewater activity data in 2005, 2007 and 2009-2010. CO2 from 6B. Update of industrial wastewater activity data in 2009-2010.
C. Waste Incineration	√	√	CO2 from 6C. Update of data from incineration plants without energy recovery in 2009 and 2010 CH4 and N2O from 6C. Activity data and emissions from pruning biomass combustion for residential heating have been reallocated from the waste sector to the energy sector for the whole time series
D. Other			
7. Other (as specified in Summary 1.A)			
Memo Items:			
International Bunkers			
Aviation			
Marine		√	CO2, CH4 and N2O. Update of marine international gasoil and fuel oil activity data
Multilateral Operations			
CO2 Emissions from Biomass	√	√	Reallocation of pruning biomass combustion for domestic heating from the waste sector to the energy sector
NIR Chapter	DESCRIPTION		REFERENCE
	Please tick where the latest NIR includes major changes in descriptions compared to the previous year NIR		If ticked please provide some more detailed information for example reference to pages in the NIR
Chapter 1.2 Institutional arrangements			
Chapter 1.6 QA/QC plan			

Table 9.2 Differences in time series between the 2013 and 2012 submissions due to recalculations

	subm	1990	1995	2000	2005	2006	2007	2008	2009	2010
Net CO₂ emissions/removals (Gg CO₂-eq.)										
	2012	400,254	396,931	419,281	434,508	428,577	439,738	411,723	359,413	369,428
	2013	421,621	414,255	435,952	449,563	444,164	456,876	426,954	374,799	381,940
<i>Differences</i>		5.34%	4.36%	3.98%	3.46%	3.64%	3.90%	3.70%	4.28%	3.39%
CO₂ emissions (without LULUCF) (Gg CO₂-eq.)										
	2012	435,012	445,151	462,485	488,163	483,614	475,486	463,962	415,434	426,087
	2013	434,656	444,944	462,278	488,078	483,543	475,441	463,922	415,089	425,499
<i>Differences</i>		-0.08%	-0.05%	-0.04%	-0.02%	-0.01%	-0.01%	-0.01%	-0.08%	-0.14%
CH₄ emissions (Gg CO₂-eq.)										
	2012	43,878	44,330	45,905	41,303	39,769	39,779	38,485	38,327	37,597
	2013	44,359	44,495	46,191	41,267	39,717	40,035	38,404	38,282	37,453
<i>Differences</i>		1.10%	0.37%	0.62%	-0.09%	-0.13%	0.64%	-0.21%	-0.12%	-0.38%
CH₄ emissions (without LULUCF) (Gg CO₂-eq.)										
	2012	43,695	44,290	45,799	41,255	39,731	39,533	38,428	38,259	37,554
	2013	43,761	44,336	45,844	41,107	39,578	39,313	38,192	38,013	37,290
<i>Differences</i>		0.15%	0.10%	0.10%	-0.36%	-0.39%	-0.56%	-0.61%	-0.64%	-0.70%
N₂O emissions (Gg CO₂-eq.)										
	2012	37,459	40,025	39,621	37,782	32,444	31,828	29,764	28,218	27,302
	2013	37,680	38,569	39,627	37,751	32,394	31,920	29,700	28,154	27,132
<i>Differences</i>		0.59%	-3.64%	0.02%	-0.08%	-0.15%	0.29%	-0.21%	-0.23%	-0.62%
N₂O emissions (without LULUCF) (Gg CO₂-eq.)										
	2012	37,368	39,933	39,589	37,751	32,418	31,808	29,750	28,211	27,217
	2013	37,396	38,422	39,483	37,668	32,322	31,679	29,615	28,053	27,076
<i>Differences</i>		0.08%	-3.78%	-0.27%	-0.22%	-0.30%	-0.41%	-0.45%	-0.56%	-0.52%
HFCs (Gg CO₂-eq.)										
	2012	351	671	1,986	5,401	6,106	6,855	7,513	8,164	8,755
	2013	351	671	1,986	5,401	6,106	6,855	7,513	8,164	8,745
<i>Differences</i>		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.12%
PFCs (Gg CO₂-eq.)										
	2012	2,487	1,266	1,217	1,715	1,714	1,652	1,501	1,063	1,331
	2013	2,487	1,266	1,217	1,715	1,714	1,652	1,501	1,063	1,331
<i>Differences</i>		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SF₆ (Gg CO₂-eq.)										
	2012	333	601	493	465	406	428	436	398	373
	2013	333	601	493	465	406	428	436	398	373
<i>Differences</i>		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total (with LULUCF) (Gg CO₂-eq.)										
	2012	484,761	483,824	508,504	521,174	509,016	520,280	489,421	435,583	444,787
	2013	506,830	499,858	525,467	536,162	524,501	537,766	504,507	450,860	456,973
<i>Differences</i>		4.55%	3.31%	3.34%	2.88%	3.04%	3.36%	3.08%	3.51%	2.74%
Total (without LULUCF) (Gg CO₂-eq.)										
	2012	519,246	531,913	551,570	574,749	563,989	555,761	541,589	491,528	501,318
	2013	518,984	530,241	551,301	574,433	563,668	555,367	541,177	490,780	500,314
<i>Differences</i>		-0.05%	-0.31%	-0.05%	-0.05%	-0.06%	-0.07%	-0.08%	-0.15%	-0.20%

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 2012, emission levels of the base year, as total emissions in CO₂ equivalent without LULUCF, slightly changed (-0.05%) due to a revision in different sectors as previously described.

If considering emission levels with LULUCF, an increase by 4.55% is observed between the 2012 and 2013 total figures in CO₂ equivalent.

The trend 'base year- year 2010' does not show a significant change from the previous to this year submission.

Figure 9.1 shows the time series of the range of total national GHG emissions due to recalculations in the last years (submissions 2001-2012) and the 2013 emission estimates. Values of the coefficient of variation are also illustrated which show that the first years of the time series were mostly affected by recalculation in terms of variability whereas lower values are observed for the last years. Moreover, it can be noted that recalculations usually result in higher figures as compared previous submissions. In total, the graph shows that improvements in methodologies guarantee accurate estimates and minor changes from one year to another for the entire time series.

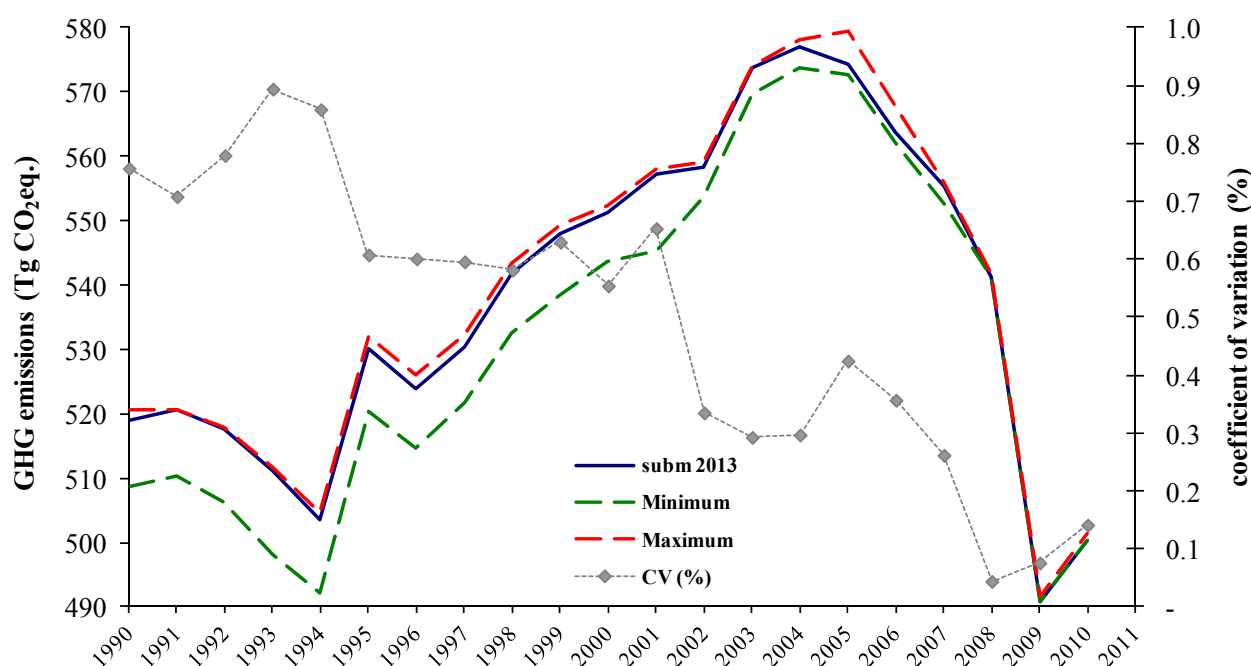


Figure 9.1 Range of national GHG emissions (Tg CO₂ eq.) in the 2001-2013 submissions and coefficient of variation (%)

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 last year 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 in emission estimates occurred since the last year submission are reported in Table 9.1 and Table 9.2.

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. CO₂ emission factors have been updated for coal derived gases, and natural gas in the last years. Fugitive emissions on account of the addition of CO₂ emissions from mining and from oil and gas exploration. A revision in the road transport sector affected CH₄ and N₂O for the use of the new version of COPERT 4; and there has also been an update in the maritime sector of CH₄ and N₂O emission factors for recreational boats in the last years. CO₂ from ferroalloys production have been excluded from the iron and steel category because already accounted for in the industrial processes. N₂O and CH₄ emission estimates from biomass pruning have been moved from the waste to the energy sector. Moreover, there has been an update of waste fuel consumption and biomass for commercial heating.

Industrial sector. Recalculations of CO₂ emissions occurred due to an update of activity data from limestone and dolomite and soda ash production. Minor recalculations occurred for HFC134a emissions from refrigeration and air conditioning equipment.

Solvent and other product use sector. Recalculations are observed due to the update of emission factors in paint application in wood and for car repairing.

Agriculture. N₂O emissions have been recalculated due to the update of N content of sludge and an update of emission factor of the storage of N excreted. CH₄ and N₂O emissions have been recalculated due to the update of the fraction of the field where “fixed” residues are burned for the rice production.

LULUCF. Recalculations affected emissions and removals from sector estimates mainly for the update in the coefficients used in the estimation process for the dead organic matter pool in the relevant categories and for the change in method used to estimate carbon stock changes in perennial crops. The LULUCF sector was also recalculated on account of availability of new information on fires areas in cropland and grassland which have been estimated and included in the inventory.

Waste. A rearrangement of incinerators database has been made which resulted in deviations from previous sectoral estimates. Other recalculations in N₂O and CH₄ emissions occurred because of a reallocation of from biomass pruning have been moved from the waste to the energy.

9.4.2 Response to the UNFCCC review process

In 2012, the Italian GHG inventory was subject to the centralised review of the 2012 inventory submission. A complete list of improvements following the UNFCCC review process is reported in Annex 12.

Improvements regarded the completeness and transparency of the information reported in the NIR.

More information on the methodology used to estimate emissions in the energy, especially fugitive, and industrial sector, F-gases estimations, and waste has been added and the description of country specific methods and the rationale behind the choice of emission factors, activity data and other related parameters for different sector has been better detailed.

Additional explanations for the trend of emission factors or emissions have been included for different sectors especially in the industrial sector.

The main improvement for LULUCF sector was the estimation of dead wood mass by the use of country specific emission factors, and the inclusion of emissions from fires in other land categories (cropland, and grassland).

9.4.3 *Planned improvements (e.g., institutional arrangements, inventory preparation)*

The main institutional and legal arrangements required under the Kyoto Protocol have been finalized. Some problems still regard the implementation of national registry for forest carbon sinks to identify areas of land and land-use change in accordance with paragraph 20 of the annex to decision 16/CMP.1, and to provide information, including estimates of emissions/removals, on activities under Article 3, paragraphs 3 and 4, of the Kyoto Protocol. Some of activities planned in this framework (in particular IUTI, inventory of land use) have been completed, resulting in land use classification, for all national territory, for the years 1990, 2000 and 2008. A process of validation and verification of IUTI data is currently on going and will supply data useful to update and improve the estimations.

Specific improvements are identified in the relevant chapters and specified in the 2013 QA/QC plan; they can be summarized in the following.

For the energy and industrial sectors, the database where information collected in the framework of different EU legislation, Large Combustion Plant, E-PRTR and Emissions Trading, is annually updated. The database has helped highlighting the main discrepancies in information and detecting potential errors leading to a better use of these data in the national inventory.

For the agriculture and waste sectors, improvements will be related to the availability of new information on emission factors, activity data as well as parameters necessary to carry out the estimates; specifically, improvements are expected for the review of nitrous oxide emission factors in the agricultural soil emissions and availability of additional information on waste composition.

For the LULUCF; activities planned in the framework of the National Registry for Forest Carbon Sinks should provide data to improve estimate of emissions by biomass burning and the final results of the INFC data related to the soils survey will definitely constitute a robust database, allowing refined estimates and lower related uncertainty.

Additional studies will regard the comparison between local inventories and national inventory and exchange of information with the 'local inventories' national expert group.

Further analyses will concern the collection of statistical data and information to estimate uncertainty in specific sectors by implementing Approach 2 of the IPCC guidelines.

**PART II: SUPPLEMENTARY INFORMATION REQUIRED
UNDER ARTICLE 7, PARAGRAPH 1**

10 KP-LULUCF

10.1 General information

Under Article 3, paragraph 3, of the Kyoto Protocol (KP), Italy reports emissions and removals from afforestation (A), reforestation (R) and deforestation, and under Article 3, paragraph 4 emissions and removals from forest management (FM). The estimates for emissions and removals under Articles 3.3 and 3.4 are consistent with the IPCC GPG LULUCF 2003 and Decisions 15/CMP.1 and 16/CMP.1 of the KP.

10.1.1 *Definition of forest and any other criteria*

Forest is defined by Italy under the Kyoto Protocol reporting using the same definition applied by the Food and Agriculture Organization of the United Nations for its Global Forest Resource assessment (FAO FRA 2000). This definition is consistent with the definition given in Decision 16/CMP.1. Forest is a land with the following threshold values for tree crown cover, land area and tree height:

- a. a minimum area of land of 0.5 hectares;
- b. tree crown cover of 10 per cent;
- c. minimum tree height of 5 meters.

Forest roads, cleared tracts, firebreaks and other open areas within the forest as well as protected forest areas are included in forest. Plantations, mainly poplars, characterized by short rotation coppice system and used for energy crops, are not included under KP-LULUCF activities, as they do not fulfill national forest definition while other plantation typologies, as chestnut and cork oak, have been included in forest and therefore included under KP-LULUCF activities.

10.1.2 *Elected activities under Article 3, paragraph 4, of the Kyoto Protocol*

Italy has chosen to elect *Forest Management* (FM) as an activity under Article 3.4. In accordance with the Annex to Decision 16/CMP.1, credits from Forest Management are capped in the first commitment period. Following the Decision 8/CMP.2, the cap is equal to 2.78 Mt C (10.19 MtCO₂) per year, or to 13.9 Mt C (50.97 MtCO₂) for the whole commitment period.

10.1.3 *Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time*

Afforestation and *reforestation* areas have been estimated on the basis of data of the two last Italian National Forest Inventories (IFN1985 and IFNC2005). *Deforestation* data have been derived from administrative records at NUT2 level collected by the National Institute of Statistics.

The definition of *forest management* is interpreted in using the broader approach as described in the GPG LULUCF 2003. All forests fulfilling the definition of forest, as given above, are considered as managed and are under forest management. The total Italian forest area is eligible under *forest management* activity, since the entire Italian forest area has to be considered managed forest lands.

Concerning *deforestation* activities, in Italy land use changes from forest to other land use categories are allowed in very limited circumstances, as stated in art. 4.2 of the Law Decree n. 227 of 2001.

10.1.4 *Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how land was classified*

As Italy has elected only *forest management* under Article 3.4 activities, there is no need to build up a hierarchy between *forest management* and other Article 3.4 activities.

10.2 Land-related information

Italy implements the Reporting Method 1 for lands subject to Article 3.3 and Article 3.4 activities. The reporting area boundaries have been identified with the administrative boundaries of Italian regions (NUTS2 level). These areas include multiple units of land subject to *afforestation/reforestation* and *deforestation* and land areas subject to *forest management*. In the reporting, the same geographical boundaries were used for Article 3.3 and Article 3.4 activities. Approach 2 has been used for representing land areas.

Data for land use and land-use changes were obtained by the National Forest Inventories ((IFN1985 and IFNC2005). IFN1985 was accomplished by means of systematic sampling with a single phase of information gathering on the ground. The sampling points were identified in correspondence to the nodes of a grid with a mesh of 3 km superimposed on the official map of the State on a scale of 1:25.000. Each point therefore represents 900 ha, for a total of 33,500 points distributed within the national territory. IFNC2005 has a three-phase sampling design; the sampling units were 300,000 and were identified in correspondence to the nodes of a grid with a mesh of 1 km superimposed on the official map of the State. A first inventory phase, consisting in interpretation of 1m resolution orthophotos, dated from 2002 to 2003, was followed by ground surveys, in order to assess the forest use, and to detect the main qualitative attributes of Italian forests. The phase 3 has consisted in ground surveys to estimate the values of the main quantitative attributes of forest stands (i.e. volume of growing stock, tree density, annual growth, aboveground biomass, carbon stock, deadwood volume and biomass). The phase 3 is currently elaborating data on soils, gained by 1,500 sampling areas selected in the IFNC2005 original grid.

10.2.1 *Spatial assessment unit used for determining the area of the units of land under Article 3.3*

The spatial assessment unit to determine the area of units of land under Article 3.3 is 0.5 ha, which is the same as the minimum area of forest.

10.2.2 *Methodology used to develop the land transition matrix*

The land transition matrix is shown in Table NIR-2 (Table 10.1). The same data sources are used for the UNFCCC greenhouse gas inventory and for the estimates of emissions and removals under Articles 3.3 and 3.4.

LUC matrices for each year of the period 1990–2011 have been assembled based on time series of national land use statistics for forest lands, croplands, grasslands, wetlands and settlement areas. Annual figures for forest land area, and consequently for *afforestation/reforestation* areas, were estimated on the basis of the forest area increase as detected by the National Forest Inventories. It has been assumed that new forest land area can only come from grassland.

Deforestation data have been derived from administrative records at NUT2 level collected by the National Institute of Statistics. Since the activities planned in the framework of the registry for carbon sinks are still in progress, for the current submission no detailed information was available on the land use of the deforested area; consequently, a conservative approach was applied hypothesising that the total deforested area is converted into settlements. In addition, it should be noted that land use changes due to wildfires are not allowed by national legislation (Law Decree 21 November 2000, n. 353, art.10.1).

Table 10.1 Land transition matrices - Areas and changes in areas between the previous and the current inventory years (2008 – 2009 – 2010 - 2011) [kha]

		2008				
		Art 3.3		Art. 3.4		total (beginning of 2008)
kha		Aff. / Ref.	Deforestation	FM	Other	
Art 3.3	Aff. / Ref.	1,401.04				1,401
	Deforestation		13.00			13
Art. 3.4	FM		0.72	7,359.19		7,360
	Other	78.63			21,281.02	21,360
	Total (end of 2008)	1,480	14	7,359	21,281	30,134

		2009				
		Art 3.3		Art. 3.4		total (beginning of 2009)
kha		Aff. / Ref.	Deforestation	FM	Other	
Art 3.3	Aff. / Ref.	1,479.67				1,480
Art. 3.4	Deforestation		13.72			14
	FM		0.72	7,358.47		7,359
	Other	78.63			21,202.39	21,281
	Total (end of 2009)	1,558	14	7,358	21,202	30,134

		2010				
		Art 3.3		Art. 3.4		total (beginning of 2010)
kha		Aff. / Ref.	Deforestation	FM	Other	
Art 3.3	Aff. / Ref.	1,558.30				1,558
	Deforestation		14.44			14
Art. 3.4	FM		0.72	7,357.74		7,358
	Other	78.63			21,123.76	21,202
	Total (end of 2010)	1,637	15	7,358	21,124	30,134

		2011				
		Art 3.3		Art. 3.4		total (beginning of 2010)
kha		Aff. / Ref.	Deforestation	FM	Other	
Art 3.3	Aff. / Ref.	1,636.93				1,637
	Deforestation		15.17			15
Art. 3.4	FM		0.72	7,357.02		7,358
	Other	79.22			21,044.54	21,124
	Total (end of 2011)	1,716	16	7,357	21,045	30,134

10.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

The Italian regions have been used as the geographical units for reporting (Figure 10.1); boundaries of reporting areas have been identified with the administrative boundaries of Italian regions (NUTS2 level). ID-codes have been assigned following the denomination of the different regions.



Figure 10.1 Geographical locations of the reporting regions and their identification codes

10.3 Activity-specific information

10.3.1 Methods for carbon stock change and GHG emission and removal estimates

10.3.1.1 Description of the methodologies and the underlying assumptions used

Methods for estimating carbon stock changes in forests (for Article 3.3 *afforestation/reforestation* and Article 3.4 *forest management*) are the same as those used for the UNFCCC greenhouse gas inventory: details are given in par. 7.2.4. A growth model, For-est, is used to estimate the net change of carbon in the five reporting pools: aboveground and belowground biomass, dead wood and litter, and soils as soil organic matter. The model has been applied at regional scale (NUTS2); input data for the forest area, per region and inventory typologies, were the First Italian National Forest Inventory (IFN1985) data and the Inventory of Forests and Carbon pools (INFC2005). Additional information on the methodological aspects can be found in Federici et al., 2008; it has to be noted that in the current submission updated activity data have been used, respect the ones reported in the paper, on the basis of the final outcome of the National Forestry Inventory and the national forest definition. Some specific parameters (i.e. biomass expansion factors, wood basic densities for aboveground biomass estimate, root/shoot ratios) used in the estimation process are the same reported in the above-mentioned article; in other cases (i.e. dead wood or litter pools) different coefficients and relations have been used to deduce the carbon stock changes in the pools.

Following the 2011 ERT's recommendation regarding soils pool, Italy has decided to apply the IPCC Tier1, assuming that, for land under Forest Management activities, the carbon stock in soil organic matter does not change, regardless of changes in forest management, types, and disturbance regimes; in other words it has to be assumed that the carbon stock in mineral soil remains constant so long as the land remains forest. Therefore carbon stock changes in soils pool, for land subject to Forest Management, have not been reported,

and transparent and verifiable information that the pool is not a net source for Italy is provided in par. 10.3.1.2.

Furthermore, following the ERT's finding in the 2011 review process, Italy has decided to use the IPCC default land use transition period of 20 years, to estimate carbon stock changes in soils pools for afforestation/reforestation activities under art. 3.3 of the Kyoto Protocol.

In the KP CRF tables changes in carbon stock are reported in terms of gains and losses, for aboveground and belowground biomass, and net carbon stock change for the remaining pools (dead wood, litter, soils).

Concerning carbon stock changes resulting from *deforestation* activities, for the current submission no detailed information was available on the land use of the deforested area, since the activities planned in the framework of the registry for carbon sinks are still in progress; consequently, a conservative approach was applied, hypothesising that the total deforested area is converted into settlements. Carbon stock changes related to the forest land areas, before deforestation activities, have been estimated, for each year and for each pool (living biomass, dead organic matter and soils), on the basis of forest land carbon stocks deduced from the model described in par. 7.2.4. In addition, it should be noted that land use changes due to wildfires are not allowed by national legislation (Law Decree 21 November 2000, n. 353, art.10, comma 1).

The loss, in terms of carbon, due to deforested area is computed assuming that the total amount of carbon, existing in the different pools before deforestation, is lost.

GHG emissions from biomass burning were estimated with the same method as described in par. 7.12.2. CO₂ emissions due to forest fires in areas subject to art. 3.3 and art 3.4 activities have been included in corresponding tables: in particular, CO₂ emissions from biomass burning in land subject to art 3.3 activities are included in Table 5(KP-I)A.1.1, Losses (Aboveground and belowground pools), while CO₂ emissions from burnt areas under *forest management* are included in Table 5(KP-I)B.1, Forest Management, Losses (Aboveground and belowground pools).

10.3.1.2 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

Following the main finding of 2011 review process, Italy has decided not to account for the soil carbon stock changes from activities under Article 3.4, providing transparent and verifiable information to demonstrate that soils pool is not a source in Italy, as required by par. 21 of the annex to decision 16/CMP.1).

Art. 3.4 – Forest Management: demonstration that soils pool is not a source

Carbon stock changes in mineral soils, for *Forest land remaining Forest land* and for land under art. 3.4 (*Forest Management*) activities, have been estimated from the aboveground carbon amount with linear relations ($SOC = f(C_{Aboveground})$), per forestry use – stands (resinous, broadleaves, mixed stands) and coppices, calculated on data collected within the European project BioSoil⁵¹ (for soils) and a Life+ project FutMon⁵² (*Further Development and Implementation of an EU-level Forest Monitoring System*), for the aboveground biomass. Soil carbon stocks of mineral soils were assessed down to 40 cm with layer-based sampling (0-10, 10-20, 20-40 cm) on 227 forest plots on a 15x18 km grid. Data have been calculated layer by layer by using measured data of layer depth and soil carbon concentration (704 values), bulk density (543 measured data, 163 estimated data in the field or using pedofunctions) and volume of coarse fragment (704 values estimated in the field). BioSoil assessed also OF and OH layer in which organic material is in various states of decomposition (down to humus). Those layers were included in the estimation of carbon stocks in mineral soils.

In Table 10.2 the different relations used to obtain soil carbon amount per ha [t C ha⁻¹] from the aboveground carbon amount per ha [t C ha⁻¹] have been reported.

⁵¹ BioSoil project – http://www3.corpoforestale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/487/UT/systemPrint;http://www.inbo.be/content/page.asp?pid=EN_MON_FSCC_condition_report

⁵² FutMon: Life+ project for the "Further Development and Implementation of an EU-level Forest Monitoring System"; <http://www.futmon.org;>
<http://www3.corpoforestale.it/flex/cm/pages/ServeAttachment.php/L/IT/D/D.e54313ecaf7ae893e249/P/BLOB%3AID%3D397>

Table 10.2 Relations soil - aboveground carbon per ha

	Inventory typology	Relation soil – aboveground C per ha	R²	Standard error
<i>stands</i>	norway spruce	$y = 0.2218x + 73.005$	0.0713	40.14
	silver fir	$y = 0.2218x + 73.005$	0.0713	40.14
	larches	$y = 0.2218x + 73.005$	0.0713	40.14
	mountain pines	$y = 0.2218x + 73.005$	0.0713	40.14
	mediterranean pines	$y = 0.2218x + 73.005$	0.0713	40.14
	other conifers	$y = 0.2218x + 73.005$	0.0713	40.14
	european beech	$y = 0.2502x + 79.115$	0.0925	44.10
	turkey oak	$y = 0.2502x + 79.115$	0.0925	44.10
	other oaks	$y = 0.2502x + 79.115$	0.0925	44.10
	other broadleaves	$y = 0.2502x + 79.115$	0.0925	44.10
<i>coppices</i>	european beech	$y = 0.2683x + 70.208$	0.073	33.39
	sweet chestnut	$y = 0.2683x + 70.208$	0.073	33.39
	hornbeams	$y = 0.2683x + 70.208$	0.073	33.39
	other oaks	$y = 0.2683x + 70.208$	0.073	33.39
	turkey oak	$y = 0.2683x + 70.208$	0.073	33.39
	evergreen oaks	$y = 0.2683x + 70.208$	0.073	33.39
	other broadleaves	$y = 0.2683x + 70.208$	0.073	33.39
	conifers	$y = 0.2218x + 73.005$	0.0713	40.14
<i>protective</i>	rupicolous forest	$y = 0.3262x + 68.648$	0.1338	38.96
	riparian forest	$y = 0.3262x + 68.648$	0.1338	38.96

Linear relationships resulted in different trends for the different forest inventory typologies. In the following Table 10.3 the Soil Organic Content (SOC) per hectare, inferred by the use of the linear relationships, is shown for the different inventory typologies and different years.

Table 10.3 Soil Organic Content (SOC) per hectare, for the different inventory typologies

	Inventory typology	1990	1995	2000	2005	2010
		<i>t C ha⁻¹</i>	<i>t C ha⁻¹</i>	<i>t C ha⁻¹</i>	<i>t C ha⁻¹</i>	<i>t C ha⁻¹</i>
<i>stands</i>	norway spruce	86.19	85.57	84.99	84.62	84.20
	silver fir	88.02	86.99	86.02	85.71	85.45
	larches	84.42	83.72	83.09	82.90	82.73
	mountain pines	84.47	85.34	86.06	87.13	87.98
	mediterranean pines	83.87	85.62	87.08	88.77	89.90
	other conifers	80.48	81.25	81.88	82.75	83.51
	european beech	99.94	99.68	99.54	99.84	99.91
	turkey oak	95.74	96.02	96.28	96.92	97.22
	other oaks	89.83	90.17	90.52	91.29	91.70
	other broadleaves	90.54	90.62	90.62	91.18	91.53
<i>coppices</i>	european beech	84.02	83.54	83.14	83.10	83.20
	sweet chestnut	84.94	88.08	90.65	93.38	95.96
	hornbeams	76.78	76.42	76.15	76.05	76.03
	other oaks	75.85	76.29	76.54	76.78	76.96
	turkey oak	79.74	79.19	78.74	78.49	78.37
	evergreen oaks	80.19	79.99	79.81	79.81	79.81
	other broadleaves	79.11	80.80	82.15	83.48	84.52
	conifers	80.42	80.85	81.25	81.86	82.45
<i>protective</i>	rupicolous forest	77.30	77.82	78.33	78.97	79.48
	riparian forest	84.53	83.93	83.47	83.19	83.00

Table 10.4 Carbon stock changes in mineral soils (Soil Organic Matter (SOM) pool)

Inventory typology	1990	1995	2000	2005	2010
	<i>Gg C</i>	<i>Gg C</i>	<i>Gg C</i>	<i>Gg C</i>	<i>Gg C</i>
stands	2,075	2,476	2,296	2,624	2,552
coppices	3,632	4,003	3,832	3,977	4,122
rupicolous and riparian forests	608	690	665	696	700
Total	6,314	7,170	6,793	7,297	7,375

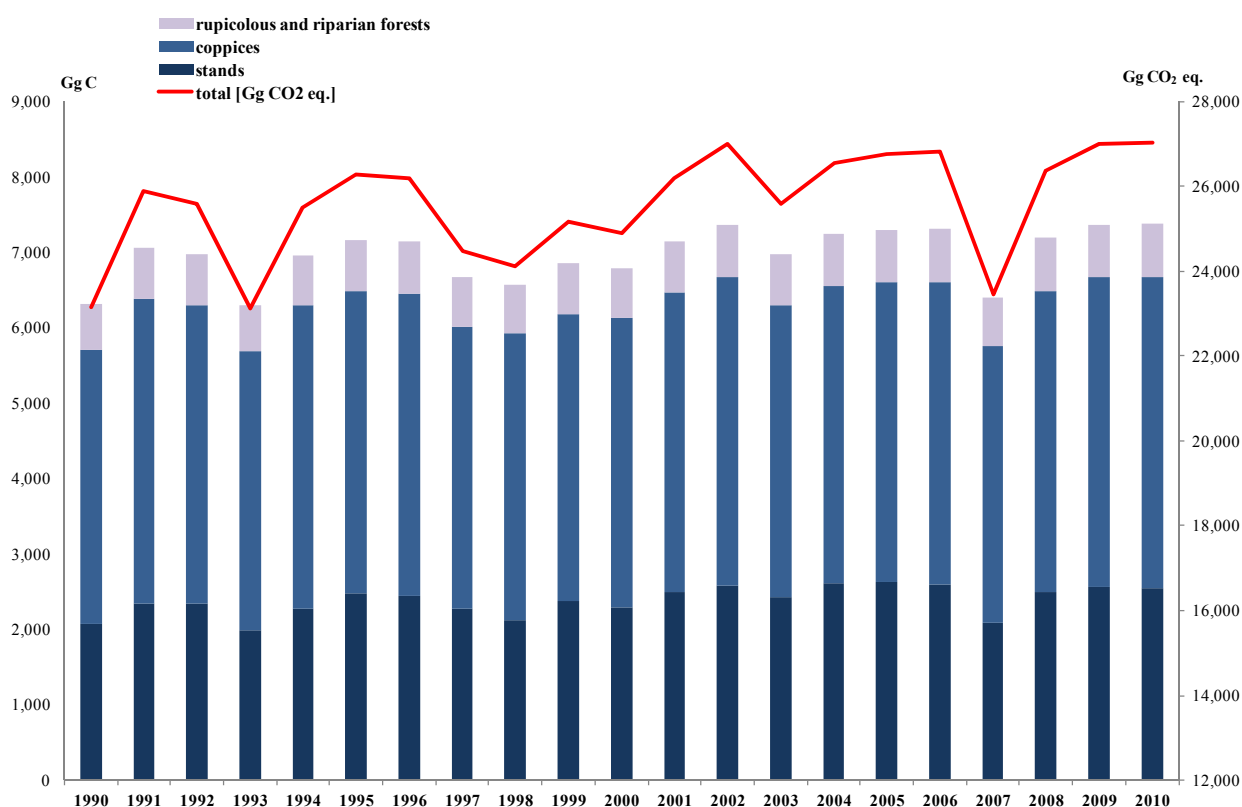


Figure 10.2 Carbon stock changes in mineral soils in the period 1990-2010 (SOM pool)

A comparison of the model results versus data measured in the framework of Italian National Forest Inventory (INFC) may be carried out on the basis of the outcomes of the soil survey of INFC. In the following Table 10.5 estimated carbon stocks for SOM and litter, for 2008, are provided:

Table 10.5 Comparison between estimated and INFC 2008 carbon stocks for SOM and litter

2008	INFC	For-est model	differences	
	<i>t C= Mg</i>	<i>t C= Mg</i>	<i>t C= Mg</i>	%
SOM	703,524,894	730,243,364	26,718,469	-3.80
litter	28,170,660	30,016,553	1,845,893	-6.55

In the 2011 submission, Montecarlo analysis has been carried out for the CO₂ emissions and removals from Forest Land remaining Forest Land, considering the different reporting pools (aboveground, belowground, litter, deadwood and soils), and the subcategories stands, coppices and rupicolous and riparian forests for the reporting year 2009, resulting equal to 49%. In the following Table 10.6, the results of the uncertainty assessment for soils pool are reported:

Table 10.6 Montecarlo uncertainty assessment for soils pool

Uncertainties for the different subcategories, year 2010	
	<i>soils</i>
stands	44.65
coppices	67.35
rupicolous and riparian forests	58.52
total	49.33

Table 5(KP-I)A.1.3 Article 3.3 activities: Afforestation and Reforestation. Units of land otherwise subject to elected activities under Article 3.4 (information item)

According to the fact that all Italian forests are managed, the whole area subject to *afforestation/reforestation* should be reported here since otherwise subject to *forest management*.

Table 5(KP-I)A.2.1 Article 3.3 activities: Deforestation. Units of land otherwise subject to elected activities under Article 3.4 (information item)

Only *forest management* has been elected under Article 3.4. As *Deforestation* is a permanent loss of forest cover, any unit of land that has been deforested under Article 3.3 cannot also be subject to *forest management* under Article 3.4.

Table 5(KP-II)1. Direct N₂O emissions from N fertilization

No N fertilization is applied to Italian forests, so emissions are reported as not occurring.

Table 5(KP-II)2. N₂O emissions from drainage of soils

Reporting of these emissions is not mandatory so no estimates are made. There is no activity data on the extent of drainage under *forest management* areas but this is currently under investigation.

Table 5(KP-II)3. N₂O emissions from disturbance associated with land use conversion to cropland.

Deforestation to Cropland has been supposed as not occurring in Italy, as total deforested area was assumed in transition into settlements. New data will become available in 2012, from the activities planned in the framework of the registry for carbon sinks; this will enable this assumption to be re-examined and new estimates to be produced if necessary.

Table 5(KP-II)4. Carbon emissions from lime application

No lime is applied to Italian forests, so emissions are reported as not occurring. This is consistent with UNFCCC reporting, where all liming is assumed to occur in Cropland remaining Cropland.

10.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

Italy has not factored out removals from elevated carbon dioxide concentrations, indirect nitrogen deposition or the dynamic effects of age structure resulting from activities prior to 1 January 1990, considering also that GPG do not give methods for factoring out. For the first commitment period, the effect of indirect and natural removals will be considered through the cap under Article 3.4 credits from *forest management*. For Italy the cap is 2.78 Mt C per year.

10.3.1.4 Changes in data and methods since the previous submission (recalculations)

Recalculations of emissions and removals have been carried out on the basis of the IPCC Good Practice Guidance for LULUCF (IPCC, 2003).

Concerning the ARD activities under art. 3.3 of the Kyoto Protocol, the main driver for the deviations from the previous sectoral estimates is the update of the coefficients used to estimate the carbon stock changes in the deadwood pool; the remaining deviations are resulting from the detection and correction of computation errors and from updating of activity data. With reference to the ARD activities, the 2013 submission results in an average decrease of 4.43%, for the Afforestation/Reforestation activities, and an average increase equal to 3.45% for Deforestation activities, respect the previous submission. Deviations are occurring, in the comparison of the current submission with the previous one for all pools: aboveground (average decrease of 6.77% for AR activities), belowground (average decrease of 7.16% for AR activities) and deadwood pool (average decrease of 151.62% for AR and of 72.32% for D activities). Remarkable deviations are occurring in the litter pool, resulting from the detection and correction of computation errors, while negligible differences are notable for the soils pool. In Table 10.7 deviations, related to the ARD activities, resulting from the comparison of the 2013 submission against the previous submission are reported.

Table 10.7 Deviations for ARD activities resulting from the comparison of the 2013 submission against 2012 submission

<i>pools</i>	1990-2008		1990-2009		1990-2010	
	AR %	D %	AR %	D %	AR %	D %
<i>aboveground</i>	-1.01	-	-4.21	-	-15.08	-0.06
<i>belowground</i>	-2.67	-	-8.84	-	-9.98	-0.05
<i>litter</i>	-1,627.84	-	-1,748.81	-	-1,932.32	-0.02
<i>deadwood</i>	-149.04	72.10	-138.60	72.32	-167.23	72.55
<i>soils</i>	-0.02	-	-0.02	-	-0.02	-0.01
total	-5.09	3.44	-8.21	3.46	-	3.45

With reference to forest management, the 2013 submission results in an average increase of 16.59% respect the previous submission. Slight deviations are noticeable respect the previous submission for aboveground biomass pool (average increase of 1.00% for aboveground), while an average decrease of 10.77% results for belowground; and an average increase of 10.26% for litter pool. Remarkable deviations affected the deadwood pool (average increase of 92.50%) resulting from the detection and correction of computation errors and from updating of activity data, as the update of the coefficients used to estimate the carbon stock changes in the deadwood pool. In Table 10.8 the deviations for Forest Management activities, resulting from the comparison of the 2013 submission against the previous submission are reported.

Table 10.8 Deviations for FM activities resulting from the comparison of the 2013 submission against 2012 submission

<i>pools</i>	2008 %	2009 %	2010 %
<i>aboveground</i>	1.07	3.08	-1.14
<i>belowground</i>	1.22	2.70	-36.23
<i>litter</i>	54.22	6.54	-29.97
<i>deadwood</i>	94.63	88.63	94.25
total	24.04	12.18	13.55

10.3.1.5 Uncertainty estimates

It was assumed that uncertainty estimates for forest land also apply for lands under FM (par. 7.2.5). The uncertainties related to the different pools are reported, for 2011, in Table 10.9.

Table 10.9 Uncertainties for the year 2011

<i>Aboveground biomass</i>	E _{AG}	79.82%
<i>Belowground biomass</i>	E _{BG}	79.82%
<i>Dead mass</i>	E _D	85.27%
<i>Litter</i>	E _L	101.62%
<i>Soil</i>	E _S	113.00%
<i>Overall uncertainty</i>	E ₂₀₁₀	70.44%

The uncertainties for Article 3.3 activities estimates are expected to be higher. It can be assumed that the given uncertainty analysis in table 10.2 covers the uncertainty of all gains and all losses in living tree biomass under FM and ARD. The Montecarlo analysis has been implemented for the LULUCF sector with particular focus on Forest land category. Detailed description can be found in Annex 1.

10.3.1.6 Information on other methodological issues

Italy has decided to account for the emissions and removals under Article 3 paragraphs 3 and 4 at the end of the commitment period. Activities planned in the framework of the registry for carbon sinks are still in progress, therefore methodologies for area changes detection and the related uncertainties will be further developed. The inventory of land use (IUTI, see Annex 10) has been completed, resulting in land use

classification, for all national territory, for the years 1990, 2000 and 2008 (Corona et al., 2012, Marchetti et al., 2012). A process of validation and verification of IUTI data is currently ongoing and is going to supply data useful to update and improve the estimations. Data on the last phase of national forest inventory, covering litter, deadwood and soils pools, at NUT2 level, have been released in 2012; deadwood coefficients were used in the estimation process of deadwood biomass, on regional basis. Research studies are currently in place to figure out the proper use of the INFC latest outcomes, in order to estimate and report emissions and removals from litter and soils pools with a lower uncertainty.

On these bases, estimates presented in the current submission for 2011 may change for the final report of the commitment period.

10.3.1.7 The year of the onset of an activity, if after 2008

For the ARD activities (Art. 3.3) Italy reports all the area subject to these activities since 1990 (that has to be considered the starting year of the ARD activities). Furthermore, for each reporting year of the commitment period, the area that annually is added to each of art. 3.3 activities has been reported in table NIR-2, for the relevant year.

Concerning Forest Management (Art. 3.4) Italy considers the entire national territory as managed, i.e. subject to human activities, consequently the entire national forest area is subject to human activities that, by-law, are aimed at sustainably manage the forest. Therefore, as described in par. 10.1.3, the whole set of human activities, implemented in forest, are part of the *forest management* activities under art. 3.4 and those activities were already in place before the starting of first commitment period of the Kyoto Protocol.

10.4 Article 3.3

Italy reports all emissions by sources and removals by sinks from the AR activities in the table 5(KP-I)A.1.1 - Afforestation/Reforestation: units of land not harvested. Italy has interpreted harvesting as clear cutting done on short rotation forests, coherently with statements reported in the par. 4.2.5.3.2 of IPCC GPG LULUCF 2003.

10.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced

Changes in forest area were detected on the basis of national forest inventories data.

The following *afforestation/reforestation* activities that occurred or could have occurred on or after 1990 (Table 10.10) are included in the reporting of these activities:

- Planted or seeded croplands;
- Planted or seeded grasslands;
- Abandoned arable lands which are naturally forested

In Italy all land use categories (cropland, grazing land, forest) are to be considered managed; therefore any land use change occurs between managed lands and, consequently, is direct human-induced.

Afforested/reforested areas are to be considered legally bound by national legislation⁵³. Usually these activities have resulted from a decision to change the land use by planting or seeding. Abandoned arable lands are left to forest naturally.

On the basis of the definitions provided in the Decision 16/CMP.1⁵⁴, natural afforestation and reforestation occurred on abandoned agricultural lands have to be included in the art. 3.3: a frequent forest management strategy, in Italy, consists, in fact, in the exploitation of natural re-growth caused, for instance, by the seed of adjacent trees. In addition the national legislation provides some references to the management strategy of

⁵³ In particular: Law Decree n. 227/2001; Law n. 353/2000; Law 1497/1939; Law Decree n. 3267/1923; 985, Law n. 431

⁵⁴ "Afforestation" is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources; "Reforestation" is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989.

abandoned lands: Law Decree n. 3267/1923 updated in 1999, (art.39 and art. 75), has planned afforestation and reforestation activities on areas for protection purposes (in particular hydro-geological purposes), explicitly forbidding clear cut or clearing on areas undergo under afforestation or reforestation activities (art. 51). Therefore the provision to avoid clear cut activities is a direct consequence of current legislation, as it provides strict constraints for different re-uses of agricultural lands. The same decree (art. 90 and 91) furthermore subsidized land owners to naturally regenerate forest on bare lands or on grasslands. Other (Law Decree 227/2001 Law 353/2000, Law 431/1985), even though focused on specific issues as forest fires and to the protection of nature and landscape are coherent with the previous decrees and complete the legislative framework on the issue; for example, for burnt areas no land use change is allowed and for forest areas, natural restoration of previous ecosystem occurs. In addition afforestation and reforestation activities are essentially linked to political decisions under the EEC Regulations 2080/92 and 1257/99 (art.10.1 and 31.1), therefore induced by man. In particular articles 10.1 and 31.1 of the EEC Regulations 1257/99 (Council Regulation (EC) No 1257/1999 of 17 May 1999 on support for rural development from the European Agricultural Guidance and Guarantee Fund (EAGGF)) refer directly to the provision of income for elderly farmers who decide to stop farming and to the support granted for the afforestation of agricultural land.

Table 10.10 Area estimates for 1990, 2008, 2009 2010 and cumulative for 1990-2008, 1990-2009, 1990-2010 and 1990-2011 (kha) under Article 3.3 activities Afforestation/Reforestation.

Afforestation /Reforestation	1990-2008	1990-2009	1990-2010	1990-2011
	<i>kha</i>			
Abruzzo	61.6	65.1	68.7	72.3
Basilicata	46.9	49.4	51.8	54.3
Calabria	82.0	85.9	89.8	93.8
Campania	62.9	66.3	69.7	73.1
Emilia-Romagna	93.7	99.1	104.5	109.9
Friuli-Venezia Giulia	58.7	61.9	65.1	68.3
Lazio	91.4	96.5	101.6	106.8
Liguria	55.0	57.5	59.8	62.2
Lombardia	100.5	105.6	110.7	115.8
Marche	49.6	52.5	55.4	58.3
Molise	21.1	22.2	23.2	24.3
Piemonte	146.5	154.7	162.9	171.1
Puglia	24.9	26.2	27.5	28.9
Sardegna	85.8	90.5	95.2	99.9
Sicilia	47.1	49.7	52.3	54.9
Toscana	176.8	185.9	195.0	204.1
Trentino Alto Adige	127.3	133.7	140.2	146.6
<i>Bolzano-Bozen</i>	<i>60.6</i>	<i>63.8</i>	<i>66.9</i>	<i>70.1</i>
<i>Trento</i>	<i>66.6</i>	<i>70.0</i>	<i>73.3</i>	<i>76.6</i>
Umbria	61.2	64.4	67.5	70.6
Valle d'Aosta	17.5	18.4	19.4	20.3
Veneto	69.1	72.9	76.7	80.6
Italia	1,479.7	1,558.3	1,636.9	1,716.2

Concerning *deforestation* activities, as mentioned above, in Italy land use changes from forest to other land use categories are allowed in very limited circumstances, as stated in art. 4.2 of the Law Decree n. 227 of 2001.

As for current submission no detailed information was available on the land use of the deforested area, a conservative approach was followed, hypothesising that the total deforested area is converted into settlements.

10.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

Extensive forest disturbances have been rare in Italy, except for wildfires. Land-use changes after damage do not occur; concerning wildfires, national legislation (Law n. 353 of 2000, art.10.1) doesn't allow any land use change after a fire event for 15 years.

Harvesting is regulated through regional rules, which establish procedures to follow in case of harvesting. Although different rules exist at regional level, a common denominator is the requirement of an explicit written communication with the localization and the extent of area to be harvested, existing forest typologies and forestry treatment. *Deforestation* is allowed only in very limited circumstances (i.e. in construction of railways the last years) and has to follow several administrative steps before being legally permitted. In addition, clear-cutting is a not allowed practice (Law Decree n. 227 of 2001, art. 6.2).

10.4.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

Restocking is assumed for forest areas that have lost forest cover through harvesting or forest disturbance, unless there is *deforestation* as described above. As such, information on the size and location of forest areas that have lost forest cover is not explicitly collected on an annual basis.

10.5 Article 3.4

10.5.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

Forests in 1 January 1990 were under *forest management*, since Italy considers all forest land managed, and, therefore, human-induced.

10.5.2 Information relating to Forest Management

Italian forest resources are totally legally bound; the two main constraints, provided by the laws n. 3267 of 1923 and n. 431 of 1985, compel private and public owners to strictly respect limitations concerning the use of their forest resources. As a matter of fact, each exploitation of forest resources must not compromise their perpetuation and therefore, any change of land use, for hydro-geological, landscape and environmental protection in general (the same limitations apply also to burnt areas, following the law n. 353 on forest fires approved in 2000). Consequently unplanned cuttings are always forbidden and local prescriptions fix strict rules to be observed for forestry.

10.6 Other information

10.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

Key category analysis for KP-LULUCF was performed according to section 5.4 of the IPCC GPG for LULUCF (IPCC, 2003).

CO₂ emissions and removals from *forest management* (art. 3.4) and from *Afforestation/Reforestation* activities (art. 3.3) have been assessed as key category, in accordance with the IPCC good practice guidance for LULUCF section 5.4.4. The figures have been compared with Table 1.6 Key categories for the latest reported year (2011) based on level of emissions (including LULUCF).

Article 3.3 Afforestation and reforestation (CO₂): CO₂ emissions and removals from the associated UNFCCC subcategory *land converting to forest land* have been identified as key category, at level and trend assessment. Therefore AR is stated to be a key category.

Article 3.4 Forest management (CO₂): The associated UNFCCC subcategory *Forest land remaining Forest land* is a key category in level and in trend assessment (Approach 1). The *forest management* category contribution is also greater than other categories in the UNFCCC key category.

10.7 Information relating to Article 6

Italy is not participating in any project under Article 6 (Joint Implementation).

11 Information on accounting of Kyoto units

11.1 Background information

The Standard Electronic Format report for 2012, containing the information required in paragraph 11 of the annex to decision 15/CMP.1 and adhering to the SEF guidelines, has been submitted to the UNFCCC Secretariat electronically (SEF_IT_2013_2_17-53-13 11-4-2013).

The report contains information on unit holdings in the Italian registry at the beginning and at the end of the reporting year as well as on transfers of units in 2012 to and from other Parties of the Kyoto Protocol. The contents of the report (Report R1) can also be found in Annex 8 of this document.

11.2 Summary of information reported in the SEF tables

At the beginning of 2012 the holdings in the Italian registry per unit type were as follow:

- a total of 2,383,241,381 AAUs: 1,602,189,698 in the party holding accounts, 213,293,289 in the entity holding accounts and 567,758,394 in the retirement account;
- a total of 2,857,200 ERUs: 2,105,194 in the entity holding accounts and 752,006 in the retirement account;
- a total of 52,430,414 CERs: 23,852,661 in the entity holding accounts and 28,577,753 in the retirement account.

At the end of 2012 the holdings in the Italian registry per unit type were as follow:

- a total of 2,378,523,048 AAUs: 1,638,291,168 in the party holding accounts, 1,970,000 in the entity holding accounts and 738,261,880 in the retirement account;
- a total of 10,711,761 ERUs: 15,815 in the party holding accounts, 5,134,484 in the entity holding accounts and 5,561,462 in the retirement account;
- a total of 57,300,900 CERs: 83,759 in the party holding accounts, 13,845,427 in the entity holding accounts and 43,371,714 in the retirement account;
- a total of 54,670 tCERs in the entity holding accounts.

During 2012 the Italian registry received in all 69,449,448 units: 27,102,731 AAUs, 10,487,305 ERUs, 31,804,742 CERs and 54,670 tCERs.

Conversely, 61,388,064 units were externally transferred to other national registries: 31,821,064 AAUs, 2,632,744 ERUs and 26,934,256 CERs.

There were no transactions of any kind involving RMUs or ICERs.

At the end of 2012 no RMUs or I-CERs were held in the Italian registry and the total amount of units corresponded to 2,446,590,379 tonnes CO₂ eq. while Italy's assigned amount is 2,416,277,898 tonnes CO₂ eq.

Full details are available in the SEF tables reported in Annex 8.

11.3 Discrepancies and notifications

During the reported period (1st January 2012 - 31st December 2012) no discrepant transactions, no CDM notifications and no non-replacements occurred.

No invalid units existed as at 31 December 2012.

11.4 Publicly accessible information

Non-confidential information required by Decision 13/CMP.1 annex II.E paragraphs 44-48, is publicly accessible at the following link <http://www.info-ets.isprambiente.it>

All required information is provided with the following exceptions:

- paragraph 45(e): representative name and contact information is deemed as confidential according to Annex XVI of the EU Registry Regulation No 916/2007/EC;
- paragraph 46: no Article 6 (Joint Implementation) project is reported as conversion to an ERU under an Article 6 project did not occur in the specified period;
- paragraph 47(a)(d)(f): holding and transaction information is provided on an account type level, due to more detailed information being declared confidential by article 75 of EC Regulation 920/2010 as amended by EC Regulation 1193/2011.

11.5 Calculation of the commitment period reserve (CPR)

The commitment period reserve for Italy is 2,174,650,108 tonnes of CO₂ equivalent (or assigned amount units). The CPR is based on the assigned amount and has not changed from the previous submission.

11.6 KP-LULUCF accounting

Italy has decided to account for Article 3.3 and 3.4 LULUCF activities at the end of the commitment period, therefore no information on KP-LULUCF accounting is included in the SEF tables.

In Table 11, information on accounting for the KP-LULUCF activities based on the reporting for the year 2008, 2009, 2010 and 2011 are given.

Table 11.1 Information table on accounting for activities under art. 3.3 and 3.4 of the Kyoto Protocol, for 2008, 2009, 2010 and 2011

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Net emissions/removals ⁽¹⁾					Accounting Parameters ⁽⁷⁾	Accounting Quantity ⁽⁸⁾
	2008	2009	2010	2011	Total ⁽⁶⁾		
A. Article 3.3 activities							
A.1. Afforestation and Reforestation							-27,888
A.1.1. Units of land not harvested since the beginning of the commitment period ⁽²⁾	-6,390	-7,218	-7,817	-6,463	-27,888		-27,888
A.1.2. Units of land harvested since the beginning of the commitment period ⁽²⁾							
A.2. Deforestation	375	377	379	380	1,511		1,511
B. Article 3.4 activities							
B.1. Forest Management	-27,944	-30,245	-31,304	-23,977	-113,470		-50,967
3.3 offset ⁽³⁾						0	0
FM cap ⁽⁴⁾						50,967	-50,967

(1) All values are reported in table 5(KP) of the CRF for the relevant inventory year as reported in the current submission and are automatically entered in this table.

(2) In accordance with paragraph 4 of the annex to decision 16/CMP.1, debits resulting from harvesting during the first commitment period following Afforestation and Reforestation since 1990 shall not be greater than credits accounted for on that unit of land.

(3) In accordance with paragraph 10 of the annex to decision 16/CMP.1, for the first commitment period, a Party included in Annex I that incurs a net source of emissions under the provisions of Article 3.3 may account for anthropogenic greenhouse gas emissions by sources and removals by sinks in areas under Forest Management under Article 3.4, up to a level that is equal to the net source of emissions under the provisions of Article 3.3, but not greater than 9.0 megatonnes of carbon times five, if the total anthropogenic

greenhouse gas emissions by sources and removals by sinks in the managed forest since 1990 is equal to, or larger than, the net source of emissions incurred under Article 3.3.

(4) In accordance with paragraph 11 of the annex to decision 16/CMP.1, for the first commitment period only, additions to and subtractions from the assigned amount of a Party resulting from Forest Management under Article 3.4, after the application of paragraph 10 of the annex to decision 16/CMP.1 and resulting from Forest Management project activities undertaken under Article 6, shall not exceed the value inscribed in the appendix of the annex to decision 16/CMP.1, times five.

(5) Net emissions and removals in the Party's base year, as established by decision 9/CP.2.

(6) Cumulative net emissions and removals for all years of the commitment period reported in the current submission.

(7) The values in the cells "3.3 offset" and "FM cap" are absolute values.

(8) The accounting quantity is the total quantity of units to be added to or subtracted from a Party's assigned amount for a particular activity in accordance with the provisions of Article 7.4 of the Kyoto Protocol.

12 Information on changes in national system

No changes with respect to last year submission occurred in the Italian National System.

13 Information on changes in national registry

13.1 Previous Review Recommendations

The SIAR Report for Italy from last year reported no recommendations.

13.2 Changes to National Registry

Directive 2009/29/EC adopted in 2009, provides for the centralization of the EU ETS operations into a single European Union registry operated by the European Commission as well as for the inclusion of the aviation sector. At the same time, and with a view to increasing efficiency in the operations of their respective national registries, the EU Member States who are also Parties to the Kyoto Protocol (25) plus Iceland, Liechtenstein and Norway decided to operate their registries in a consolidated manner in accordance with all relevant decisions applicable to the establishment of Party registries - in particular Decision 13/CMP.1 and decision 24/CP.8.

With a view to complying with the new requirements of Commission Regulation 920/2010 and Commission Regulation 1193/2011, in addition to implementing the platform shared by the consolidating Parties, the registry of EU has undergone a major re-development. The consolidated platform which implements the national registries in a consolidated manner (including the registry of EU) is called Consolidated System of EU registries (CSEUR) and was developed together with the new EU registry on the basis the following modalities:

1. Each Party retains its organization designated as its registry administrator to maintain the national registry of that Party and remains responsible for all the obligations of Parties that are to be fulfilled through registries;
2. Each Kyoto unit issued by the Parties in such a consolidated system is issued by one of the constituent Parties and continues to carry the Party of origin identifier in its unique serial number;
3. Each Party retains its own set of national accounts as required by paragraph 21 of the Annex to Decision 15/CMP.1. Each account within a national registry keeps a unique account number comprising the identifier of the Party and a unique number within the Party where the account is maintained;
4. Kyoto transactions continue to be forwarded to and checked by the UNFCCC Independent Transaction Log (ITL), which remains responsible for verifying the accuracy and validity of those transactions;
5. The transaction log and registries continue to reconcile their data with each other in order to ensure data consistency and facilitate the automated checks of the ITL;
6. The requirements of paragraphs 44 to 48 of the Annex to Decision 13/CMP.1 concerning making non-confidential information accessible to the public would be fulfilled by each Party individually;
7. All registries reside on a consolidated IT platform sharing the same infrastructure technologies. The chosen architecture implements modalities to ensure that the consolidated national registries are uniquely identifiable, protected and distinguishable from each other, notably:

With regards to the data exchange, each national registry connects to the ITL directly and establishes a distinct and secure communication link through a consolidated communication channel (VPN tunnel);

The ITL remains responsible for authenticating the national registries and takes the full and final record of all transactions involving Kyoto units and other administrative processes such that those actions cannot be disputed or repudiated;

With regards to the data storage, the consolidated platform continues to guarantee that data is kept confidential and protected against unauthorized manipulation;

The data storage architecture also ensures that the data pertaining to a national registry are distinguishable and uniquely identifiable from the data pertaining to other consolidated national registries;

In addition, each consolidated national registry keeps a distinct user access entry point (URL) and a distinct set of authorisation and configuration rules.

Following the successful implementation of the CSEUR platform, the 28 national registries concerned were re-certified in June 2012 and switched over to their new national registry on 20 June 2012. During the go-live process, all relevant transaction and holdings data were migrated to the CSEUR platform and the individual connections to and from the ITL were re-established for each Party.

The following changes to the national registry of Italy have therefore occurred in 2012, as a consequence of the transition to the CSEUR platform:

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	No changes in the name or contact information of the registry administrator occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	<p>The EU Member States who are also Parties to the Kyoto Protocol (25) plus Iceland, Liechtenstein and Norway have decided to operate their registries in a consolidated manner. The Consolidated System of EU registries was certified on 1 June 2012 and went to production on 20 June 2012.</p> <p>A complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. This description includes:</p> <ul style="list-style-type: none"> • Readiness questionnaire • Application logging • Change management procedure • Disaster recovery • Manual Intervention • Operational Plan • Roles and responsibilities • Security Plan • Time Validation Plan • Version change Management <p>The documents above are provided as an appendix to this document.</p> <p>A new central service desk was also set up to support the registry administrators of the consolidated system. The new service desk acts as 2nd level of support to the local support provided by the Parties. It also plays a key communication role with the ITL Service Desk with regards notably to connectivity or reconciliation issues.</p>
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	<p>In 2012, the EU registry has undergone a major redevelopment with a view to comply with the new requirements of Commission Regulation 920/2010 and Commission Regulation 1193/2011 in addition to implementing the Consolidated System of EU registries (CSEUR).</p> <p>The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission.</p> <p>During certification, the consolidated registry was notably subject to connectivity testing, connectivity reliability testing, distinctness testing and interoperability testing to demonstrate capacity and conformance to the Data Exchange Standard (DES). All tests were executed successfully and lead to successful certification on 1 June 2012.</p>
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	<p>The overall change to a Consolidated System of EU Registries triggered changes to the registry software and required new conformance testing. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission.</p> <p>During certification, the consolidated registry was notably subject to connectivity testing, connectivity reliability testing, distinctness testing and interoperability testing to demonstrate capacity and conformance to the DES. All tests were executed successfully and lead to successful certification on 1 June 2012.</p>

15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	The overall change to a Consolidated System of EU Registries also triggered changes to discrepancies procedures, as reflected in the updated manual intervention document and the operational plan . The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	The overall change to a Consolidated System of EU Registries also triggered changes to security, as reflected in the updated security plan . The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No changes to the list of publicly available information occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	The new internet address of the Italian registry is: https://ets-registry.webgate.ec.europa.eu/euregistry/IT/index.xhtml The new internet address of the support portal is: http://www.info-ets.isprambiente.it
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	The overall change to a Consolidated System of EU Registries also triggered changes to data integrity measures, as reflected in the updated disaster recovery plan . The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	On 2 October 2012 a new software release (called V4) including functionalities enabling the auctioning of phase 3 and aviation allowances, a new EU ETS account type (trading account) and a trusted account list went into Production. The trusted account list adds to the set of security measures available in the CSEUR. This measure prevents any transfer from a holding account to an account that is not trusted.
The previous Annual Review recommendations	No recommendations from previous year are reported.

14 Information on minimization of adverse impacts in accordance with Article 3, paragraph 14

14.1 Overview

In the framework of the EU Burden Sharing Agreement, Italy has committed to reduce its GHG emissions by 6.5% below base-year levels (1990) over the first commitment period, 2008-2012. After the review of the initial report of Italy under the Kyoto Protocol (KP), the Kyoto objective was fixed in 483.255 MtCO₂ per year for each year of the “commitment period” (UNFCCC, 2007; MATTM, 2009).

In this section Italy provides an overview of its commitments under Article 3.1, and specifically how it is striving to implement individually its commitment under Article 3 paragraph 14 of the KP. Under Article 3.14 of the KP:

“Each Party included in Annex I shall strive to implement the commitments mentioned in paragraph 1⁵⁵ above in such a way as to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9⁵⁶, of the Convention. In line with relevant decisions of the Conference of the Parties on the implementation of those paragraphs, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session, consider what actions are necessary to minimize the adverse effects of climate change and/or the impacts of response measures on Parties referred to in those paragraphs. Among the issues to be considered shall be the establishment of funding, insurance and transfer of technology.

For the preparation of this chapter ISPRA has collected information through the revision of peer review international articles on sustainable development (SD) of ex-ante/ex-post assessments related to activities on climate change mitigation, and through personal communication with people/institutions involved in project/programs/policy implementation of climate change activities. Moreover, experts from the Ministry for the Environment, Land and Sea (*Ministero dell'Ambiente e della Tutela del Territorio e del Mare*, MATTM) and the Directorate General for Development Co-operation (DGCS) from the Ministry of Foreign Affairs (*Ministero degli Affari Esteri*, MAE) were contacted. This chapter has been updated with new information according to the on-going activities at national and international level.

As the reporting obligation related to Article 3, paragraph 14 does not include an obligation to report on each specific mitigation policy. Italy briefly describes how EU is striving to minimize adverse impacts, because Italy is member of the European Union, thus incorporated into its European legal system to implement directives/policies; and individually how is striving to implement Article 3.14 with specific examples.

Two main parts are requested under Article 3.14 for reporting purposes: commitments to minimize adverse effects (section 14.2, 14.3) and priority actions (section 14.4, 14.5). Future improvements/research activities are expected for next submissions (section 14.6).

14.2 European Commitment under Art 3.14 of the Kyoto Protocol

The EU is well aware of the need to assess impacts, and has built up thorough procedures in line with obligations. This includes bilateral dialogues and different platforms that allow interacting with third

⁵⁵ **Kyoto Protocol, Art. 3 Par. 1** “The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012.”

⁵⁶ **UNFCCC, Art 4. Par 8.** “In the implementation of the commitments in this Article, the Parties shall give full consideration to what actions are necessary under the Convention, including actions related to funding, insurance and the transfer of technology, to meet the specific needs and concerns of developing country Parties arising from the adverse effects of climate change and/or the impact of the implementation of response measures, especially on: (a) Small island countries; (b) Countries with low-lying coastal areas; (c) Countries with arid and semi-arid areas, forested areas and areas liable to forest decay; (d) Countries with areas prone to natural disasters; (e) Countries with areas liable to drought and desertification; (f) Countries with areas of high urban atmospheric pollution; (g) Countries with areas with fragile ecosystems, including mountainous ecosystems; (h) Countries whose economies are highly dependent on income generated from the production, processing and export, and/or on consumption of fossil fuels and associated energy-intensive products; and (i) Landlocked and transit countries. Further, the Conference of the Parties may take actions, as appropriate, with respect to this paragraph.” **UNFCCC Art 4. Par. 9.** “The Parties shall take full account of the specific needs and special situations of the least developed countries in their actions with regard to funding and transfer of technology.”

countries, explain new policy initiatives and receive comments from third countries. Impacts on third countries are mostly indirect and can frequently neither be directly attributed to a specific EU policy, nor directly measured by the EU in developing countries. A wide-ranging impact assessment (IA) system accompanying all new policy initiatives has been established. This approach ensures that potential adverse social, environmental and economic impacts on various stakeholders are identified and minimized within the legislative process (European Commission, 2010).

At European level, IA is required for most important Commission initiatives, policy and programs and those which will have the most far-reaching impacts. In 2009, IA was adopted, replacing the previous Guidelines 2005 and also the 2006 update. In general, the IA evidence advantages and disadvantages of possible policy options by assessing their potential impacts. Among different issues, it should be assessed which are the likely social, environmental and economic impacts of those options (European Commission, 2009[a]). Since 2003 all IA of EU policies are listed and published online by subject (European Commission, 2013). Key questions on economic, social and environmental impacts in relation to third countries are listed in Table 14.1.

Table 14.1 Questions in relation to impacts on Third countries

Economic	Social	Environmental
<ul style="list-style-type: none"> How does the policy initiative affect trade or investment flows between the EU and third countries? How does it affect EU trade policy and its international obligations, including in the WTO? Does the option affect specific groups (foreign and domestic businesses and consumers) and if so in what way? Does the policy initiative concern an area in which international standards, common regulatory approaches or international regulatory dialogues exist? Does it affect EU foreign policy and EU development policy? What are the impacts on third countries with which the EU has preferential trade arrangements? Does it affect developing countries at different stages of development (least developed and other low-income and middle income countries) in a different manner? Does the option impose adjustment costs on developing countries? Does the option affect goods or services that are produced or consumed by developing countries? 	<ul style="list-style-type: none"> Does the option have a social impact on third countries that would be relevant for overarching EU policies, such as development policy? Does it affect international obligations and commitments of the EU arising from e.g. the ACP-EU Partnership Agreement or the Millennium Development Goals? Does it increase poverty in developing countries or have an impact on income of the poorest populations? 	<ul style="list-style-type: none"> Does the option affect the emission of greenhouse gases (e.g. carbon dioxide, methane etc) into the atmosphere? Does the option affect the emission of ozone-depleting substances (CFCs, HCFCs etc)? Does the option affect our ability to adapt to climate change? Does the option have an impact on the environment in third countries that would be relevant for overarching EU policies, such as development policy?

Source: European Commission, 2010

A review of European response measures for two EU policies were chosen for further description because the IA identified potential impacts on thirds countries. These measures are the Directive 2009/28/EC on the promotion of the use of renewable energy, and the EU emission trading scheme for the inclusion of the aviation (see European Commission, 2009[b]; European Commission, 2010).

Directive on the promotion of the use of renewable energy

EU will reach a 20% share of energy from renewable sources in the overall energy consumption by 2020 (with individual targets for each Member State) and a 10% share of renewable energy specifically in the transport sector, which includes biofuels, biogas, hydrogen and electricity from renewables. IAs related to enhanced use in the EU showed that the cultivation of energy crops have positive (growing of EU demand for bioenergy generates new export revenues and employment opportunities for developing countries and boosts rural economies), and negative (biodiversity, soil and water resources and have positive/ negative effects on air pollutants) impacts. For this reason, Article 17 of the EU's Directive has created "sustainability criteria", applicable to all biofuels (biomass used in the transport sector) and bioliquids, which consider to establish a threshold for GHG emission reductions that have to be achieved from the use of biofuels; to exclude the use of biofuels from land with high biodiversity value (primary forest and wooded land, protected areas or highly biodiverse grasslands), and to exclude the use of biofuels from land with high C

stocks, such as wetlands, peatlands or continuously forested areas. In this context, developing country representatives as well as other stakeholder were extensively consulted during the development of the sustainability criteria and preparation of the directive and the extensive consultation process has been documented. The Commission also reports on biofuels' potential indirect land use change effect and the positive and negative impact on social sustainability in the Union and in third countries, including the availability of foodstuffs at affordable prices, in particular for people living in developing countries, and wider development issues. The first reports were submitted in 2012 (European Commission, 2010).

Inclusion of aviation in the EU emission trading scheme

In 2005 the Commission adopted a Communication entitled "Reducing the Climate Change Impact of Aviation", which evaluated the policy options available to this end and was accompanied by an IA. The assessment concluded that, in view of the likely strong future growth in air traffic emissions, further measures are urgently needed. Aircraft operators from developing countries will be affected to the extent they operate on routes covered by the scheme. As operators from third countries generally represent a limited share of emissions covered, the impact is also modest. On the other hand, to the extent that aviation's inclusion in the EU ETS creates additional demand for credits from JI and CDM projects, there will also be indirect positive effects as such projects imply additional investments in clean technologies in developing countries (European Commission, 2010).

Common Agricultural Policy

Furthermore, many developing countries and least developed countries (LDC) are based on the agricultural production, therefore, it will be important to understand how the *EU Common Agricultural Policy (CAP) Health Check*, together with the new targets on climate change and renewable energies will potentially influence developing countries. Some information on cereal intervention options on third parties have been identified (European Commission, 2008). Some studies on the impact of agricultural policies on developing countries are also available (Schmidhuber, 2009; Hallam, 2010). Brooks et al (2010) has recently presented DEVPEM⁵⁷ a companion to the OECD-country PEM⁵⁸ as a tool for policy evaluation in developing countries. Preliminary results for Malawi indicate that agricultural policies may have fundamentally different impacts on incomes in low income countries to those obtained in developed OECD countries.

14.3 Italian commitment under Art 3.14 of the Kyoto Protocol

Article 3, paragraph 14 of the KP is related to Annex I Parties' way of implementing commitments under Article 3.1 of the KP. Therefore, it addresses the implementation of the quantified emission limitation and reduction objectives (QELROs) under Article 3.1, the implementation of LULUCF activities under Article 3 paragraphs 3 and 4, the use of Emission Reduction Units (ERUs) and Certified Emission Reductions (CERs) under Article 3 paragraphs 10, 11, and 12.

Italy is aware of the potential direct and indirect impact of measures/policies and tries to ensure that the implementation of national mitigation policies under the KP does not impact other parties. Minimizing adverse effects of policies/measures are described in Chapter 4.6 in the Fifth National Communication (MATTM, 2009). Information of activities under Article 3 paragraphs 3 and 4 of the KP is described in 'Chapter 10' KP-LULUCF' of this report.

National and sectoral Italian policies are expected to have no direct impacts in developing countries. Policies and measures in the Italian energy sector aim to increase energy efficiency and develop a low-carbon energy system but in the context of a global energy scenarios that do not foresee a decline in income for fossil fuel exporting countries (IEA, World Energy Outlook 2008).

Efforts to tackle adverse social, economic, and environmental impacts of mitigation actions are directly expected in the framework of the Kyoto Mechanisms. Hence, this chapter has concentrated efforts to analyze the Clean Development Mechanism and Joint Implementation in order to provide response to reporting requirements under Article 3.14 of KP.

⁵⁷ DEVPEM, Development Policy Evaluation Model

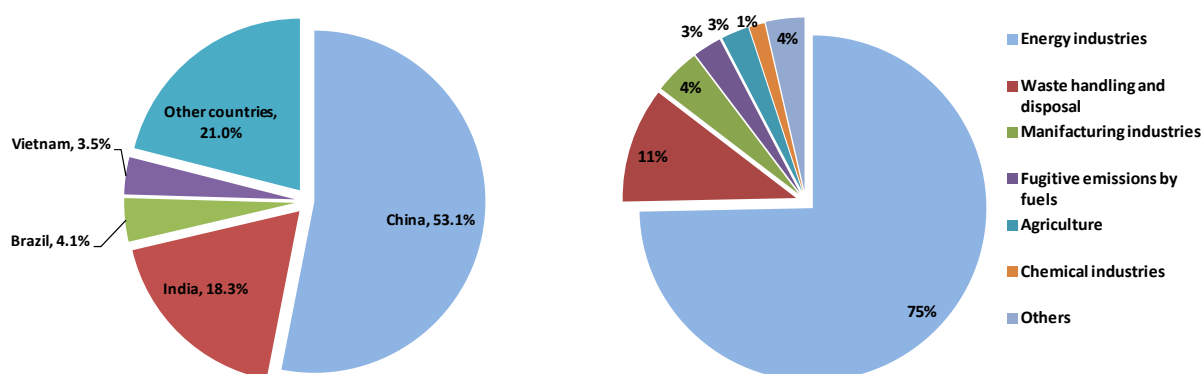
⁵⁸ PEM, Policy Evaluation Model examine the effects of agricultural policies in member countries

Procedure for assessing sustainability at local and national level for CDM and JI

The Clean Development Mechanism (CDM), defined in Article 12 of the KP, allows a country with an emission-limitation commitment (Annex B Party) to implement an emission-reduction project in developing countries.

For this section, information was collected from the UNFCCC CDM Project Search Database (UNFCCC, 2013[a]). On 13 March 2013, the UNFCCC CDM Database reported a total of 6,558 registered project activities. By the time the CDM database was consulted world-wide 85.3% of CDM projects were registered in Asia and the Pacific Region, 12.0% in Latin America and Caribbean, 2.1% in Africa, and 0.4% in Countries with economies in transition. The distribution of registered projects by scope activity was mainly: energy industries (74.7%), waste handling and disposal (10.7%) and manufacturing industries (4.3%). Registered projects by Host Party were mainly in China (53.1%), India (18.3%), Brazil (4.1%) and Vietnam (3.5%). The distribution of CDM projects by Host country and scope is presented in Figure 14.1.

Italy as investor Party, contributes with 1.6% of world-wide CDM project portfolio. Italy is involved in more than 100 CDM projects at different stage, and is involved directly, as government, in 27 registered CDM (MATTM, 2011[a]). Up to day Italy is involved in 106 CDM registered projects (UNFCCC, 2013[a]), 37.7% more than the beginning of 2012. Projects by dimension are 55.7% large scale and 44.3% small-scale. Italy is the only proposer for 50% of the CDM projects. In Annex A8.2.4 a complete list of CDM projects is available.



Source: UNFCCC (UNFCCC, 2013)

Figure 14.1 Italian CDM projects by Host country and scope (as for 13/03/2013)

Parties should follow a project cycle to propose CDM projects (first designing phase and realization phase). During the first phase, among other activities, Parties participating in the CDM shall designate a national authority (DNA). Each Host Party has implemented a procedure for assessing CDM projects. The DNA evaluates project documentation against a set of pre-defined criteria, which tend to encompass social, environmental and economic aspects. For instance, India has SD criteria such as the social, economic, environmental and technological 'well-being'. Instead, China discriminated projects by priority area and by gas based-approach (Olsen and Fenhann, 2008; Boyd et al., 2009).

Most of the CDM projects (if large-scale) are subject to ex-ante assessments. For instance, environmental impact assessments (EIA) are required. In other cases, because of the size of the project, EIA are not necessary. Still some CDM projects have performed voluntary EIA. This is the case for the *Santa Rosa* Hydroelectric CDM project in Peru (Endesa Carbone, 2010). After, a second evaluation is performed by the DNA as described previously. For example, in the Peruvian DNA, the process follows the: submission of the project to the Ministry of competence on the activities, a site visit of the project done by the Ministry of Environment, and the conformation of an *ad hoc* committee that evaluate projects considering legal, social, environmental and economic criteria (MINAM, 2010). Thus, possible impacts of the CDM projects are mainly subject to local and national verification.

In some cases, an ex-post assessment could be also performed by the Designated Operational Entities (DOE), which validated CDM projects and certifies as appropriate and requests the Board to issue CERs. For some CDM projects, for instance, *Poehos I* Hydroelectric project (Peru), CERs are approve only if the project complies also with social and environmental conditions (Endesa Carbone, 2010). In addition, Italy agreed to accept in principle common guidelines for approval of large hydropower project activities. EU Member States have arrived at uniform guidelines on the application of Article 11b(6) of the Directive 2004/101/EC

to ensure compliance (of such projects) with the international criteria and guidelines, including those contained in the World Commission on Dams 2000 Report. It aims to ensure that hydro projects are developed along the SD and the not damaging to the environment (exploring possible alternatives) and addressing such issues as gaining public acceptance, and fair and equitable treatment of stakeholders, including local and indigenous people (MATTM, 2010[a]).

Another feedback for participating to CDM project with SD characteristics comes from the carbon funds. For instance, Italy participates to the *BioCarbon Fund* (BCF), the *Community Development Carbon Fund* (CDCF) and the *Italian Carbon Fund* (ICF). The first two funds aim to finance projects with strong social impact at local level, that combine community development attributed with emission reductions and will significantly improve the life of the poor and their local environment (MATTM, 2010[a]). Italian CDM projects which are under the CDCF initiative are listed in Annex A8.2.4.

The Joint implementation (JI) is defined in Article 6 of the KP allowing a country with a limitation commitment (Annex B) to earn emission reduction units (ERUs) from an emission-reduction or emission removal project in another Annex B Party. Two procedures could be followed. ‘Track 1’ procedures apply when the Host Party and investors meets all of the eligibility requirements to transfer and/or acquire ERUs, and the project is additional to any that would otherwise occur. ‘Track 2’ applies when the Host Party fulfils with a limited set of eligibility requirements or there is not an institutional authority able to follow up the project cycle. In this case the project should go through the verification procedure under the Joint Implementation Supervisory Committee (JISC). The development of the project is divided in a design and implementation phases (see MATTM 2011[b]). Parties involved in JI activities should designated focal point for approving projects, and prepared Guidelines and Procedures for approving Art.6 Projects, including the consideration of stakeholders’ (MATTM, 2010[b]). By the time the JI database from EGIS source show only one project with Italy involved. The task of the project is to reduce fugitive emissions (IGES, 2013).

Voluntary validation of sustainable development is taking place at international level for CDM and JI projects. The UNEP Risoe Centre database⁵⁹ highlights the Gold Standard (GS) and the Climate, Community and Biodiversity Alliance (CCB) for assessing SD on CDM project, and only GS for JI projects. The GS operates a certification scheme for premium quality carbon credits and promotes sustainable development (GS label). Indicators include air/water quality, soil condition, biodiversity, quality of employment, livelihood of the poor, access to affordable and clean energy services, etc (Gold Standard, 2011). After labelling, these projects are tracked in the UNFCCC/CDM Registry. The CCBA is a voluntary standard, which support the design and identification of land management activities that simultaneously minimize climate change, support sustainable development, and conserve biodiversity. Project design standards include: climate, community, and biodiversity indicators (CCBA, 2011). Up to 13 March 2013, the UNEP Risoe database reports 756 JI projects (track1+track2) from which 596 projects are registered (91.9% track 1+8.1% track 2). Up to 13 March 2013, the UNEP Risoe database reports 9,016 CDM projects with 6,556 registered from which 3 projects are validated with CCB, and 130 projects with GS.

Assessment of social, environmental, and economic effects of CDM and JI projects

The assessment of adverse social, environmental, and economic impacts contribution of CDM projects has been concentrated in the energy sector (or non-forestry CDM projects). Results from most relevant peer-review literature are available in this section.

Most common used methodologies for assessing sustainability are checklists and multicriteria assessments (Olsen 2007). For instance, Sirohi (2007) has qualitatively analyzed and discussed the Project Design Document (PDD) of 65 CDM projects covering all the types of CDM project activity in India. Results from this paper show that the benefits of the projects focusing on improving energy efficiency in industries, fossil fuel switching in industrial units and destruction of HFC-23 would remain largely “firm-specific” and are unlikely to have an impact on rural poverty. Boyd et al. (2009) have chosen randomly 10 CDM projects that capture diversity of project types and regions. Environment and development benefits (environment, economic, technology transfer, health, employment, education and other social) were assessed qualitatively. This review shows divergences and no causal relationship between project types and SD outcomes. Sutter and Parreño (2007) assessed CDM projects in terms of their contribution to employment generation, equal distribution of CDM returns, and improvement of local air quality. The multi-attribute assessment

⁵⁹ <http://uneprisoe.org/>

methodology (MATA-CDM) for non-forestry CDM projects was used for assessing 16 CDM projects registered at UNFCCC as of August 30, 2005. Results indicated that projects might contribute to one of the two CDM objectives (GHG emission reductions and SD in the Host country), but neither contributes strongly to both objectives. Uruguay's DNA has adopted this tool for approval of CDM projects. Nussbaumer (2009) has presented a SD assessment of 39 CDM projects. Label CDM projects ('Gold Standard' label and CDCF focuses) were compared to similar non-labelled CDM projects. Results show that labelled CDM activities tend to slightly outperform comparable projects, although not unequivocally. Nussbaumer selected criteria based on those from Sutter (2003) including social (stakeholder participation, improved service availability, equal distribution, capacity development), environmental (fossil energy resources, air quality, water quality, land resource) and economic (regional economy, microeconomic efficiency, employment generation, sustainable technology transfer) issues.

Some studies have also addressed the assessment of forestry CDM projects. Olsen and Fenhann (2008) have developed a taxonomy for sustainability assessment based on PDD text analysis. These authors concluded that the taxonomy can be supportive of DNAs to decide what the consequences should be, if a CDM project at the verification stage does not show signs of realizing its potential SD benefits. Palm et al (2009) developed a ranking process to assess sustainability of forest plantation projects in India. They concluded that successful implementation of forest-based project activities will require local participation and are likely to involve multiple forest products and environmental services demanded by the local community. For the first time an study has addressed the choice of an appropriate method for measuring strong sustainability. In a decision-aiding process, 10 UNFCCC/CDM afforestation/reforestation projects were evaluated through criteria that reflect global and local interests using a non-compensatory multicriteria method. Criteria for assessing SD included: social (land tenure, equitably share natural, skill development, ensure local participation), economic (employment, financial resource to local entities, financial forestry incentives) and environmental (use of native species, conservation and maintenance of soil/water resources, biodiversity conservation) issues. The multicriteria assessment allows sorting forestry projects in three ordered categories: synergistic, reasonably synergistic, and not synergistic. This means that those projects, which are synergistic comply with a higher number of criteria (Córdor et al., 2010).

A recent report from the UNFCCC concluded that most studies of hydrofluorocarbon and nitrous oxide related projects yield the fewest SD benefits, but the studies differ in their assessment of other project types. It also reports that other studies suggest a trade-off between the goals of the CDM in favour of producing low-cost emission reductions at the expense of achieving SD benefits (UNFCCC, 2011[b]).

For this section we have accessed project databases (UNFCCC, Carbon Finance, UNEP Risoe Centre) and peer-reviewed articles (see Annex A8.2.4 for detailed information on CDM research studies). For non-forestry CDM projects, Nussbaumer (2009) have published results of SD assessment from Honduras and Peru (Hydroelectric), Nepal (Biogas), Argentina (landfill), Moldova (Biomass), India (small hydroelectric and wind) and China (hydropower), and Sirohi (2007) for projects in India (biomass, F-gas, hydroelectric). For forestry CDM projects, Córdor et al. (2010) has assessed 3 out from 13 CDM projects in which Italy is involved. 'The Moldova Soil Conservation' project was classified as a 'synergistic' project, while the 'Assisted Natural Regeneration of Degraded Lands' project in Albania and the 'Facilitating Reforestation for Guangxi Watershed Management' project in China were classified as 'reasonably synergistic'. The higher the assignment of the project, the better the performance respect to social, economic and environmental criteria including climate change, biodiversity and desertification issues.

Most articles found for JI are related with institutional arrangements (Evans et al., 2000; Streimikiene and Mikalauskiene, 2007; Firsova and Taplin, 2008) or the integration of JI with other mechanisms such as the white certificates (Oikonomou and van der Gaast, 2008). On peer-review article, no much information was found regarding JI and SD assessment. However, Cha et al. (2008) developed Environmental-Efficiency and Economic-Productivity indicators to choose an environmentally and economically-efficient CDM and JI project.

14.4 Funding, strengthening capacity and transfer of technology

According to Art 3.14 of the KP information on funding and transfer of technology need to be described, thus, brief information is provided in this section.

The flow of financial resources to developing countries and multilateral organisations from Italy is shown in Table 14.2 (OECD, 2013). Between 2006 and 2008 the Ministry of Foreign Affairs has contributed with around 30 million EUR in bilateral and multilateral cooperation with developing countries for climate change related activities. In order to contribute to the implementation of the commitment foreseen in the “Bonn Declaration”, since 2002 the Ministry for the Environment, Land and Sea, has been authorized to finance bilateral and multilateral activities in developing countries for 55.1 million EUR/year as of 2008 (MATTM, 2009). A recent peer review report of the Development Assistance Committee (DAC) describes bilateral and multilateral cooperation funding activities in Italy. The Directorate General for Development Co-operation (DGCS) from the Ministry of Foreign Affairs in collaboration with other players in Italian Co-operation is in charge of implementing recommendations (OECD, 2009). The most important institutional actor is the Ministry for the Environment, Land and Sea, because of its contribution to implementing the Kyoto Protocol and other Rio conventions in developing countries.

The Ministry of Foreign Affairs defined the Programming Guidelines and Directions of Italian Development Co-operation 2011-2013, where priority areas are identified (MAE, 2010[c]): i) agriculture/food security; ii) human development, particularly referred to health and education/training; iii) governance and civil society; iv) support for endogenous development, inclusive and sustainable, the private sector, and v) environment, land and natural resources management, particularly referred to water and mitigation/adaptation to climate change. The aid effectiveness is a top priority for the Italian cooperation as described in the ‘Aid Effectiveness Action Plan’ (DGCS, 2009). The Ministry of Foreign Affairs has a database of environmental projects available online (DGCS, 2013). The ecosystem approach management is a strategy adopted by Italian cooperation. In the environment field, projects that have been monitored by the Central Technical Unit/DGCS - Ministry of Foreign Affairs, are subject to field visit and ex-post assessments in order to verify compliance in the framework of climate change activities (MAE, 2010[a]).

Table 14.2 Financial resources to developing countries and multilateral organisations from Italy

	Italy				
	2000-01	2008	2009	2010	2011
NET DISBURSEMENTS			USD million		
I. Official Development Assistance (ODA) (A + B)	1 502	4 861	3 297	2 996	4 326
ODA as % of GNI	0.14	0.22	0.16	0.15	0.20
A. Bilateral Official Development Assistance	409	1 838	875	759	1 703
of which: General budget support		55	9	5	1
Core support to national NGOs	56	-	-	15	-
Investment projects	- 134	81	37	- 34	310
Administrative costs	27	67	59	42	53
Other in-donor expenditures	12	15	5	5	526
of which: Refugees in donor countries	10	3		3	525
B. Contributions to Multilateral Institutions	1 092	3 022	2 423	2 237	2 623
of which: UN	203	210	205	170	150
EU	628	1 713	1 862	1 557	1 924
IDA	120	556	214	386	179
Regional Development Banks	76	351	24	6	206
II. Other Official Flows (OOF) net (C + D)	- 24	408	- 72	- 151	- 214
C. Bilateral Other Official Flows (1 + 2)	- 24	408	- 72	- 151	- 214
1. Official export credits	16	34	- 28	- 28	117
2. Equities and other bilateral assets	- 40	374	- 44	- 123	- 330
D. Multilateral Institutions					
III. Grants by Private Voluntary Agencies	35	105	162	150	111
IV. Private Flows at Market Terms (long-term) (1 to 4)	3 817	207	2 181	6 612	7 689
1. Direct investment	1 317	1 544	129	4 366	7 530
2. Private export credits	663	2	463	882	1 234
3. Bilateral portfolio investment	1 837	-1 339	1 590	1 365	-1 074
4. Securities of multilateral agencies	-	-	-	-	-
V. Total Resource Flows (long-term) (I to IV)	5 329	5 581	5 569	9 608	11 912
Total Resource Flows as a % of GNI	0.49	0.25	0.27	0.47	0.55

Source: OECD (OECD, 2013) http://www.oecd.org/document/9/0,3746,en_2649_34447_1893129_1_1_1_1,00.html

Italian multilateral cooperation on climate change has been performed with different United Nations organizations, funds, and institutions⁶⁰. Cooperation has involved from the supply of financial resources, to the design and implementation of programmes and projects, the promotion of transfer of environmentally-sound technologies aiming at reducing the impacts of human activities on climate change, and support to adaptation measures. Italian bilateral cooperation continues activities described in the Fourth National Communication to the UNFCCC and has implemented new projects on climate change. Focus is given to different geographical regions world-wide⁶¹. Funding climate change and related topics in developing countries has different and ambitious objective: efficient use of energy, implementation of innovative financial mechanisms, efficient water management, carbon sequestration, professional training, and exchange of know-how, promotion of eco-efficient technologies. Further detailed description is given in 'Chapter 7 Financial assistance and Technology Transfer' of the Fifth National Communication from Italy (MATTM, 2007; 2009).

The DGCS of the Ministry of Foreign Affairs is contributing with bilateral projects in the energy sector, for example, in Albania, Bangladesh, Sierra Leone and Palestinian territories (improvement of electric system or hydroelectric power generation) (DGCS, 2011). An example is the hydroelectric project in Ethiopia that has been supported by the Ministry of Foreign Affairs. Next step of this project will be an ex-post assessment of

⁶⁰ Italian multilateral cooperation with the United Nations Educational, Scientific and Cultural Organization (UNESCO), United Nations Industrial Development Organization (UNIDO), Food and Agriculture Organization of the United Nations (FAO), the Regional Environmental Centre for Central and Eastern Europe (REC), the Global Environment Facility (GEF), the World Bank (WB), International Union for Conservation of Nature (IUCN), the United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP) and the Mediterranean Action Plan (MAP).

⁶¹ Italian bilateral cooperation with the Asian and Middle East countries (China, Iraq, Thailand and India), Mediterranean and African region (Algeria, Egypt, Israel, Tunisia, Morocco), Central and Eastern European countries (Albania, Bosnia, Croatia, Bulgaria, Serbia, Montenegro, Macedonia, Poland, Romania, Turkey, Hungary, Kyrgyzstan and Tajikistan), and Latin America, the Caribbean and the Pacific Islands (Belize, Argentina, Mexico, Cuba, Brazil, 14 countries of the South Pacific Small Islands Developing States).

adverse effects through the use of the OECD-DAC guidelines (MAE, 2010[b]). These guidelines include the assessment of the relevance, effectiveness, efficiency, impact (positive/negative) and sustainability of the activities (OECD, 2008). In June 2010 the guidelines for on-going and ex- post evaluation of official development assistance implemented by the DGCS-Ministry of Foreign Affairs were published (MAE, 2010[d]).

Evidence of technology transfer activities were found in the context of the Kyoto Mechanisms. An study analyzed comprehensively technology transfer in the CDM: 3296 registered and proposed projects (Seres et al., 2009). Results address that roughly 36% of the projects accounting for 59% of the annual emission reductions claim to involve technology transfer. These authors concluded that as the number of projects increases, technology transfer occurs beyond the individual projects. This is observed for several of the most common project types in China and Brazil with the result that the rate of technology transfer for new projects in those countries has fallen significantly.

14.5 Priority actions in implementing commitments under Article 3 paragraph 14

For the purposes of completeness in reporting, and according to the reporting guidelines for supplementary information (UNFCCC, 2002), a summary of how Italy gives priority to the actions specified in Decision 15/CMP.1, paragraph 24 is given below. More detailed information is found in the Fifth National Communication under the UNFCCC, Chapter 5 Projections and effects of policies and measures and Chapter 7 Financial resources and transfer of technology (MATTM, 2009). The preparation of this paragraph was discussed with energy experts from ISPRA (ISPRA, 2011[a], [b]).

Paragraph 24 (a)

The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse gas emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities.

EU emissions trading scheme, promotion of biomass and biofuel, Common Agricultural Policy can potentially have impacts in developing countries (European Commission, 2009[b]; 2010[b]). Italy is subject to the European legal system and it will implement the EU legislation. At national level, it is not planned to further increase biomass – biofuel objectives already established (ISPRA, 2011[a]).

Paragraph 24 (b)

Removing subsidies associated with the use of environmentally unsound and unsafe technologies.

Council regulation EC No 1407/2002 rules for granting state aid to contribute to restructure coal industry (European Commission, 2010). Anyway, Italy has a negligible domestic coal production.

Paragraph 24 (c)

Cooperating in the technological development of non-energy uses of fossil fuels, and supporting developing country Parties to this end.

At European level and national level, ‘non-energy uses of fossil fuels’ is not a current research priority (European Commission, 2010).

Paragraph 24 (d)

Cooperating in the development, diffusion, and transfer of less greenhouse gas emitting advanced fossil-fuel technologies, and/or technologies relating to fossil fuels that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort.

The ongoing activities on multilateral and bilateral Italian cooperation are coordinated through the Ministry of Foreign Affairs and the Ministry for the Environment, Land and Sea, see MATTM (2009).

For example, Italy has signed with India a Memorandum of Understanding (MoU) on “Co-operation in the Area of Climate Change and Development and Implementation of Projects under the CDM/ Kyoto Protocol”. In this framework, the MATTM supported a project on Carbon Sequestration Potential Assessment.

The Italian Government has already funded research on carbon capture and storage (CCS) technologies carried out by several organizations and institutions: total value 10-15 million euro for the period 2009-2011. A draft decree transposing EU directive 2009/31/CE in the Italian legislation has been presented to the Parliament by the MATTM and the Ministry for Economic Development. ENEL and ENI, the two major energy utilities in the country, have signed a general agreement for CCS development and will apply for EU funds to set up a pilot unit in Brindisi and a demonstration unit in Porto Tolle. At the international level, Enel is developing a project to build a CO₂ capture system in China and has signed agreements for the development of CCS with other countries like South Korea (ISPRA, 2011[b]).

Paragraph 24 (e)

Strengthening the capacity of developing country Parties identified in Article 4, paragraphs 8 and 9, of the Convention for improving efficiency in upstream and downstream activities relating to fossil fuels, taking into consideration the need to improve the environmental efficiency of these activities.

The ongoing activities on multilateral and bilateral Italian cooperation are coordinated through the Ministry of Foreign Affairs and the Ministry for the Environment, Land and Sea, see MATTM (2009).

For example, in Central Eastern Europe Italy has multilateral activities within the Regional Environmental Center for Central and Eastern Europe (REC CEE). More than 100 projects have been implemented for the region, specifically, to climate change and energy issues, several programs were carried out on training and capacity building, energy efficiency in small and medium-sized enterprises, public access to information and participation in climate decision-making processes, promotion of climate change mitigation and adaptation policies, development of solar passive and active systems and development of national GHG emission registries.

Paragraph 24 (f)

Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies.

The ongoing activities on multilateral and bilateral Italian cooperation are coordinated through the Ministry of Foreign Affairs and the Ministry for the Environment, Land and Sea, see MATTM (2009). For example, within the framework of the Mediterranean Renewable Energy Programme (MEDREP) Initiative, the MATTM has signed a MoU with UNEP-DTIE in order to carry out projects helping the establishment of a regional RET market in the Mediterranean region (Tunisia, Egypt, Montenegro and Albania). After, the Mediterranean Investment Facility was launched aiming to the development (2007–2011) of several projects having an important impact on CO₂ emissions by diversifying the use of small scale renewable energy and energy efficiency technologies by targeting different niche markets.

In 2007, the MATTM supported the “Observatory for Renewable Energy in Latin America and the Caribbean” through the signature of a Trust Fund Agreement with UNIDO. Activities are focused on biomass utilization in Uruguay and Brazil in order to reduce the methane emissions and the GHGs’ climate change effects, promoting the utilization of bio-digester plants for the electricity production into the livestock farms, based on a local energy management distributed generation system.

14.6 Additional information and future activities related to the commitment of Article 3.14 of the Kyoto Protocol

Italy is aware of its commitments under Article 3.14 of KP, and it is also well aware of the need to assess social, environmental and economic impacts. Different national and international mechanisms and guidelines are guiding the prevention of adverse effects while implementing projects in developing countries. Different activities have been identified for future commitments under Art 3.14. For instance, priority actions need to be further classified into positive and negative, direct and indirect features.

Italian private companies are participating to flexible mechanisms. For instance, ENI an Italian world-wide energy company, projects to reduce gas flaring associated with oil production, with the goal of reducing by

70% emissions from gas flaring, compared to 2007. For some of these projects, ENI promotes the recognition flexible mechanisms within the CDM (ENI, 2010). ENEL is the Italian largest power company that is one of the main worldwide operators applying the CDM. Most of these initiatives were developed bilaterally between Enel-Endesa and the Host country. The group portfolio includes 105 direct participation projects, mostly located in China (79 projects) and other located in India, Africa and Latin America. As for the JI mechanism, the Group's portfolio includes 7 projects in Uzbekistan and Ukraine and 32 indirect-participation projects in the European Union, Russia, Moldova and Ukraine (ENEL, 2011).

Finally, projects from decentralized development cooperation are to be considered (OICS, 2011). Principles, actors, priority areas and instruments relating to programs conducted by DGCS with the regions and local authorities (provinces and municipalities) are defined in specific guidelines for decentralized cooperation (MAE, 2010[e]).

14.7 Review process of Article 3.14 of the Kyoto Protocol

In 2011 an in-country review process for the Fifth National Communication took place. During this process also the minimization of adverse impacts in accordance with Article 3, paragraph 14, of the Kyoto Protocol was reviewed. Additional information reported for submission 2010 and 2011 related with this theme was also provided. According to the UNFCCC review report, the Expert review team (ERT) considers the reported information to be transparent and complete. The ERT also commends Italy for its comprehensive, transparent and well-documented information on the minimization of adverse impacts and encourages it to continue exploring and reporting on the adverse impacts of the response measures (UNFCCC, 2011[a]).

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ANNEX 1: KEY CATEGORIES AND UNCERTAINTY

A1.1 Introduction

The 2006 IPCC Guidelines (IPCC, 2006) recommends as good practice the identification of *key categories* in national GHG inventories. A *key 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, referring to categories, 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 *category* is used, it includes both sources and sinks. The 2006 Guidelines provide a harmonized method to deal with both sources and removals and correct some inconsistencies between the previous versions. For these reasons, the updated IPCC guidelines have been followed to implement the key category and uncertainty analyses in the Italian inventory.

Two different approaches are reported in the guidelines according to whether or not a country has performed an uncertainty analysis of the inventory: Approach 1 and Approach 2.

When using Approach 1, key categories are identified by means of a pre-determined cumulative emissions threshold, usually fixed at 95% of the total. If an uncertainty analysis is carried out at category level for the inventory, Approach 2 can be used to identify key categories. Approach 2 is a more detailed analysis that builds on Approach 1; in fact, the results of Approach 1 are multiplied by the relative uncertainty of each source/sink category. Key categories are those that represent 90% of the uncertainty contribution.

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 approaches are applied it is good practice to use the results of the Approach 2 analysis.

For the Italian inventory, a key category analysis has been carried out according to both the methods, excluding and including the LULUCF sector. National emissions have been disaggregated, as far as possible, into the categories proposed in the IPCC guidelines; 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 has been carried out.

Summary of the results of the key category analysis, for the base year and 2011, 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 Approach 1, Approach 2 or both.

For the base year, 20 categories were individuated according to Approach 1, whereas 17 categories were carried out by Approach 2. Including the LULUCF sector in the analysis, 23 categories were selected jointly by the Approach 1 and Approach 2.

For the year 2011, 18 categories were individuated by the Approach 1 accounting for 95% of the total emissions, without LULUCF; for the trend 16 key categories were selected. Jointly for the Approach 1, both level and trend, 21 key categories were totally individuated.

Repeating the *key category* analysis for the full inventory including the LULUCF sector, 22 categories were individuated accounting for 95% of the total emissions and removals in 2011, and 21 key categories in trend assessment. Jointly for the Approach 1, both level and trend, 29 key categories were totally individuated.

The application of the Approach 2 to the 2011 emission levels gives as a result 16 key categories accounting for the 90% of the total levels with uncertainty; when applying the trend analysis the key categories are equal to 18 with differences with respect to the previous list.

The application of the Approach 2 including the LULUCF categories results in 19 key categories, for the year 2011, accounting for the 90% of the total levels with uncertainty; for the trend analysis including LULUCF categories, the results were 18 key categories. Jointly for both the level and trend, 23 key categories were totally individuated.

A1.2 Approach 1 key category assessment

As described in the 2006 IPCC Guidelines (IPCC, 2006), and previously in the IPCC Good Practice Guidance (IPCC, 2000; IPCC, 2003), the Approach 1 for identifying key categories assesses the impact of

various categories on the level and on the trend of the national emission inventory. Both level and trend assessments should be applied to an emission GHG inventory.

As regards the level assessment, the contribution of each source or sink category to the total national inventory level is calculated as follows:

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

$$L_{x,t} = |E_{x,t}| / \sum_y |E_{y,t}|$$

where

$L_{x,t}$ = level assessment for source or sink x in year t ;

$|E_{x,t}|$ = absolute value of emission and removal estimate of source or sink category x in year t ;

$\sum_y |E_{y,t}|$ = total contribution, which is the sum of the absolute values of emissions and removals in year t .

The contribution of all categories (including the LULUCF sector) is entered as absolute values.

Therefore, key categories are those which, when summed in descending order of magnitude, add up to over 95% of the total emissions.

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:

Category Trend Assessment =

(Source or Sink Category Level Assessment) · |Source or Sink Category Trend - Total Trend|

$$T_{x,t} = |E_{x,0}| / \sum_y |E_{y,0}| \cdot \left| \left[(E_{x,t} - E_{x,0}) / |E_{x,0}| \right] - \left[(E_t - E_0) / \sum_y |E_{y,0}| \right] \right|$$

where

$T_{x,t}$ = trend assessment, which is the contribution of the source or sink category trend to the overall inventory trend;

$|E_{x,0}|$ = absolute value of emission and removal estimate of source or sink category x in the base year (year 0);

$\sum_y |E_{y,0}|$ = total contribution, which is the sum of the absolute values of emissions and removals in year 0;

$E_{x,t}$ and $E_{x,0}$ = real values of estimates of source or sink category x in years t and 0, respectively;

E_t and $E_0 = \sum_y E_{y,t}$ and $\sum_y E_{y,0}$ = total inventory estimates in years t and 0, respectively.

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 latest inventory year estimate and dividing by the absolute value of the latest inventory 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.

In circumstances where the base year emissions for a given category are zero, the expression is reformulated to avoid zero in the denominator:

$$T_{x,t} = \left| E_{x,t} / E_{x,0} \right|$$

As differences in trend are more significant to the overall inventory level for larger 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 for which 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 for the 2011 inventory.

The results of Approach 1 are shown in Table A1.1 and Table A1.2, level and trend assessments without LULUCF categories. Results of the key category analysis with the LULUCF are reported in Table A1.3 and Table A1.4.

Table A1.1 Results of the key category analysis without LULUCF. Approach 1 Level assessment, year 2011

CATEGORIES	2011 CO₂ eq.	Level assessment	Cumulative Percentage
CO ₂ stationary combustion gaseous fuels	148,023	0.303	0.30
CO ₂ Mobile combustion: Road Vehicles	108,426	0.222	0.52
CO ₂ stationary combustion solid fuels	61,736	0.126	0.65
CO ₂ stationary combustion liquid fuels	58,282	0.119	0.77
CO ₂ Cement production	12,583	0.026	0.80
CH ₄ from Solid waste Disposal Sites	12,533	0.026	0.82
CH ₄ Enteric Fermentation in Domestic Livestock	10,761	0.022	0.84
HFC, PFC substitutes for ODS	9,294	0.019	0.86
Direct N ₂ O Agricultural Soils	7,350	0.015	0.88
Indirect N ₂ O from Nitrogen used in agriculture	6,473	0.013	0.89
CO ₂ stationary combustion other fuels	5,471	0.011	0.90
CH ₄ Fugitive emissions from Oil and Gas Operations	5,008	0.010	0.91
CO ₂ Mobile combustion: Waterborne Navigation	4,873	0.010	0.92
N ₂ O stationary combustion	3,775	0.008	0.93
N ₂ O Manure Management	3,716	0.008	0.94
CH ₄ Emissions from Wastewater Handling	2,734	0.006	0.94
CO ₂ Fugitive emissions from Oil and Gas Operations	2,315	0.005	0.95
CO ₂ Mobile combustion: Aircraft	2,299	0.005	0.95
CH ₄ Manure Management	2,114	0.004	0.96
CO ₂ Lime production	2,069	0.004	0.96
N ₂ O Emissions from Wastewater Handling	1,937	0.004	0.97
CO ₂ Other industrial processes	1,906	0.004	0.97
CH ₄ from Rice production	1,550	0.003	0.97
N ₂ O from animal production	1,549	0.003	0.98
CO ₂ Limestone and Dolomite Use	1,481	0.003	0.98
CH ₄ stationary combustion	1,373	0.003	0.98
CO ₂ Mobile combustion: Other	1,325	0.003	0.98
CO ₂ Iron and Steel production	1,297	0.003	0.99
PFC from the production of halocarbons and SF ₆	1,266	0.003	0.99
CO ₂ Emissions from solvent use	1,080	0.002	0.99
N ₂ O Mobile combustion: Road Vehicles	1,044	0.002	0.99
CO ₂ Ammonia production	839	0.002	1.00
N ₂ O Emissions from solvent use	577	0.001	1.00
SF ₆ Electrical Equipment	298	0.001	1.00
CH ₄ Mobile combustion: Road Vehicles	271	0.001	1.00
CO ₂ Emissions from Waste Incineration	235	0.000	1.00
N ₂ O Nitric Acid	179	0.000	1.00
PFC, HFC, SF ₆ Semiconductor manufacturing	169	0.000	1.00
N ₂ O Adipic Acid	116	0.000	1.00
PFC Aluminium production	81	0.000	1.00

Table A1.2 Results of the key category analysis without LULUCF. Approach 1 Trend assessment, 1990- 2011

CATEGORIES	Contribution to trend (%)	Cumulative Percentage
CO2 stationary combustion liquid fuels	0.382	0.38
CO2 stationary combustion gaseous fuels	0.301	0.68
CO2 Mobile combustion: Road Vehicles	0.091	0.77
HFC, PFC substitutes for ODS	0.041	0.82
CO2 stationary combustion solid fuels	0.027	0.84
CO2 stationary combustion other fuels	0.021	0.86
N2O Adipic Acid	0.019	0.88
CO2 Cement production	0.011	0.89
CH4 Fugitive emissions from Oil and Gas Operations	0.008	0.90
CH4 from Solid waste Disposal Sites	0.008	0.91
N2O Nitric Acid	0.008	0.92
CO2 Ammonia production	0.008	0.93
Direct N2O Agricultural Soils	0.008	0.93
CO2 Iron and Steel production	0.007	0.94
PFC Aluminium production	0.007	0.95
Indirect N2O from Nitrogen used in agriculture	0.005	0.95
CH4 Manure Management	0.005	0.96
CO2 Limestone and Dolomite Use	0.004	0.96
CH4 Emissions from Wastewater Handling	0.004	0.97
CO2 Fugitive emissions from Oil and Gas Operations	0.004	0.97
CH4 Enteric Fermentation in Domestic Livestock	0.004	0.97
CO2 Mobile combustion: Aircraft	0.003	0.98
CH4 stationary combustion	0.003	0.98
PFC from the production of halocarbons and SF6	0.002	0.98
CH4 Mobile combustion: Road Vehicles	0.002	0.98
CO2 Emissions from solvent use	0.002	0.99
CO2 Mobile combustion: Other	0.002	0.99
N2O stationary combustion	0.002	0.99
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	0.001	0.99
CO2 Emissions from Waste Incineration	0.001	0.99
CO2 Mobile combustion: Waterborne Navigation	0.001	0.99
N2O Emissions from Wastewater Handling	0.001	0.99
N2O Mobile combustion: Road Vehicles	0.001	0.99
N2O Emissions from solvent use	0.001	1.00
PFC, HFC, SF6 Semiconductor manufacturing	0.001	1.00
CO2 Lime production	0.001	1.00
CO2 Other industrial processes	0.001	1.00
SF6 Production of SF6	0.000	1.00
SF6 Electrical Equipment	0.000	1.00
N2O from animal production	0.000	1.00
CH4 from Rice production	0.000	1.00
N2O Mobile combustion: Other	0.000	1.00

Table A1.3 Results of the key category analysis with LULUCF. Approach 1 Level assessment, year 2011

CATEGORIES	2011 CO₂ eq.	Level assessment	Cumulative Percentage
CO ₂ stationary combustion gaseous fuels	148,023	0.278	0.28
CO ₂ Mobile combustion: Road Vehicles	108,426	0.203	0.48
CO ₂ stationary combustion solid fuels	61,736	0.116	0.60
CO ₂ stationary combustion liquid fuels	58,282	0.109	0.71
CO ₂ Forest land remaining Forest Land	-23,742	0.045	0.75
CO ₂ Cement production	12,583	0.024	0.77
CH ₄ from Solid waste Disposal Sites	12,533	0.023	0.80
CH ₄ Enteric Fermentation in Domestic Livestock	10,761	0.020	0.82
HFC, PFC substitutes for ODS	9,294	0.017	0.84
CO ₂ Land converted to Grassland	-7,665	0.014	0.85
Direct N ₂ O Agricultural Soils	7,350	0.014	0.86
Indirect N ₂ O from Nitrogen used in agriculture	6,473	0.012	0.88
CO ₂ Land converted to Forest Land	-5,801	0.011	0.89
CO ₂ stationary combustion other fuels	5,471	0.010	0.90
CH ₄ Fugitive emissions from Oil and Gas Operations	5,008	0.009	0.91
CO ₂ Mobile combustion: Waterborne Navigation	4,873	0.009	0.91
N ₂ O stationary combustion	3,775	0.007	0.92
N ₂ O Manure Management	3,716	0.007	0.93
CO ₂ Land converted to Settlements	3,397	0.006	0.94
CO ₂ Cropland remaining Cropland	3,339.01	0.01	0.94
CH ₄ Emissions from Wastewater Handling	2,733.94	0.01	0.95
CO ₂ Fugitive emissions from Oil and Gas Operations	2,315	0.004	0.95
CO ₂ Mobile combustion: Aircraft	2,299	0.004	0.96
CH ₄ Manure Management	2,114	0.004	0.96
CO ₂ Lime production	2,069	0.004	0.96
N ₂ O Emissions from Wastewater Handling	1,937	0.004	0.97
CO ₂ Other industrial processes	1,906	0.004	0.97
CH ₄ from Rice production	1,550	0.003	0.97
N ₂ O from animal production	1,549	0.003	0.98
CO ₂ Limestone and Dolomite Use	1,481	0.003	0.98
CH ₄ stationary combustion	1,373	0.003	0.98
CO ₂ Mobile combustion: Other	1,325	0.002	0.98
CO ₂ Iron and Steel production	1,297	0.002	0.99
PFC from the production of halocarbons and SF ₆	1,266	0.002	0.99
CO ₂ Emissions from solvent use	1,080	0.002	0.99
N ₂ O Mobile combustion: Road Vehicles	1,044	0.002	0.99
CO ₂ Ammonia production	839	0.002	0.99
N ₂ O Emissions from solvent use	577	0.001	1.00
CO ₂ Grassland remaining Grassland	-366	0.001	1.00
SF ₆ Electrical Equipment	298	0.001	1.00
CH ₄ Mobile combustion: Road Vehicles	271	0.001	1.00

Table A1.4 Results of the key category analysis with LULUCF. Approach 1 Trend assessment, 1990-2011

CATEGORIES	Contribution to trend (%)	Cumulative Percentage
CO2 stationary combustion liquid fuels	0.315	0.32
CO2 stationary combustion gaseous fuels	0.279	0.59
CO2 Mobile combustion: Road Vehicles	0.094	0.69
HFC, PFC substitutes for ODS	0.036	0.72
CO2 stationary combustion solid fuels	0.033	0.76
CO2 Land converted to Grassland	0.030	0.79
CO2 Forest land remaining Forest Land	0.026	0.81
CO2 Cropland remaining Cropland	0.021	0.83
CO2 stationary combustion other fuels	0.018	0.85
N2O Adipic Acid	0.016	0.87
CO2 Land converted to Forest Land	0.015	0.88
CO2 Grassland remaining Grassland	0.015	0.90
CO2 Cement production	0.008	0.91
N2O Nitric Acid	0.007	0.91
CO2 Ammonia production	0.007	0.92
CH4 Fugitive emissions from Oil and Gas Operations	0.006	0.93
CO2 Iron and Steel production	0.006	0.93
PFC Aluminium production	0.006	0.94
Direct N2O Agricultural Soils	0.005	0.94
CH4 from Solid waste Disposal Sites	0.005	0.95
CO2 Land converted to Settlements	0.004	0.95
CH4 Manure Management	0.004	0.96
CH4 Emissions from Wastewater Handling	0.004	0.96
Indirect N2O from Nitrogen used in agriculture	0.003	0.96
CO2 Mobile combustion: Aircraft	0.003	0.97
CO2 Limestone and Dolomite Use	0.003	0.97
CO2 Fugitive emissions from Oil and Gas Operations	0.003	0.97
CO2 Land converted to Cropland	0.003	0.97
CH4 stationary combustion	0.003	0.98
N2O stationary combustion	0.002	0.98
PFC from the production of halocarbons and SF6	0.002	0.98
CH4 Mobile combustion: Road Vehicles	0.002	0.98
CO2 Emissions from solvent use	0.002	0.98
CO2 Mobile combustion: Other	0.002	0.99
CH4 Enteric Fermentation in Domestic Livestock	0.001	0.99
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	0.001	0.99
N2O Emissions from Wastewater Handling	0.001	0.99
CH4 Grassland remaining Grassland	0.001	0.99
N2O Mobile combustion: Road Vehicles	0.001	0.99
CO2 Emissions from Waste Incineration	0.001	0.99
CO2 Lime production	0.001	0.99
CO2 Other industrial processes	0.001	0.99
N2O Manure Management	0.001	1.00
PFC, HFC, SF6 Semiconductor manufacturing	0.001	1.00
N2O Emissions from solvent use	0.001	1.00
CH4 from Rice production	0.000	1.00

The application of Approach 1, excluding LULUCF categories, gives as a result 18 key categories accounting for the 95% of the total levels; when applying the trend analysis, excluding LULUCF categories, the key categories decreased to 16 with some differences with respect to the previous list (Tables A1.1, A1.2).

The Approach 1 *key category* level assessment, repeated for the full inventory including the LULUCF, results in 23 key categories (sources and sinks), whereas 21 key categories outcome from the trend analysis, with some differences as respect to the list resulting from level assessment (Tables A1.3, A1.4).

A1.3 Uncertainty assessment (IPCC Approach 1)

Approach 2 for the identification of key categories implies the assessment of the uncertainty analysis to an emission inventory.

As already mentioned, the IPCC Approach 1 has been applied to the Italian GHG inventory to estimate uncertainties for the base year and the last submitted year. In this section, detailed results are reported for the 2011 inventory.

The uncertainty analysis has also been implemented both excluding and including the LULUCF sector in the national totals.

Results are reported in Table A1.5, for the year 2011, excluding the LULUCF sector.

Details on the method used for LULUCF are described in the relevant chapter, chapter 7. In Table A1.6, results by category, concerning only CO₂ emissions and removals, are reported whereas in Table A1.7, results include CO₂, CH₄, N₂O emissions and removals. Finally, in Table A1.8 figures of inventory total uncertainty, including the LULUCF sector, are shown.

Table A1.5 Results of the uncertainty analysis excluding LULUCF (Approach 1). Year 2011

IPCC category	Gas	Emissions		Uncertainty			Sensitivity			Uncertainty in trend		
		1990	2011	AD	EF	Combined	Contribution to variance	Type A	Type B	introduced	introduced	in total national emissions
										by EF uncertainty	by AD uncertainty	
Gg CO ₂ eq.												
CO2 stationary combustion liquid fuels	CO2	153,467	58,282	3%	3%	0.042	0.000	0.166	0.112	0.005	0.005	0.000
CO2 stationary combustion solid fuels	CO2	58,993	61,736	3%	3%	0.042	0.000	0.012	0.119	0.000	0.005	0.000
CO2 stationary combustion gaseous fuels	CO2	85,066	148,023	3%	3%	0.042	0.000	0.131	0.285	0.004	0.012	0.000
CO2 stationary combustion other fuels	CO2	887	5,471	3%	3%	0.042	0.000	0.009	0.011	0.000	0.000	0.000
CH4 stationary combustion	CH4	784	1,373	3%	50%	0.501	0.000	0.001	0.003	0.001	0.000	0.000
N2O stationary combustion	N2O	3,533	3,775	3%	50%	0.501	0.000	0.001	0.007	0.000	0.000	0.000
CO2 Mobile combustion: Road Vehicles	CO2	93,387	108,426	3%	3%	0.042	0.000	0.039	0.209	0.001	0.009	0.000
CH4 Mobile combustion: Road Vehicles	CH4	791	271	3%	40%	0.401	0.000	0.001	0.001	0.000	0.000	0.000
N2O Mobile combustion: Road Vehicles	N2O	900	1,044	3%	50%	0.501	0.000	0.000	0.002	0.000	0.000	0.000
CO2 Mobile combustion: Waterborne Navigation	CO2	5,420	4,873	3%	3%	0.042	0.000	0.000	0.009	0.000	0.000	0.000
CH4 Mobile combustion: Waterborne Navigation	CH4	29	21	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
N2O Mobile combustion: Waterborne Navigation	N2O	39	37	3%	100%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Mobile combustion: Aircraft	CO2	1,613	2,299	3%	3%	0.042	0.000	0.002	0.004	0.000	0.000	0.000
CH4 Mobile combustion: Aircraft	CH4	1	1	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
N2O Mobile combustion: Aircraft	N2O	14	20	3%	100%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Mobile combustion: Other	CO2	1,894	1,325	3%	5%	0.058	0.000	0.001	0.003	0.000	0.000	0.000
CH4 Mobile combustion: Other	CH4	5	2	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
N2O Mobile combustion: Other	N2O	131	59	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	127	71	3%	200%	2.000	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Fugitive emissions from Oil and Gas Operations	CO2	3,344	2,315	3%	25%	0.252	0.000	0.002	0.004	0.000	0.000	0.000
CH4 Fugitive emissions from Oil and Gas Operations	CH4	7,298	5,008	3%	25%	0.252	0.000	0.004	0.010	0.001	0.000	0.000
N2O Fugitive emissions from Oil and Gas Operations	N2O	12	11	3%	25%	0.252	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Cement production	CO2	16,084	12,583	3%	10%	0.104	0.000	0.005	0.024	0.000	0.001	0.000
CO2 Lime production	CO2	2,042	2,069	3%	10%	0.104	0.000	0.000	0.004	0.000	0.000	0.000
CO2 Limestone and Dolomite Use	CO2	2,540	1,481	3%	10%	0.104	0.000	0.002	0.003	0.000	0.000	0.000
CO2 Iron and Steel production	CO2	3,124	1,297	3%	10%	0.104	0.000	0.003	0.002	0.000	0.000	0.000
CO2 Ammonia production	CO2	2,765	839	3%	10%	0.104	0.000	0.003	0.002	0.000	0.000	0.000
CO2 Other industrial processes	CO2	1,880	1,906	3%	10%	0.104	0.000	0.000	0.004	0.000	0.000	0.000
N2O Adipic Acid	N2O	4,579	116	3%	10%	0.104	0.000	0.008	0.000	0.001	0.000	0.000
N2O Nitric Acid	N2O	2,086	179	3%	10%	0.104	0.000	0.003	0.000	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	58	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000

Table A1.5 Results of the uncertainty analysis excluding LULUCF (Approach 1). Year 2011 (continued)

IPCC category	Gas	Emissions		Uncertainty			Sensitivity			Uncertainty in trend		
		1990	2011	AD	EF	Combined	Contribution to variance	Type A	Type B	introduced by EF	introduced by AD	in total national
										uncertainty	uncertainty	emissions
Gg CO2 eq.												
PFC Aluminium production	PFC	1,673	81	5%	10%	0.112	0.000	0.003	0.000	0.000	0.000	0.000
SF6, HFC Magnesium production	SF6-HI	0	4	5%	5%	0.071	0.000	0.000	0.000	0.000	0.000	0.000
SF6 Electrical Equipment	SF6	213	298	5%	10%	0.112	0.000	0.000	0.001	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-HFC	0	169	30%	50%	0.583	0.000	0.000	0.000	0.000	0.000	0.000
HFC, PFC substitutes for ODS	HFC	0	9,294	30%	50%	0.583	0.000	0.018	0.018	0.009	0.008	0.000
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	HFC	351	0	5%	10%	0.112	0.000	0.001	0.000	0.000	0.000	0.000
PFC from the production of halocarbons and SF6	PFC	813	1,266	5%	10%	0.112	0.000	0.001	0.002	0.000	0.000	0.000
CH4 Enteric Fermentation in Domestic Livestock	CH4	12,278	10,761	20%	20%	0.283	0.000	0.002	0.021	0.000	0.006	0.000
CH4 Manure Management	CH4	3,462	2,114	20%	100%	1.020	0.000	0.002	0.004	0.002	0.001	0.000
N2O Manure Management	N2O	3,921	3,716	20%	100%	1.020	0.000	0.000	0.007	0.000	0.002	0.000
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	9,607	7,350	20%	100%	1.020	0.000	0.003	0.014	0.003	0.004	0.000
Indirect N2O from Nitrogen used in agriculture	N2O	8,141	6,473	20%	100%	1.020	0.000	0.002	0.012	0.002	0.004	0.000
CH4 from Rice production	CH4	1,576	1,550	3%	20%	0.202	0.000	0.000	0.003	0.000	0.000	0.000
N2O from animal production	N2O	1,736	1,549	20%	100%	1.020	0.000	0.000	0.003	0.000	0.001	0.000
CH4 from Solid waste Disposal Sites	CH4	15,254	12,533	20%	30%	0.361	0.000	0.004	0.024	0.001	0.007	0.000
CH4 Emissions from Wastewater Handling	CH4	1,990	2,734	100%	30%	1.044	0.000	0.002	0.005	0.000	0.007	0.000
N2O Emissions from Wastewater Handling	N2O	1,831	1,937	30%	30%	0.424	0.000	0.000	0.004	0.000	0.002	0.000
CO2 Emissions from Waste Incineration	CO2	507	235	5%	25%	0.255	0.000	0.000	0.000	0.000	0.000	0.000
CH4 Emissions from Waste Incineration	CH4	44	51	5%	20%	0.206	0.000	0.000	0.000	0.000	0.000	0.000
N2O Emissions from Waste Incineration	N2O	39	26	5%	100%	1.001	0.000	0.000	0.000	0.000	0.000	0.000
CH4 Emissions from Other Waste	CH4	0	5	10%	100%	1.005	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Emissions from solvent use	CO2	1,642	1,080	30%	50%	0.583	0.000	0.001	0.002	0.000	0.001	0.000
N2O Emissions from solvent use	N2O	812	577	50%	10%	0.510	0.000	0.000	0.001	0.000	0.001	0.000
TOTAL		518,984	488,792				0.001					0.001
						Percentage uncertainty in total inventory	3.4%				Trend uncertainty	2.6%

Table A1.6 Results of the uncertainty analysis for the LULUCF sector – CO₂ (Approach 1)

IPCC	Gas	Emissions		Uncertainty		Sensitivity				Trend uncertainty		
Category		1990	2011	AD	EF	Combined uncertainty	Contribution to variance	Type A	Type B	in LULUCF emissions introduced by EF uncertainty	in LULUCF emissions introduced by AD uncertainty	in total LULUCF emissions
Gg CO ₂ eq												
A. Forest Land	CO ₂	-17,282	-29,544	27%	43%	51%	24%	86%	227%	37%	87%	88%
B. Cropland	CO ₂	-1,112	3,333	75%	75%	106%	1%	46%	26%	34%	27%	19%
C. Grassland	CO ₂	2,843	-8,031	75%	75%	106%	8%	113%	62%	85%	65%	115%
D. Wetlands	CO ₂	0	0			0%	0%	0%	0%	0%	0%	0%
E. Settlements	CO ₂	2,516	3,397	75%	75%	106%	1%	20%	26%	15%	28%	10%
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		-13,035	-30,845				34%					232%
						Percentage uncertainty	58%				Trend uncertainty	152%

^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 A1.7 Results of the uncertainty analysis for the LULUCF sector – CO₂, CH₄, N₂O (Approach 1)

IPCC	Gas	Emissions		Uncertainty		Sensitivity			Trend uncertainty			
Category		1990	2011	AD	EF	Combined uncertainty	Contribution to variance	Type A	Type B	in LULUCF emissions introduced by EF uncertainty	in LULUCF emissions introduced by AD uncertainty	in total LULUCF emissions
Gg CO ₂ eq												
A. Forest Land	CO ₂ eq	-17,098	-29,480	27%	43%	51%	24%	110%	243%	47%	93%	108%
B. Cropland	CO ₂ eq	-1,015	3,344	75%	75%	106%	1%	48%	28%	36%	29%	22%
C. Grassland	CO ₂ eq	3,444	-7,852	75%	75%	106%	7%	136%	65%	102%	69%	151%
D. Wetlands	CO ₂ eq	0	0			0%	0%	0%	0%	0%	0%	0%
E. Settlements	CO ₂ eq	2,516	3,397	75%	75%	106%	1%	24%	28%	18%	30%	12%
F. Other Land	CO ₂ eq	0	0			0%	0%	0%	0%	0%	0%	0%
G. Other	CO ₂ eq	0	0			0%	0%	0%	0%	0%	0%	0%
TOTAL		-12,154	-30,590				34%					293%
						Percentage uncertainty	58%				Trend uncertainty	171%

Table A1.8 Results of the uncertainty analysis including LULUCF (Approach 1). Year 2011

IPCC category	Emissions			Uncertainty			Sensitivity			Uncertainty in trend		
	Gas	1990	2011	AD	EF	Combined	Contribution to variance	Type A	Type B	introduced by EF	introduced by AD	in total national emissions
		Gg	Gg							uncertainty	uncertainty	
CO2 stationary combustion liquid fuels	CO2	153,467	58,282	3%	3%	0.042	0.000	0.158	0.115	0.005	0.005	0.000
CO2 stationary combustion solid fuels	CO2	58,993	61,736	3%	3%	0.042	0.000	0.017	0.122	0.000	0.005	0.000
CO2 stationary combustion gaseous fuels	CO2	85,066	148,023	3%	3%	0.042	0.000	0.140	0.292	0.004	0.012	0.000
CO2 stationary combustion other fuels	CO2	887	5,471	3%	3%	0.042	0.000	0.009	0.011	0.000	0.000	0.000
CH4 stationary combustion	CH4	784	1,373	3%	50%	0.501	0.000	0.001	0.003	0.001	0.000	0.000
N2O stationary combustion	N2O	3,533	3,775	3%	50%	0.501	0.000	0.001	0.007	0.001	0.000	0.000
CO2 Mobile combustion: Road Vehicles	CO2	93,387	108,426	3%	3%	0.042	0.000	0.047	0.214	0.001	0.009	0.000
CH4 Mobile combustion: Road Vehicles	CH4	791	271	3%	40%	0.401	0.000	0.001	0.001	0.000	0.000	0.000
N2O Mobile combustion: Road Vehicles	N2O	900	1,044	3%	50%	0.501	0.000	0.000	0.002	0.000	0.000	0.000
CO2 Mobile combustion: Waterborne Navigation	CO2	5,420	4,873	3%	3%	0.042	0.000	0.000	0.010	0.000	0.000	0.000
CH4 Mobile combustion: Waterborne Navigation	CH4	29	21	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
N2O Mobile combustion: Waterborne Navigation	N2O	39	37	3%	100%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Mobile combustion: Aircraft	CO2	1,613	2,299	3%	3%	0.042	0.000	0.002	0.005	0.000	0.000	0.000
CH4 Mobile combustion: Aircraft	CH4	1	1	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
N2O Mobile combustion: Aircraft	N2O	14	20	3%	100%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
Other	CO2	1,894	1,325	3%	5%	0.058	0.000	0.001	0.003	0.000	0.000	0.000
CH4 Mobile combustion: Other	CH4	5	2	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
N2O Mobile combustion: Other	N2O	131	59	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	127	71	3%	200%	2.000	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Fugitive emissions from Oil and Gas Operations	CO2	3,344	2,315	3%	25%	0.252	0.000	0.001	0.005	0.000	0.000	0.000
CH4 Fugitive emissions from Oil and Gas Operations	CH4	7,298	5,008	3%	25%	0.252	0.000	0.003	0.010	0.001	0.000	0.000
N2O Fugitive emissions from Oil and Gas Operations	N2O	12	11	3%	25%	0.252	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Cement production	CO2	16,084	12,583	3%	10%	0.104	0.000	0.004	0.025	0.000	0.001	0.000
CO2 Lime production	CO2	2,042	2,069	3%	10%	0.104	0.000	0.000	0.004	0.000	0.000	0.000
CO2 Limestone and Dolomite Use	CO2	2,540	1,481	3%	10%	0.104	0.000	0.002	0.003	0.000	0.000	0.000
CO2 Iron and Steel production	CO2	3,124	1,297	3%	10%	0.104	0.000	0.003	0.003	0.000	0.000	0.000
CO2 Ammonia production	CO2	2,765	839	3%	10%	0.104	0.000	0.003	0.002	0.000	0.000	0.000
CO2 Other industrial processes	CO2	1,880	1,906	3%	10%	0.104	0.000	0.000	0.004	0.000	0.000	0.000
N2O Adipic Acid	N2O	4,579	116	3%	10%	0.104	0.000	0.008	0.000	0.001	0.000	0.000
N2O Nitric Acid	N2O	2,086	179	3%	10%	0.104	0.000	0.003	0.000	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	58	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
PFC Aluminium production	PFC	1,673	81	5%	10%	0.112	0.000	0.003	0.000	0.000	0.000	0.000
SF6, HFC Magnesium production	SF6-H	0	4	5%	5%	0.071	0.000	0.000	0.000	0.000	0.000	0.000
SF6 Electrical Equipment	SF6	213	298	5%	10%	0.112	0.000	0.000	0.001	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	169	30%	50%	0.583	0.000	0.000	0.000	0.000	0.000	0.000
HFC, PFC substitutes for ODS	HFC	0	9,294	30%	50%	0.583	0.000	0.018	0.018	0.009	0.008	0.000
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	HFC	351	0	5%	10%	0.112	0.000	0.001	0.000	0.000	0.000	0.000
PFC from the production of halocarbons and SF6	PFC	813	1,266	5%	10%	0.112	0.000	0.001	0.002	0.000	0.000	0.000

Table A1.8 Results of the uncertainty analysis including LULUCF (Approach 1). Year 2011(continued)

IPCC category	Emissions			Uncertainty			Sensitivity			Uncertainty in trend		
	Gas	1990	2011	AD	EF	Combined	Contribution to variance	Type A	Type B	introduced by EF uncertainty	introduced by AD uncertainty	in total national emissions
	Gg	Gg										
CH4 Enteric Fermentation in Domestic Livestock	CH4	12,278	10,761	20%	20%	0.283	0.000	0.001	0.021	0.000	0.006	0.000
CH4 Manure Management	CH4	3,462	2,114	20%	100%	1.020	0.000	0.002	0.004	0.002	0.001	0.000
N2O Manure Management	N2O	3,921	3,716	20%	100%	1.020	0.000	0.000	0.007	0.000	0.002	0.000
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	9,607	7,350	20%	100%	1.020	0.000	0.003	0.015	0.003	0.004	0.000
Indirect N2O from Nitrogen used in agriculture	N2O	8,141	6,473	20%	100%	1.020	0.000	0.002	0.013	0.002	0.004	0.000
CH4 from Rice production	CH4	1,576	1,550	3%	20%	0.202	0.000	0.000	0.003	0.000	0.000	0.000
N2O from animal production	N2O	1,736	1,549	20%	100%	1.020	0.000	0.000	0.003	0.000	0.001	0.000
CH4 from Solid waste Disposal Sites	CH4	15,254	12,533	20%	30%	0.361	0.000	0.002	0.025	0.001	0.007	0.000
CH4 Emissions from Wastewater Handling	CH4	1,990	2,734	100%	30%	1.044	0.000	0.002	0.005	0.001	0.008	0.000
N2O Emissions from Wastewater Handling	N2O	1,831	1,937	30%	30%	0.424	0.000	0.001	0.004	0.000	0.002	0.000
CO2 Emissions from Waste Incineration	CO2	507	235	5%	25%	0.255	0.000	0.000	0.000	0.000	0.000	0.000
CH4 Emissions from Waste Incineration	CH4	44	51	5%	20%	0.206	0.000	0.000	0.000	0.000	0.000	0.000
N2O Emissions from Waste Incineration	N2O	39	26	5%	100%	1.001	0.000	0.000	0.000	0.000	0.000	0.000
CH4 Emissions from Other Waste	CH4	0	5	10%	100%	1.005	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Emissions from solvent use	CO2	1,642	1,080	30%	50%	0.583	0.000	0.001	0.002	0.000	0.001	0.000
N2O Emissions from solvent use	N2O	812	577	50%	10%	0.510	0.000	0.000	0.001	0.000	0.001	0.000
CO2 Forest land remaining	CO2	-15,574	-23,742	27%	43%	0.506	0.001	0.019	0.047	0.008	0.018	0.000
CH4 Forest land remaining	CH4	128	45	27%	43%	0.506	0.000	0.000	0.000	0.000	0.000	0.000
N2O Forest land remaining	N2O	1	0	27%	43%	0.506	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Cropland remaining	CO2	-1,858	3,339	75%	75%	1.061	0.000	0.010	0.007	0.007	0.007	0.000
CH4 Cropland remaining	CH4	5	2	75%	75%	1.061	0.000	0.000	0.000	0.000	0.000	0.000
N2O Cropland remaining	N2O	2	1	75%	75%	1.061	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Land converted to Forest Land	CO2	-1,708	-5,801	75%	75%	1.061	0.000	0.008	0.011	0.006	0.012	0.000
CH4 Land converted to Forest Land	CH4	55	19	75%	75%	0.506	0.000	0.000	0.000	0.000	0.000	0.000
N2O Land converted to Forest Land	N2O	0	0	75%	75%	0.506	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Land converted to Cropland	CO2	746	-6	1	1	1.061	0.000	0.001	0.000	0.001	0.000	0.000
CO2 Grassland remaining	CO2	3,784	-366	1	1	1.061	0.000	0.007	0.001	0.006	0.001	0.000
CH4 Grassland remaining	CH4	410	122	1	1	1.061	0.000	0.000	0.000	0.000	0.000	0.000
N2O Grassland remaining	N2O	190	57	1	1	1.061	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Land converted to Grassland	CO2	-941	-7,665	1	1	1.061	0.000	0.013	0.015	0.010	0.016	0.000
N2O Land converted to Cropland	N2O	90	8	1	1	1.061	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Land converted to Settlements	CO2	2,516	3,397	1	1	1.061	0.000	0.002	0.007	0.002	0.007	0.000
TOTAL		506,830	458,202				0.003					0.002
					Percentage uncertainty in total inventory		5.1%				Trend uncertainty	4.2%

Emission sources of the Italian inventory are disaggregated into a detailed level, 58 sources, according to the IPCC list in the guidelines and taking into account national circumstances and importance. Considering also the LULUCF sector, sources and sinks of the Italian inventory are disaggregated into 74 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 and Guidelines, as well as expert judgement have been used; standard deviations have also been considered whenever measurements were available.

The assumptions on which uncertainty estimations are based on are documented for each 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 and the 2006 IPCC Guidelines (IPCC, 2000; IPCC, 2006). 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 and guidelines (IPCC, 2000; IPCC, 2006) 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 estimated by Approach 1 is equal to 3.5%; if considering the LULUCF sector the overall uncertainty increases to 4.1%.

In 2011, the results of Approach 1 suggest an uncertainty of 3.4% in the combined GWP total emissions. The analysis also estimates an uncertainty of 2.6 % in the trend between 1990 and 2011.

For the LULUCF sector, the uncertainty value resulting from Approach 1 is 58% in the combined GWP total emissions for the year 2011, whereas the uncertainty in the trend is 171%. The same figures, for the level, result from the analysis applied to CO₂ emissions only. Details are shown in Tables A1.6 and A1.7.

Including the LULUCF sector in the total uncertainty assessment, Approach 1 shows an uncertainty of 5.1% in the combined GWP total emissions for the year 2011, whereas the uncertainty in the trend between 1990 and 2011 is equal to 4.2%. Results are shown in Table A1.8.

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 Approach 2 key category assessment

Approach 2 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 to reduce overall uncertainty.

Under Approach 2, the source or sink category uncertainties are incorporated by weighting the Approach 1 level and trend assessment results with the source category's relative uncertainty.

Therefore the following equations:

$$\text{Level Assessment, with Uncertainty} = \text{Approach 1 Level Assessment} \cdot \text{Relative Category Uncertainty}$$

$$\text{Trend Assessment, with Uncertainty} = \text{Approach 1 Trend Assessment} \cdot \text{Relative Category Uncertainty}$$

Approach 2 has been applied both to the base and the current year submission. In this section, detailed results are reported for the 2011 inventory, whereas for the base year results of the analysis excluding and including LULUCF categories are reported in Table A1.13 and Table A1.14.

The results of the Approach 2 key category analysis, without LULUCF categories, are provided in Table A1.9, for 2011, while in Table A1.10 results, including LULUCF categories, are shown.

The application of Approach 2 to the base year gives as a result 17 key categories accounting for the 90% of the total levels uncertainty. Including the LULUCF categories, 22 key categories result accounting for 90% of the total uncertainty levels.

For the year 2011, 16 key categories accounting for the 90% of the total levels uncertainty were identified; when applying the trend analysis the key categories increased to 18 with differences with respect to the previous list.

The application of Approach 2 to the inventory, including the LULUCF categories, results in 19 key categories which account for the 90% of the total levels uncertainty; for the trend analysis, with LULUCF, the number of key categories decreases to 18 with differences with respect to the previous list.

Table A1.9 Results of the key category analysis without LULUCF. Approach 2 Level assessment, year 2011

CATEGORIES	Share	Uncertainty	L*U	Level assessment with uncertainty	Cumulative Percentage
Direct N2O Agricultural Soils	0.02	1.0198	0.0153	0.1171	0.12
Indirect N2O from Nitrogen used in agriculture	0.01	1.0198	0.0135	0.1032	0.22
CO2 stationary combustion gaseous fuels	0.30	0.0424	0.0128	0.0981	0.32
HFC, PFC substitutes for ODS	0.02	0.5831	0.0111	0.0847	0.40
CO2 Mobile combustion: Road Vehicles	0.22	0.0424	0.0094	0.0719	0.48
CH4 from Solid waste Disposal Sites	0.03	0.3606	0.0092	0.0706	0.55
N2O Manure Management	0.01	1.0198	0.0078	0.0592	0.60
CH4 Enteric Fermentation in Domestic Livestock	0.02	0.2828	0.0062	0.0476	0.65
CH4 Emissions from Wastewater Handling	0.01	1.0440	0.0058	0.0446	0.70
CO2 stationary combustion solid fuels	0.13	0.0424	0.0054	0.0409	0.74
CO2 stationary combustion liquid fuels	0.12	0.0424	0.0051	0.0386	0.78
CH4 Manure Management	0.00	1.0198	0.0044	0.0337	0.81
N2O stationary combustion	0.01	0.5009	0.0039	0.0295	0.84
N2O from animal production	0.00	1.0198	0.0032	0.0247	0.86
CO2 Cement production	0.03	0.1044	0.0027	0.0205	0.89
CH4 Fugitive emissions from Oil and Gas Operations	0.01	0.2518	0.0026	0.0197	0.90
N2O Emissions from Wastewater Handling	0.00	0.4243	0.0017	0.0128	0.92
CH4 stationary combustion	0.00	0.5009	0.0014	0.0107	0.93
CO2 Emissions from solvent use	0.00	0.5831	0.0013	0.0098	0.94
CO2 Fugitive emissions from Oil and Gas Operations	0.00	0.2518	0.0012	0.0091	0.95
N2O Mobile combustion: Road Vehicles	0.00	0.5009	0.0011	0.0082	0.96
CH4 from Rice production	0.00	0.2022	0.0006	0.0049	0.96
N2O Emissions from solvent use	0.00	0.5099	0.0006	0.0046	0.96
CO2 stationary combustion other fuels	0.01	0.0424	0.0005	0.0036	0.97
CO2 Lime production	0.00	0.1044	0.0004	0.0034	0.97
CO2 Mobile combustion: Waterborne Navigation	0.01	0.0424	0.0004	0.0032	0.98
CO2 Other industrial processes	0.00	0.1044	0.0004	0.0031	0.98
CO2 Limestone and Dolomite Use	0.00	0.1044	0.0003	0.0024	0.98
CH4 Fugitive emissions from Coal Mining and Handling	0.00	2.0002	0.0003	0.0022	0.98
PFC from the production of halocarbons and SF6	0.00	0.1118	0.0003	0.0022	0.99
CO2 Iron and Steel production	0.00	0.1044	0.0003	0.0021	0.99
CH4 Mobile combustion: Road Vehicles	0.00	0.4011	0.0002	0.0017	0.99
PFC, HFC, SF6 Semiconductor manufacturing	0.00	0.5831	0.0002	0.0015	0.99
CO2 Mobile combustion: Aircraft	0.00	0.0424	0.0002	0.0015	0.99
CO2 Ammonia production	0.00	0.1044	0.0002	0.0014	0.99
CO2 Mobile combustion: Other	0.00	0.0583	0.0002	0.0012	0.99
CO2 Emissions from Waste Incineration	0.00	0.2550	0.0001	0.0009	1.00
N2O Mobile combustion: Other	0.00	1.0004	0.0001	0.0009	1.00
N2O Mobile combustion: Waterborne Navigation	0.00	1.0004	0.0001	0.0006	1.00
SF6 Electrical Equipment	0.00	0.1118	0.0001	0.0005	1.00
CH4 Industrial Processes	0.00	0.5009	0.0001	0.0005	1.00
N2O Emissions from Waste Incineration	0.00	1.0012	0.0001	0.0004	1.00
N2O Mobile combustion: Aircraft	0.00	1.0004	0.0000	0.0003	1.00
N2O Nitric Acid	0.00	0.1044	0.0000	0.0003	1.00
N2O Adipic Acid	0.00	0.1044	0.0000	0.0002	1.00
CH4 Mobile combustion: Waterborne Navigation	0.00	0.5009	0.0000	0.0002	1.00
CH4 Emissions from Waste Incineration	0.00	0.2062	0.0000	0.0002	1.00

Table A1.10 Results of the key category analysis without LULUCF. Approach 2 Trend assessment, 1990- 2011

CATEGORIES	Trend assessment			Relative trend assessment with uncertainty	
	assessment	Uncertainty	T*U	with uncertainty	Cumulative Percentage
HFC, PFC substitutes for ODS	0.0179	0.5831	0.0104	0.232	0.23
CO2 stationary combustion liquid fuels	0.1662	0.0424	0.0071	0.156	0.39
CO2 stationary combustion gaseous fuels	0.1308	0.0424	0.0056	0.123	0.51
Direct N2O Agricultural Soils	0.0033	1.0198	0.0033	0.074	0.59
Indirect N2O from Nitrogen used in agriculture	0.0023	1.0198	0.0023	0.052	0.64
CH4 Manure Management	0.0022	1.0198	0.0023	0.050	0.69
CH4 Emissions from Wastewater Handling	0.0017	1.0440	0.0017	0.038	0.73
CO2 Mobile combustion: Road Vehicles	0.0394	0.0424	0.0017	0.037	0.76
CH4 from Solid waste Disposal Sites	0.0035	0.3606	0.0013	0.028	0.79
CH4 Fugitive emissions from Oil and Gas Operations	0.0036	0.2518	0.0009	0.020	0.81
N2O Adipic Acid	0.0081	0.1044	0.0008	0.019	0.83
CH4 stationary combustion	0.0012	0.5009	0.0006	0.014	0.84
CO2 Emissions from solvent use	0.0009	0.5831	0.0005	0.012	0.86
CO2 Cement production	0.0049	0.1044	0.0005	0.011	0.87
CO2 stationary combustion solid fuels	0.0119	0.0424	0.0005	0.011	0.88
CH4 Enteric Fermentation in Domestic Livestock	0.0015	0.2828	0.0004	0.010	0.89
N2O stationary combustion	0.0009	0.5009	0.0004	0.010	0.90
CO2 Fugitive emissions from Oil and Gas Operations	0.0016	0.2518	0.0004	0.009	0.91
CO2 stationary combustion other fuels	0.0089	0.0424	0.0004	0.008	0.91
CH4 Mobile combustion: Road Vehicles	0.0009	0.4011	0.0004	0.008	0.92
N2O Nitric Acid	0.0034	0.1044	0.0004	0.008	0.93
CO2 Ammonia production	0.0034	0.1044	0.0004	0.008	0.94
CO2 Iron and Steel production	0.0032	0.1044	0.0003	0.007	0.95
PFC Aluminium production	0.0029	0.1118	0.0003	0.007	0.95
PFC, HFC, SF6 Semiconductor manufacturing	0.0003	0.5831	0.0002	0.004	0.96
N2O Mobile combustion: Road Vehicles	0.0004	0.5009	0.0002	0.004	0.96
N2O Emissions from solvent use	0.0004	0.5099	0.0002	0.004	0.97
CH4 Fugitive emissions from Coal Mining and Handling	0.0001	2.0002	0.0002	0.004	0.97
CO2 Limestone and Dolomite Use	0.0018	0.1044	0.0002	0.004	0.97
N2O Emissions from Wastewater Handling	0.0004	0.4243	0.0002	0.004	0.98
N2O from animal production	0.0002	1.0198	0.0002	0.004	0.98
N2O Mobile combustion: Other	0.0001	1.0004	0.0001	0.003	0.98
CO2 Emissions from Waste Incineration	0.0005	0.2550	0.0001	0.003	0.99
PFC from the production of halocarbons and SF6	0.0010	0.1118	0.0001	0.002	0.99
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	0.0006	0.1118	0.0001	0.002	0.99
CO2 Mobile combustion: Aircraft	0.0015	0.0424	0.0001	0.001	0.99
CO2 Mobile combustion: Other	0.0009	0.0583	0.0001	0.001	0.99
N2O Manure Management	0.0000	1.0198	0.0000	0.001	0.99
CH4 Industrial Processes	0.0001	0.5009	0.0000	0.001	1.00
CO2 Lime production	0.0003	0.1044	0.0000	0.001	1.00
CO2 Other industrial processes	0.0003	0.1044	0.0000	0.001	1.00
CH4 from Rice production	0.0001	0.2022	0.0000	0.001	1.00
SF6 Production of SF6	0.0002	0.1118	0.0000	0.001	1.00
SF6 Electrical Equipment	0.0002	0.1118	0.0000	0.000	1.00
N2O Emissions from Waste Incineration	0.0000	1.0012	0.0000	0.000	1.00
CO2 Mobile combustion: Waterborne Navigation	0.0004	0.0424	0.0000	0.000	1.00
N2O Mobile combustion: Aircraft	0.0000	1.0004	0.0000	0.000	1.00
CH4 Emissions from Other Waste	0.0000	1.0050	0.0000	0.000	1.00
CH4 Mobile combustion: Waterborne Navigation	0.0000	0.5009	0.0000	0.000	1.00
CH4 Emissions from Waste Incineration	0.0000	0.2062	0.0000	0.000	1.00
CH4 Mobile combustion: Other	0.0000	0.5009	0.0000	0.000	1.00
N2O Other industrial processes	0.0000	0.1044	0.0000	0.000	1.00
CH4 Agricultural Residue Burning	0.0000	0.5385	0.0000	0.000	1.00

Table A1.11 Results of the key category analysis with LULUCF. Approach 2 Level assessment, year 2011

CATEGORIES	Share	Uncertainty	L*U	Level assessment with uncertainty	Cumulative Percentage
CO2 Forest land remaining Forest Land	0.04	0.5063	0.0225	0.1226	0.12
CO2 Land converted to Grassland	0.01	1.0607	0.0152	0.0829	0.21
Direct N2O Agricultural Soils	0.01	1.0198	0.0141	0.0764	0.28
Indirect N2O from Nitrogen used in agriculture	0.01	1.0198	0.0124	0.0673	0.35
CO2 stationary combustion gaseous fuels	0.28	0.0424	0.0118	0.0640	0.41
CO2 Land converted to Forest Land	0.01	1.0607	0.0115	0.0627	0.48
HFC, PFC substitutes for ODS	0.02	0.5831	0.0102	0.0553	0.53
CO2 Mobile combustion: Road Vehicles	0.20	0.0424	0.0086	0.0469	0.58
CH4 from Solid waste Disposal Sites	0.02	0.3606	0.0085	0.0461	0.62
N2O Manure Management	0.01	1.0198	0.0071	0.0386	0.66
CO2 Land converted to Settlements	0.01	1.0607	0.0068	0.0367	0.70
CO2 Cropland remaining Cropland	0.01	1.0607	0.0066	0.0361	0.74
CH4 Enteric Fermentation in Domestic Livestock	0.02	0.2828	0.0057	0.0310	0.77
CH4 Emissions from Wastewater Handling	0.01	1.0440	0.0054	0.0291	0.80
CO2 stationary combustion solid fuels	0.12	0.0424	0.0049	0.0267	0.82
CO2 stationary combustion liquid fuels	0.11	0.0424	0.0046	0.0252	0.85
CH4 Manure Management	0.00	1.0198	0.0040	0.0220	0.87
N2O stationary combustion	0.01	0.5009	0.0035	0.0193	0.89
N2O from animal production	0.00	1.0198	0.0030	0.0161	0.91
CO2 Cement production	0.02	0.1044	0.0025	0.0134	0.92
CH4 Fugitive emissions from Oil and Gas Operations	0.01	0.2518	0.0024	0.0129	0.93
N2O Emissions from Wastewater Handling	0.00	0.4243	0.0015	0.0084	0.94
CH4 stationary combustion	0.00	0.5009	0.0013	0.0070	0.95
CO2 Emissions from solvent use	0.00	0.5831	0.0012	0.0064	0.95
CO2 Fugitive emissions from Oil and Gas Operations	0.00	0.2518	0.0011	0.0059	0.96
N2O Mobile combustion: Road Vehicles	0.00	0.5009	0.0010	0.0053	0.96
CO2 Grassland remaining Grassland	0.00	1.0607	0.0007	0.0040	0.97
CH4 from Rice production	0.00	0.2022	0.0006	0.0032	0.97
N2O Emissions from solvent use	0.00	0.5099	0.0006	0.0030	0.97
CO2 stationary combustion other fuels	0.01	0.0424	0.0004	0.0024	0.98
CO2 Lime production	0.00	0.1044	0.0004	0.0022	0.98
CO2 Mobile combustion: Waterborne Navigation	0.01	0.0424	0.0004	0.0021	0.98
CO2 Other industrial processes	0.00	0.1044	0.0004	0.0020	0.98
CO2 Limestone and Dolomite Use	0.00	0.1044	0.0003	0.0016	0.98
CH4 Fugitive emissions from Coal Mining and Handling	0.00	2.0002	0.0003	0.0015	0.99
PFC from the production of halocarbons and SF6	0.00	0.1118	0.0003	0.0014	0.99
CO2 Iron and Steel production	0.00	0.1044	0.0003	0.0014	0.99
CH4 Grassland remaining Grassland	0.00	1.0607	0.0002	0.0013	0.99
CH4 Mobile combustion: Road Vehicles	0.00	0.4011	0.0002	0.0011	0.99
PFC, HFC, SF6 Semiconductor manufacturing	0.00	0.5831	0.0002	0.0010	0.99
CO2 Mobile combustion: Aircraft	0.00	0.0424	0.0002	0.0010	0.99
CO2 Ammonia production	0.00	0.1044	0.0002	0.0009	0.99
CO2 Mobile combustion: Other	0.00	0.0583	0.0001	0.0008	1.00
N2O Grassland remaining Grassland	0.00	1.0607	0.0001	0.0006	1.00
CO2 Emissions from Waste Incineration	0.00	0.2550	0.0001	0.0006	1.00
N2O Mobile combustion: Other	0.00	1.0004	0.0001	0.0006	1.00

Table A1.12 Results of the key category analysis with LULUCF. Approach 2 Trend assessment, 1990- 2011

CATEGORIES	Trend assessment	Uncertainty	T*U	Relative trend assessment	Cumulative Percentage
				with uncertainty	
CO2 Land converted to Grassland	0.0140	1.0607	0.0149	0.16	0.16
CO2 Cropland remaining Cropland	0.0098	1.0607	0.0104	0.11	0.28
HFC, PFC substitutes for ODS	0.0170	0.5831	0.0099	0.11	0.38
CO2 Land converted to Forest Land	0.0072	1.0607	0.0076	0.08	0.47
CO2 Grassland remaining Grassland	0.0069	1.0607	0.0073	0.08	0.55
CO2 stationary combustion liquid fuels	0.1471	0.0424	0.0062	0.07	0.61
CO2 Forest land remaining Forest Land	0.0122	0.5063	0.0062	0.07	0.68
CO2 stationary combustion gaseous fuels	0.1300	0.0424	0.0055	0.06	0.74
Direct N2O Agricultural Soils	0.0024	1.0198	0.0025	0.03	0.77
CO2 Land converted to Settlements	0.0021	1.0607	0.0022	0.02	0.79
CH4 Manure Management	0.0019	1.0198	0.0019	0.02	0.81
CO2 Mobile combustion: Road Vehicles	0.0439	0.0424	0.0019	0.02	0.83
CH4 Emissions from Wastewater Handling	0.0017	1.0440	0.0018	0.02	0.85
Indirect N2O from Nitrogen used in agriculture	0.0016	1.0198	0.0017	0.02	0.87
CO2 Land converted to Cropland	0.0012	1.0607	0.0013	0.01	0.89
CH4 from Solid waste Disposal Sites	0.0023	0.3606	0.0008	0.01	0.89
N2O Adipic Acid	0.0074	0.1044	0.0008	0.01	0.90
CH4 Fugitive emissions from Oil and Gas Operations	0.0029	0.2518	0.0007	0.01	0.91
CO2 stationary combustion solid fuels	0.0154	0.0424	0.0007	0.01	0.92
CH4 stationary combustion	0.0012	0.5009	0.0006	0.01	0.92
N2O stationary combustion	0.0011	0.5009	0.0005	0.01	0.93
CH4 Grassland remaining Grassland	0.0005	1.0607	0.0005	0.01	0.94
CO2 Emissions from solvent use	0.0007	0.5831	0.0004	0.00	0.94
CO2 Cement production	0.0036	0.1044	0.0004	0.00	0.94
CO2 stationary combustion other fuels	0.0085	0.0424	0.0004	0.00	0.95
CO2 Fugitive emissions from Oil and Gas Operations	0.0013	0.2518	0.0003	0.00	0.95
CH4 Mobile combustion: Road Vehicles	0.0008	0.4011	0.0003	0.00	0.96
N2O Nitric Acid	0.0031	0.1044	0.0003	0.00	0.96
N2O Manure Management	0.0003	1.0198	0.0003	0.00	0.96
CO2 Ammonia production	0.0030	0.1044	0.0003	0.00	0.97
PFC Aluminium production	0.0026	0.1118	0.0003	0.00	0.97
CO2 Iron and Steel production	0.0028	0.1044	0.0003	0.00	0.97
N2O Grassland remaining Grassland	0.0002	1.0607	0.0002	0.00	0.98
N2O Emissions from Wastewater Handling	0.0005	0.4243	0.0002	0.00	0.98
N2O Mobile combustion: Road Vehicles	0.0004	0.5009	0.0002	0.00	0.98
PFC, HFC, SF6 Semiconductor manufacturing	0.0003	0.5831	0.0002	0.00	0.98
CH4 Enteric Fermentation in Domestic Livestock	0.0006	0.2828	0.0002	0.00	0.98
CH4 Fugitive emissions from Coal Mining and Handling	0.0001	2.0002	0.0002	0.00	0.99
CO2 Limestone and Dolomite Use	0.0015	0.1044	0.0002	0.00	0.99
N2O Emissions from solvent use	0.0003	0.5099	0.0001	0.00	0.99
N2O Land converted to Cropland	0.0001	1.0607	0.0001	0.00	0.99
PFC from the production of halocarbons and SF6	0.0010	0.1118	0.0001	0.00	0.99
N2O Mobile combustion: Other	0.0001	1.0004	0.0001	0.00	0.99
CO2 Emissions from Waste Incineration	0.0004	0.2550	0.0001	0.00	0.99
CH4 Forest land remaining Forest Land	0.0001	0.5063	0.0001	0.00	0.99
CO2 Mobile combustion: Aircraft	0.0015	0.0424	0.0001	0.00	1.00
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	0.0006	0.1118	0.0001	0.00	1.00
CH4 from Rice production	0.0002	0.2022	0.0000	0.00	1.00

Table A1.13 Results of the key category analysis without LULUCF. Approach 2 Level assessment, year 1990

CATEGORIES	Share	Uncertainty	L*U	Level assessment with uncertainty	Cumulative Percentage
Direct N2O Agricultural Soils	0.02	1.0198	0.0189	0.1435	0.14
Indirect N2O from Nitrogen used in agriculture	0.02	1.0198	0.0160	0.1216	0.27
CO2 stationary combustion liquid fuels	0.30	0.0424	0.0125	0.0954	0.36
CH4 from Solid waste Disposal Sites	0.03	0.3606	0.0106	0.0806	0.44
N2O Manure Management	0.01	1.0198	0.0077	0.0586	0.50
CO2 Mobile combustion: Road Vehicles	0.18	0.0424	0.0076	0.0580	0.56
CO2 stationary combustion gaseous fuels	0.16	0.0424	0.0070	0.0529	0.61
CH4 Manure Management	0.01	1.0198	0.0068	0.0517	0.66
CH4 Enteric Fermentation in Domestic Livestock	0.02	0.2828	0.0067	0.0509	0.71
CO2 stationary combustion solid fuels	0.11	0.0424	0.0048	0.0367	0.75
CH4 Emissions from Wastewater Handling	0.00	1.0440	0.0040	0.0304	0.78
CH4 Fugitive emissions from Oil and Gas Operations	0.01	0.2518	0.0035	0.0269	0.81
N2O from animal production	0.00	1.0198	0.0034	0.0259	0.83
N2O stationary combustion	0.01	0.5009	0.0034	0.0259	0.86
CO2 Cement production	0.03	0.1044	0.0032	0.0246	0.88
CO2 Emissions from solvent use	0.00	0.5831	0.0018	0.0140	0.90
CO2 Fugitive emissions from Oil and Gas Operations	0.01	0.2518	0.0016	0.0123	0.91
N2O Emissions from Wastewater Handling	0.00	0.4243	0.0015	0.0114	0.92
N2O Adipic Acid	0.01	0.1044	0.0009	0.0070	0.93
N2O Mobile combustion: Road Vehicles	0.00	0.5009	0.0009	0.0066	0.93
N2O Emissions from solvent use	0.00	0.5099	0.0008	0.0061	0.94
CH4 stationary combustion	0.00	0.5009	0.0008	0.0058	0.95
CO2 Iron and Steel production	0.01	0.1044	0.0006	0.0048	0.95
CH4 from Rice production	0.00	0.2022	0.0006	0.0047	0.96
CH4 Mobile combustion: Road Vehicles	0.00	0.4011	0.0006	0.0046	0.96
CO2 Ammonia production	0.01	0.1044	0.0006	0.0042	0.96
CO2 Limestone and Dolomite Use	0.00	0.1044	0.0005	0.0039	0.97
CH4 Fugitive emissions from Coal Mining and Handling	0.00	2.0002	0.0005	0.0037	0.97
CO2 Mobile combustion: Waterborne Navigation	0.01	0.0424	0.0004	0.0034	0.98
N2O Nitric Acid	0.00	0.1044	0.0004	0.0032	0.98
CO2 Lime production	0.00	0.1044	0.0004	0.0031	0.98
CO2 Other industrial processes	0.00	0.1044	0.0004	0.0029	0.99
PFC Aluminium production	0.00	0.1118	0.0004	0.0027	0.99
N2O Mobile combustion: Other	0.00	1.0004	0.0003	0.0019	0.99
CO2 Emissions from Waste Incineration	0.00	0.2550	0.0002	0.0019	0.99
CO2 Mobile combustion: Other	0.00	0.0583	0.0002	0.0016	0.99
PFC from the production of halocarbons and SF6	0.00	0.1118	0.0002	0.0013	0.99
CO2 Mobile combustion: Aircraft	0.00	0.0424	0.0001	0.0010	1.00
CH4 Industrial Processes	0.00	0.5009	0.0001	0.0008	1.00
N2O Mobile combustion: Waterborne Navigation	0.00	1.0004	0.0001	0.0006	1.00
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	0.00	0.1118	0.0001	0.0006	1.00

Table A1.14 Results of the key category analysis with LULUCF. Approach 2 Level assessment, year 1990

CATEGORIES	Share	Uncertainty	L*U	Level assessment with uncertainty	Cumulative Percentage
Direct N2O Agricultural Soils	0.02	1.0198	0.0179	0.1097	0.11
Indirect N2O from Nitrogen used in agriculture	0.01	1.0198	0.0152	0.0930	0.20
CO2 Forest land remaining Forest Land	0.03	0.5063	0.0144	0.0883	0.29
CO2 stationary combustion liquid fuels	0.28	0.0424	0.0119	0.0729	0.36
CH4 from Solid waste Disposal Sites	0.03	0.3606	0.0101	0.0616	0.43
CO2 Grassland remaining Grassland	0.01	1.0607	0.0073	0.0450	0.47
N2O Manure Management	0.01	1.0198	0.0073	0.0448	0.52
CO2 Mobile combustion: Road Vehicles	0.17	0.0424	0.0072	0.0444	0.56
CO2 stationary combustion gaseous fuels	0.16	0.0424	0.0066	0.0404	0.60
CH4 Manure Management	0.01	1.0198	0.0065	0.0395	0.64
CH4 Enteric Fermentation in Domestic Livestock	0.02	0.2828	0.0063	0.0389	0.68
CO2 Land converted to Settlements	0.00	1.0607	0.0049	0.0299	0.71
CO2 stationary combustion solid fuels	0.11	0.0424	0.0046	0.0280	0.74
CH4 Emissions from Wastewater Handling	0.00	1.0440	0.0038	0.0233	0.76
CO2 Cropland remaining Cropland	0.00	1.0607	0.0036	0.0221	0.78
CH4 Fugitive emissions from Oil and Gas Operations	0.01	0.2518	0.0034	0.0206	0.80
CO2 Land converted to Forest Land	0.00	1.0607	0.0033	0.0203	0.82
N2O from animal production	0.00	1.0198	0.0032	0.0198	0.84
N2O stationary combustion	0.01	0.5009	0.0032	0.0198	0.86
CO2 Cement production	0.03	0.1044	0.0031	0.0188	0.88
CO2 Land converted to Grassland	0.00	1.0607	0.0018	0.0112	0.89
CO2 Emissions from solvent use	0.00	0.5831	0.0018	0.0107	0.90
CO2 Fugitive emissions from Oil and Gas Operations	0.01	0.2518	0.0015	0.0094	0.91
CO2 Land converted to Cropland	0.00	1.0607	0.0014	0.0089	0.92
N2O Emissions from Wastewater Handling	0.00	0.4243	0.0014	0.0087	0.93
N2O Adipic Acid	0.01	0.1044	0.0009	0.0054	0.94
N2O Mobile combustion: Road Vehicles	0.00	0.5009	0.0008	0.0050	0.94
CH4 Grassland remaining Grassland	0.00	1.0607	0.0008	0.0049	0.95
N2O Emissions from solvent use	0.00	0.5099	0.0008	0.0046	0.95
CH4 stationary combustion	0.00	0.5009	0.0007	0.0044	0.95
CO2 Iron and Steel production	0.01	0.1044	0.0006	0.0037	0.96
CH4 from Rice production	0.00	0.2022	0.0006	0.0036	0.96
CH4 Mobile combustion: Road Vehicles	0.00	0.4011	0.0006	0.0036	0.97
CO2 Ammonia production	0.01	0.1044	0.0005	0.0032	0.97
CO2 Limestone and Dolomite Use	0.00	0.1044	0.0005	0.0030	0.97
CH4 Fugitive emissions from Coal Mining and Handling	0.00	2.0002	0.0005	0.0028	0.97
CO2 Mobile combustion: Waterborne Navigation	0.01	0.0424	0.0004	0.0026	0.98
N2O Nitric Acid	0.00	0.1044	0.0004	0.0024	0.98
CO2 Lime production	0.00	0.1044	0.0004	0.0024	0.98
N2O Grassland remaining Grassland	0.00	1.0607	0.0004	0.0023	0.98
CO2 Other industrial processes	0.00	0.1044	0.0004	0.0022	0.99
PFC Aluminium production	0.00	0.1118	0.0003	0.0021	0.99
N2O Mobile combustion: Other	0.00	1.0004	0.0002	0.0015	0.99
CO2 Emissions from Waste Incineration	0.00	0.2550	0.0002	0.0014	0.99
CO2 Mobile combustion: Other	0.00	0.0583	0.0002	0.0012	0.99
N2O Land converted to Cropland	0.00	1.0607	0.0002	0.0011	0.99
PFC from the production of halocarbons and SF6	0.00	0.1118	0.0002	0.0010	0.99
CO2 Mobile combustion: Aircraft	0.00	0.0424	0.0001	0.0008	1.00
CH4 Forest land remaining Forest Land	0.00	0.5063	0.0001	0.0007	1.00
CH4 Land converted to Forest Land	0.00	1.0607	0.0001	0.0007	1.00

A1.5 Uncertainty assessment (IPCC Approach 2)

Montecarlo analysis was applied in the last two year submissions to estimate uncertainty of some of the key categories of the Italian inventory. In the last year submission, the analysis was carried out for the remaining key categories of the agriculture sector as reported in Table A1.15. Most of the results prove that both approaches (Approach 1 and 2) produce comparable results.

In Table A.1.15 the outcomes of the Approach 1 (error propagation) and Approach 2 (Montecarlo analysis) are shown.

Table A1.15 Comparison between uncertainty assessment by Approach 1 and Approach 2

<i>Sector</i>	<i>Categories</i>	<i>Key</i>	Approach 1 %	Approach 2 (Montecarlo) %
Energy	CO ₂ stationary combustion liquid fuels	L, T	4.2	3.3
Energy	CO ₂ stationary combustion solid fuels	L, T1	4.2	5.1
Energy	CO ₂ stationary combustion gaseous fuels	L, T	4.2	5.8
Energy	CO ₂ Mobile combustion: Road Vehicles	L, T	4.2	7.4
Energy	CH ₄ Mobile combustion: Road Vehicles	-	40.1	77.8
Energy	N ₂ O Mobile combustion: Road Vehicles	-	50.1	19.4
Energy	CH ₄ Fugitive emissions from Oil and Gas Operations	L1, T1	25.2	17.4
Industrial Processes	CO ₂ Cement production	L1	10.4	10.0
Agriculture	CH ₄ Enteric Fermentation in Domestic Livestock	L	28.3	-21.8; +31.7
Agriculture*	Direct N ₂ O Agriculture soils	L, T	101.9	21.34
Agriculture*	Indirect N ₂ O from Nitrogen used in agriculture	L, T	101.9	21.67
Agriculture*	N ₂ O Manure management	L	101.9	10.19
Agriculture*	CH ₄ Manure management	L, T2	101.9	22.96
Waste	CH ₄ from Solid waste Disposal Sites	L, T1	36.1	12.6
LULUCF	CO ₂ Forest land remaining Forest land	L, T	49.0	42.9
LULUCF	CO ₂ Land converted to Forest land	-	106.1	-147.6; 192.3
LULUCF	CO ₂ Cropland remaining Cropland	L, T	106.1	-108.5; 210.2
LULUCF	CO ₂ Land converted to Cropland	T2	106.1	-408.2; 178.5
LULUCF	CO ₂ Grassland remaining Grassland	L, T	106.1	-67.7; 75.0
LULUCF	CO ₂ Land converted to Grassland	L, T	106.1	-119.3; 194.5
LULUCF	CO ₂ Land converted to Settlements	L, T	106.1	-100.3; 49.2

* These categories have been processes in 2012 submission

A summary of the results is described in the following by category.

Energy: CO₂ from stationary combustion liquid fuels

Montecarlo analysis has been carried out for CO₂ emissions from stationary combustion of liquid fuels, for the reporting year 2009. In Table A1.16 a description of the main statistics resulting from the Montecarlo analysis is shown.

Table A1.16 Statistics of the Montecarlo analysis for CO₂ emissions from stationary combustion of liquid fuels, year 2009

	<u>Value</u>
Trials	5000
Mean	72,096,300
Median	72,096,998
Standard Deviation	1,181,053
Range Minimum	68,046,555
Range Maximum	77,401,681
Uncertainty (%)	3.28

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.1.

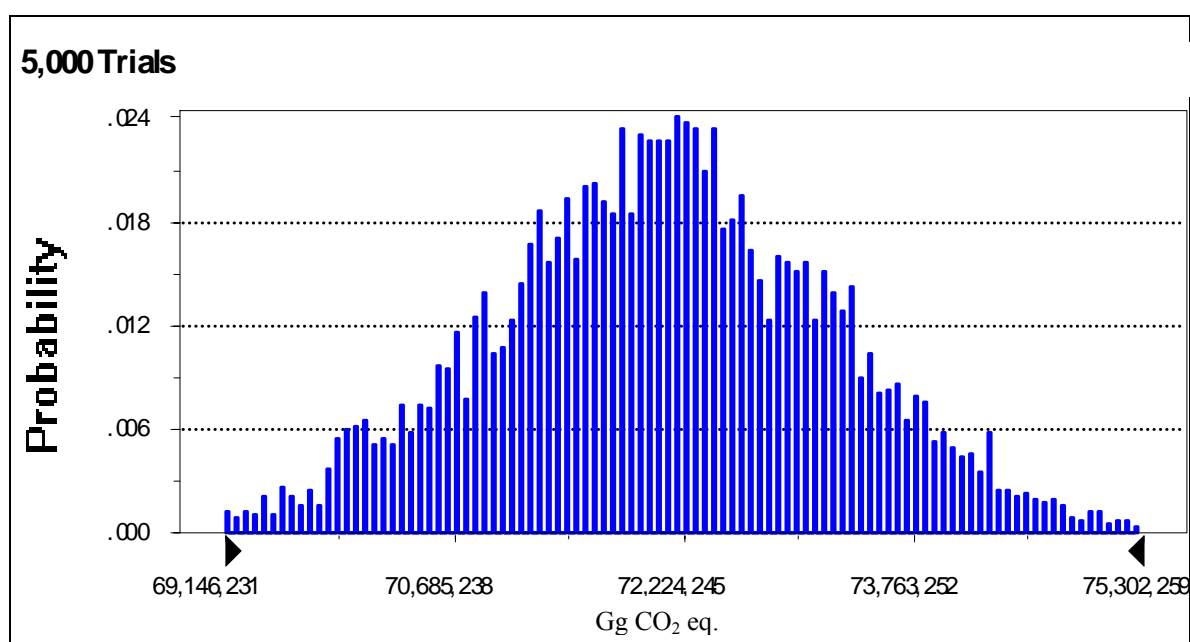


Figure A1.1 Probability density function resulting from Montecarlo analysis for CO₂ emissions from stationary combustion of liquid fuels, year 2009

Energy: CO₂ from stationary combustion solid fuels

Montecarlo analysis has been carried out for the CO₂ emissions from stationary combustion of solid fuels, for the reporting year 2009. In Table A1.17 a description of the main statistics resulting from the Montecarlo analysis is shown.

Table A1.17 Statistics of the Montecarlo analysis for CO₂ emissions from stationary combustion of solid fuels, year 2009

	Value
Trials	5000
Mean	49,289,917
Median	49,285,332
Standard Deviation	1,253,323
Range Minimum	44,384,889
Range Maximum	53,681,603
Uncertainty (%)	5.08

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.2.

5,000 Trials

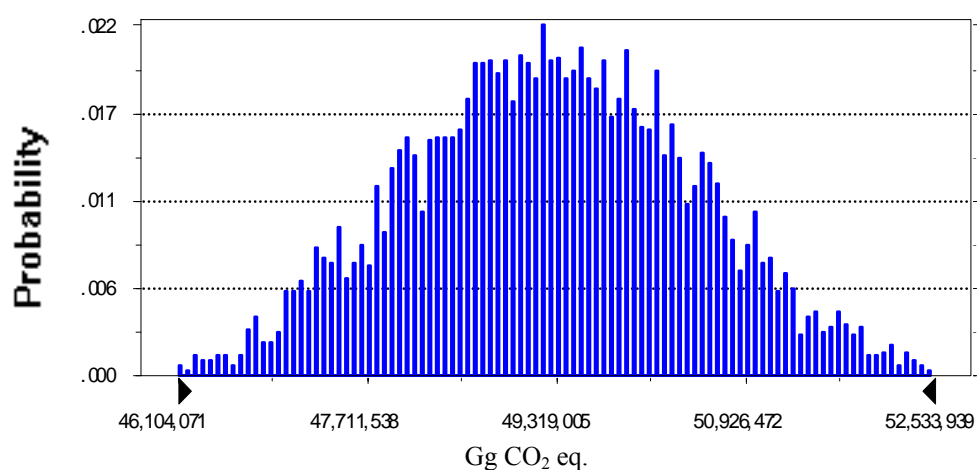


Figure A1.2 Probability density function resulting from Montecarlo analysis for CO₂ emissions from stationary combustion of solid fuels, year 2009

Energy: CO₂ from stationary combustion gaseous fuels

Montecarlo analysis has been carried out for the CO₂ emissions from stationary combustion of gaseous fuels, for the reporting year 2009. In Table A1.18 a description of the main statistics resulting from the Montecarlo analysis is shown.

Table A1.18 Statistics of the Montecarlo analysis for CO₂ emissions from stationary combustion of gaseous fuels, year 2009

	<u>Value</u>
Trials	5000
Mean	149,122,449
Median	149,184,196
Standard Deviation	4,355,657
Range Minimum	133,814,642
Range Maximum	165,672,245
Uncertainty (%)	5.84

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.3.

5,000 Trials

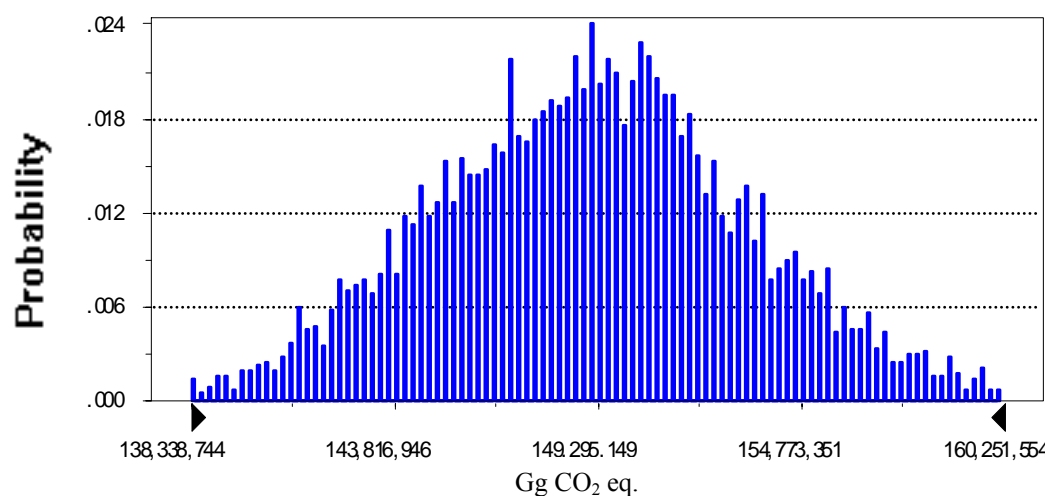


Figure A1.3 Probability density function resulting from Montecarlo analysis for CO₂ emissions from stationary combustion of gaseous fuels, year 2009

Energy: CO₂, CH₄ and N₂O Mobile combustion: Road Vehicles

Uncertainty of road transport emissions, at national level, has been assessed in the framework of study⁶² “Uncertainty estimates and guidance for road transport emission calculations” performed by EMISIA⁶³ on behalf of the Joint Research Centre. The uncertainty has been assessed on the basis of 2005 input parameters of the COPERT 4 model (v. 7.0). In Table A1.19 a description of the statistics resulting for Mobile combustion: Road Vehicles is shown.

Table A1.19 Statistics of the Montecarlo analysis for GHG emissions from Mobile combustion: Road Vehicles, year 2005

	CO ₂	CH ₄	N ₂ O
Mean	110,735	19	614
Median	110,622	18	608
Standard Deviation	4,079	7	59
Variation (%)	4	34	10
Uncertainty (%)	7.37	77.78	19.41

The probability density functions, for CO₂, CH₄ and N₂O emissions from mobile combustion, resulting from the Montecarlo assessment is shown in Figure A1.4.

⁶² Kouridis C., Gkatzoflias D., Kioutsioukis I., Ntziachristos L., Pastorello P., Dilara P., 2010 .Uncertainty Estimates and Guidance for Road Transport Emission Calculations, Joint Research Centre 2010; URL: <http://www.emisia.com/docs/COPERT%20uncertainty.pdf>

⁶³ EMISIA: www.emisia.com

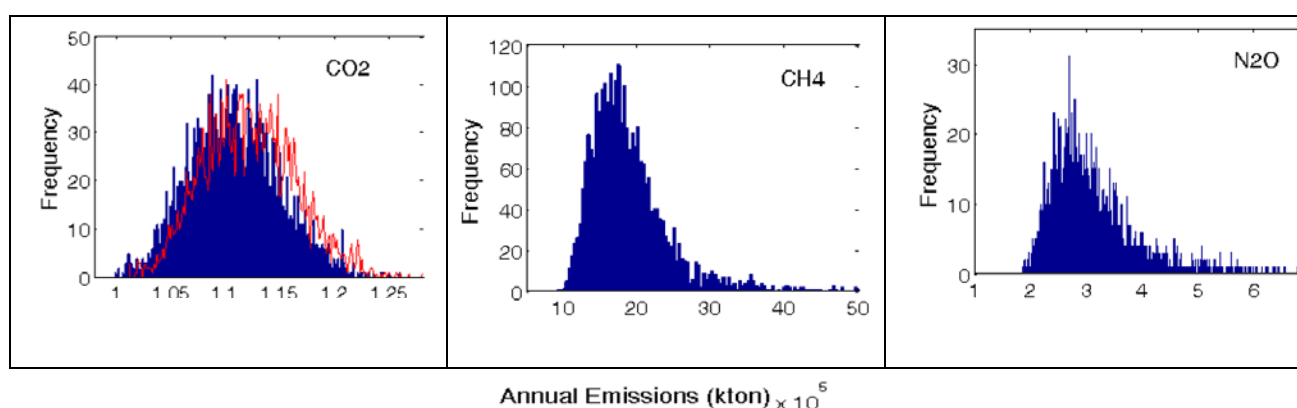


Figure A1.4 Probability density function resulting from Montecarlo analysis for CO₂, CH₄ and N₂O emissions from Mobile combustion: Road Vehicles, year 2005 (Kouridis et al., 2010)

Industrial Processes: CO₂ from Cement production

Montecarlo analysis has been carried out for the CO₂ emissions from cement production, for the reporting year 2009. In Table A1.20 a description of the statistics resulting from the Montecarlo analysis is shown.

Table A1.20 Statistics of the Montecarlo analysis for CO₂ emissions from cement production, year 2009

	<u>Value</u>
Trials	5000
Mean	13,447,765
Median	13,452,009
Standard Deviation	670,995
Range Minimum	11,167,723
Range Maximum	16,119,133
Uncertainty (%)	9.98

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.5.

5,000 Trials

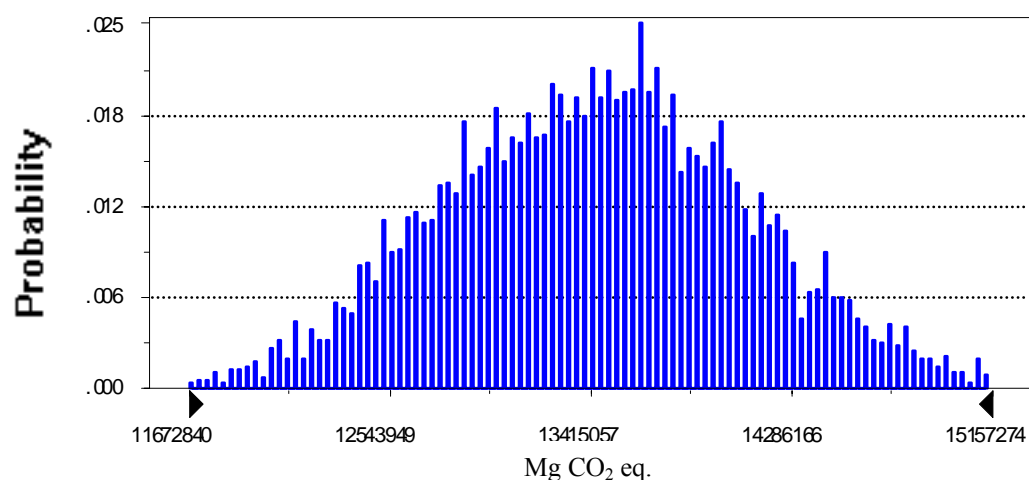


Figure A1.5 Probability density function resulting from Montecarlo analysis for CO₂ emissions from cement production, year 2009

Energy: CH₄ Fugitive emissions from Oil and Gas Operations

Montecarlo analysis has been carried out for CH₄ fugitive emissions from oil and gas operations, for the reporting year 2009. In Table A1.21 a description of the statistics resulting from the Montecarlo analysis is shown.

Table A1.21 Statistics of the Montecarlo analysis for CH₄ from fugitive emissions, year 2009

	<u>Value</u>
Trials	5000
Mean	4904
Median	4903
Standard Deviation	427
Range Minimum	3027
Range Maximum	6532
Uncertainty (%)	17.40

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.6.

5,000 Trials

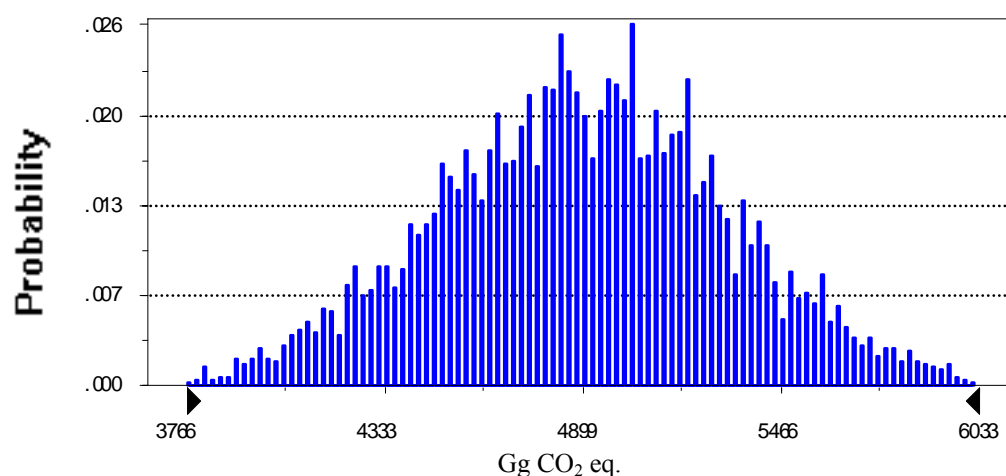


Figure A1.6 Probability density function resulting from Montecarlo analysis for CH₄ from fugitive emissions, year 2009

Agriculture: CH₄ Enteric Fermentation in Domestic Livestock

Montecarlo analysis has been carried out for the CH₄ emissions from enteric fermentation in domestic livestock, for the reporting year 2009. In Table A1.22 a description of the statistics resulting from the Montecarlo analysis is shown.

Table A1.22 Statistics of the Montecarlo analysis for CH₄ emissions from enteric fermentation, year 2009

	<u>Value</u>
Trials	5000
Mean	519,226
Median	512,480
Standard Deviation	71,264
Range Minimum	340,639
Range Maximum	869,092
Uncertainty (%)	-21.8; +31.7

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.7.

5,000 Trials

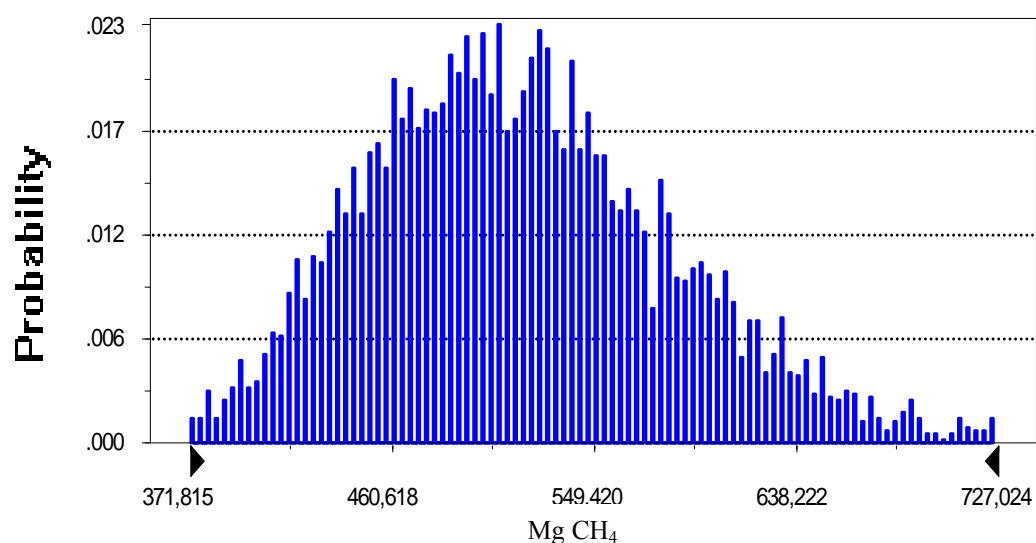


Figure A1.7 Probability density function resulting from Montecarlo analysis for CH₄ emissions from enteric fermentation, year 2009

Agriculture: Direct N₂O Agriculture soils

Montecarlo analysis has been carried out for the Direct N₂O emissions from Agriculture soils, for the reporting year 2010. In Table A1.23 a description of the statistics resulting from the Montecarlo analysis is shown.

Table A1.23 Statistics of the Montecarlo analysis for Direct N₂O Agriculture soils emissions, year 2010

	<u>Value</u>
Trials	10000
Mean	23.24
Median	23.08
Standard Deviation	2.48
Range Minimum	16.85
Range Maximum	33.43
Uncertainty (%)	21.34

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.8.

10,000 Trials

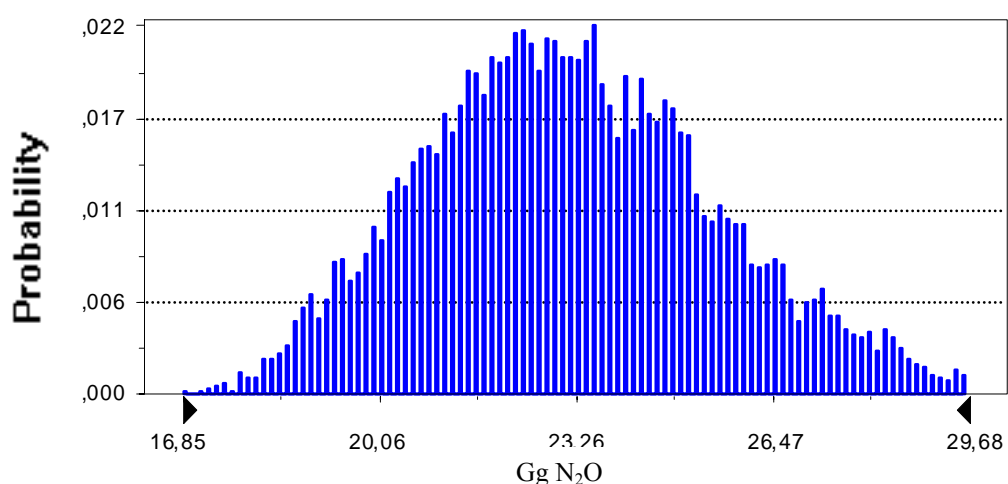


Figure A1.8 Probability density function resulting from Montecarlo analysis for Direct N₂O Agriculture soils emissions, year 2010

Agriculture: Indirect N₂O from Nitrogen used in agriculture

Montecarlo analysis has been carried out for the indirect N₂O emission from nitrogen used in agriculture, for the reporting year 2010. In Table A1.24 a description of the statistics resulting from the Montecarlo analysis is shown.

Table A1.24 Statistics of the Montecarlo analysis for indirect N₂O emissions from nitrogen used in agriculture, year 2010

	<u>Value</u>
Trials	10000
Mean	20.58
Median	20.47
Standard Deviation	2.23
Range Minimum	13.53
Range Maximum	29.42
Uncertainty (%)	21.67

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.9.

10,000 Trials

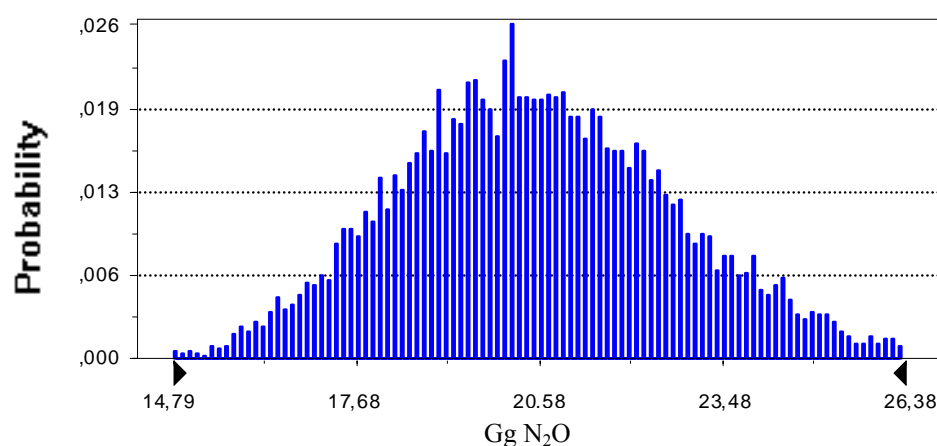


Figure A1.9 Probability density function resulting from Montecarlo analysis for indirect N₂O emissions from nitrogen used in agriculture, year 2010

Agriculture: N₂O manure management

Montecarlo analysis has been carried out for N₂O emissions from manure management, for the reporting year 2010. In Table A1.25 a description of the statistics resulting from the Montecarlo analysis is shown.

Table A1.25 Statistics of the Montecarlo analysis for N₂O emissions from Manure management, year 2010

	<u>Value</u>
Trials	10000
Mean	11.9438
Median	11.9284
Standard Deviation	0.6087
Range Minimum	9.5877
Range Maximum	14.6361
Uncertainty (%)	10.19

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.10.

10.000 Trials

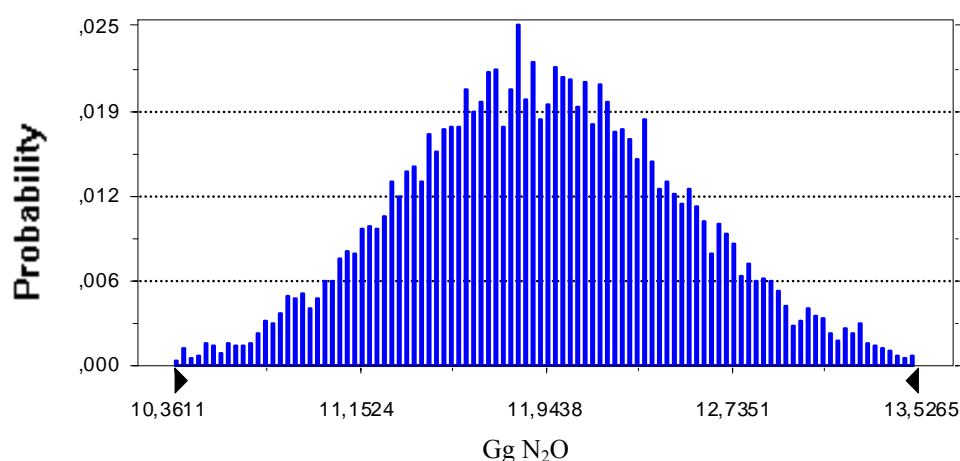


Figure A1.10 Probability density function resulting from Montecarlo analysis for N₂O emissions from Manure management, year 2010

Agriculture: CH₄ manure management

Montecarlo analysis has been carried out for the CH₄ emissions from manure management, for the reporting year 2010. In Table A1.26 a description of the statistics resulting from the Montecarlo analysis is shown.

Table A1.26 Statistics of the Montecarlo analysis for CH₄ emissions from enteric fermentation, year 2010

	<u>Value</u>
Trials	10000
Mean	121.44
Median	120.93
Standard Deviation	13.94
Range Minimum	78.05
Range Maximum	180.80
Uncertainty (%)	22.96

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.11.

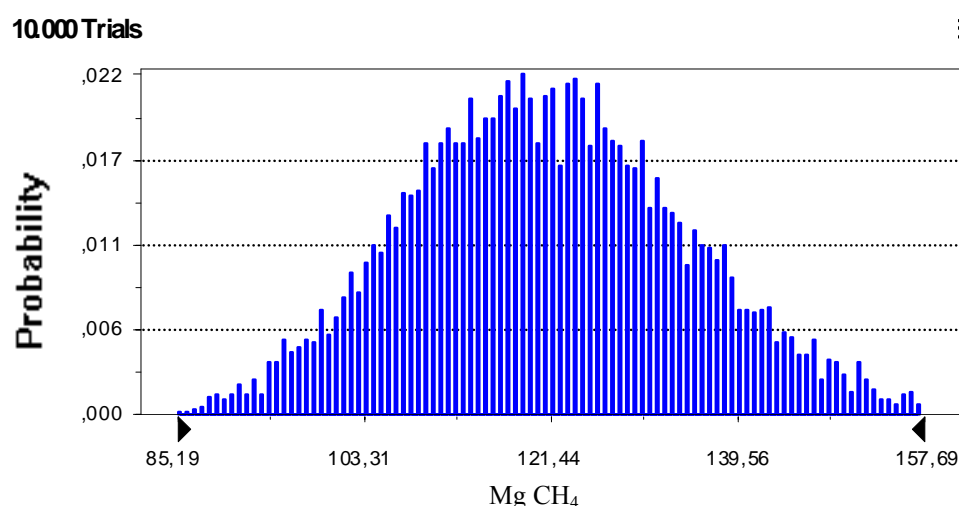


Figure A1.11 Probability density function resulting from Montecarlo analysis for CH₄ emissions from enteric fermentation, year 2010

LULUCF: CO₂ Forest Land remaining Forest Land

Montecarlo analysis has been carried out for the CO₂ emissions and removals from *Forest Land remaining Forest Land*, considering the different reporting pools (*aboveground*, *belowground*, *litter*, *deadwood* and *soils*), and the subcategories stands, coppices and rupicolous and riparian forests for the reporting year 2009. In Table A1.27 a description of the statistics resulting from the Montecarlo analysis is shown.

Table A1.27 Statistics of the Montecarlo analysis for CO₂ emissions and removals from Forest Land remaining Forest Land, year 2009

	<i>aboveground</i>	<i>belowground</i>	<i>litter</i>	Value <i>deadwood</i>	<i>soils</i>	total
Trials	10000	10000	10000	10000	10000	10000
Mean	433	75	31	64	493	1,097
Median	431	75	31	64	494	1,098
Standard Deviation	82	14	12	12	122	236
Range Minimum	152	24	-16	24	2	197
Range Maximum	822	129	79	117	947	2,063
Uncertainty (%)	37.86	37.18	79.40	36.87	49.33	42.93

In Table A1.28 the results of the uncertainty assessment for the different subcategories are reported, related to the year 2009.

Table A1.28 Uncertainties assessed for the different subcategories, year 2009

	<i>aboveground</i>	<i>belowground</i>	<i>litter</i>	<i>deadwood</i>	<i>soils</i>	total
stands	40.78	39.93	88.16	39.32	44.65	41.91
coppices	53.81	54.99	74.81	53.47	67.35	59.51
rupicolous and riparian forests	56.53	61.49	79.66	56.91	58.52	55.03
total	37.86	37.18	79.40	36.87	49.33	42.93

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.12.

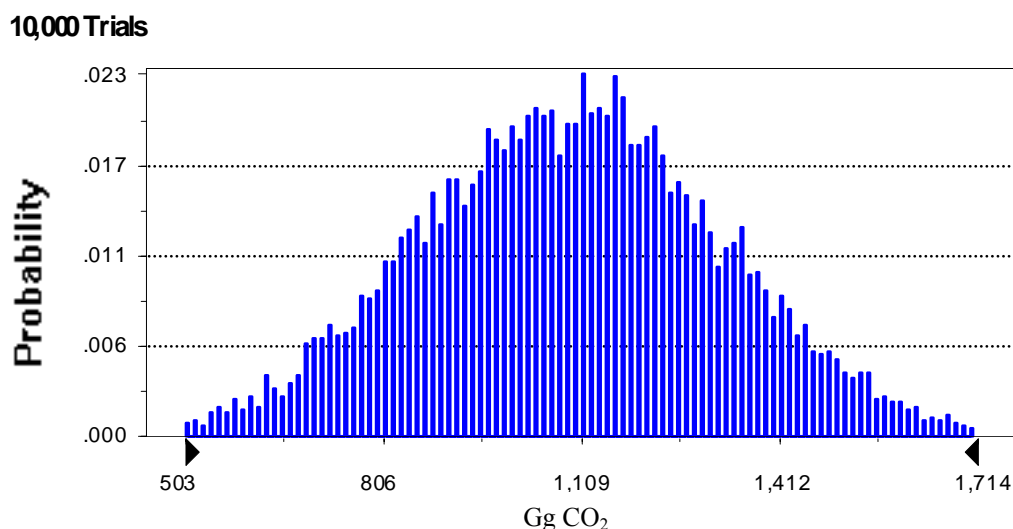


Figure A1.12 Probability density function resulting from Montecarlo analysis for the CO₂ emissions and removals from Forest Land remaining Forest Land category, year 2009

In Table A.1.29 the outcomes of the Approach 1 (error propagation) and Approach 2 (Montecarlo analysis) are shown, for the reporting pools. A general reduction in the uncertainty estimates has to be noted by comparing Montecarlo analysis results with the Approach 1 outcomes.

Table A1.29 Comparison between uncertainty assessment with Approach 1 and Approach 2

Uncertainty	Approach 1 %	Approach 2 (Montecarlo analysis) %
aboveground	42.68	37.86
belowground	42.68	37.18
litter	52.17	79.40
deadwood	101.62	36.80
soils	113.00	49.33
total	67.98	42.93

LULUCF: CO₂ Land converting to Forest Land

For *Land converting to Forest Land* category, Approach 2 has been carried out taking into account the different reporting pools (aboveground, belowground, litter, deadwood and soils), for the year 2009. In Table A1.30 a description of the statistics resulting from the Montecarlo analysis is shown.

Table A1.30 Statistics of the Montecarlo analysis for Land converting to Forest Land, year 2009

	Value					
	<i>aboveground</i>	<i>belowground</i>	<i>litter</i>	<i>deadwood</i>	<i>soils</i>	total
Trials	10000	10000	10000	10000	10000	10000
Mean	6	1	0.43	0.83	13.64	22
Median	6	1	0.40	0.82	12.25	20
Standard Deviation	2	0	0.25	0.34	18.63	18
Range Minimum	-1	0	-0.01	-0.18	-48.94	-37
Range Maximum	15	2	1.74	2.21	108.58	108
Uncertainty (%)	-72.6; 85.8	-72.5; 86.2	-91.3; 153.1	-72.5; 84.8	-257.2; 342.8	-147.6; 192.3

The probability function resulting from the Montecarlo assessment is shown in Figure A1.13.

10,000 Trials

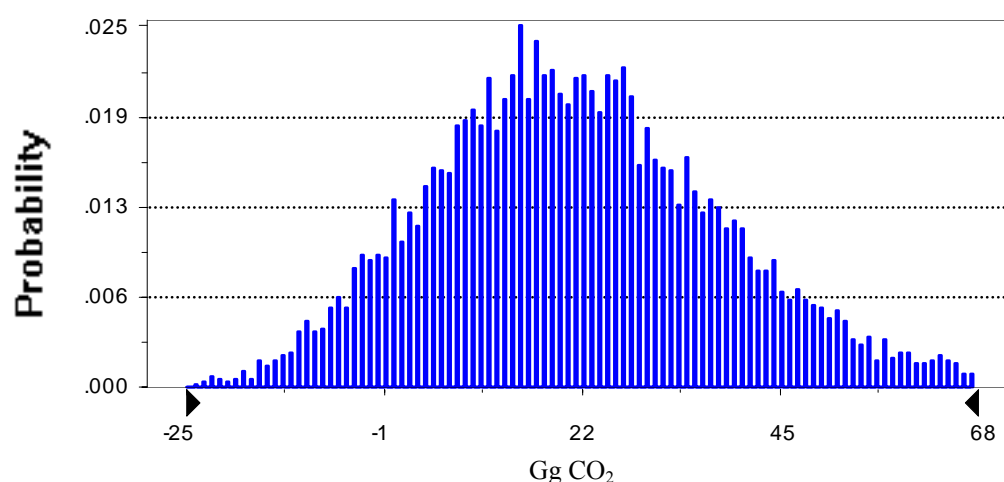


Figure A1.13 Probability density function resulting from Montecarlo analysis for the Land converting to Forest Land, year 2009

LULUCF: CO₂ Cropland remaining Cropland

For CO₂ emissions and removals from Cropland remaining Cropland, Approach 2 has been carried out taking into account the reporting subcategories (*woody crops, plantations, CO₂ emissions from organic soils, CO₂ emissions from lime application*), for the year 2009. In Table A1.31 a description of the statistics resulting from the Montecarlo analysis is shown.

Table A1.31 Statistics of the Montecarlo analysis for CO₂ emissions and removals from Cropland remaining Cropland, year 2009

	Value				
	<i>woody crops</i>	<i>plantations</i>	<i>CO₂ emissions from organic soils</i>	<i>CO₂ emissions from lime application</i>	total
Trials	10000	10000	10000	10000	10000
Mean	3,017	-3.58	-90.26	-4.58	2,919
Median	2,662	-35.06	-81.65	-4.50	2,568
Standard Deviation	2,090	369.65	41.40	1.20	2,124
Range Minimum	-1,403	-1,595	-427.49	-10.59	-1913
Range Maximum	18,326	1739	409.17	-0.97	18,865
Uncertainty (%)	-100.2; 199.4	-2173; 2454	-136.4; 57.3	-58.5; 46.4	-108.5; 210.2

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.14.

10,000 Trials

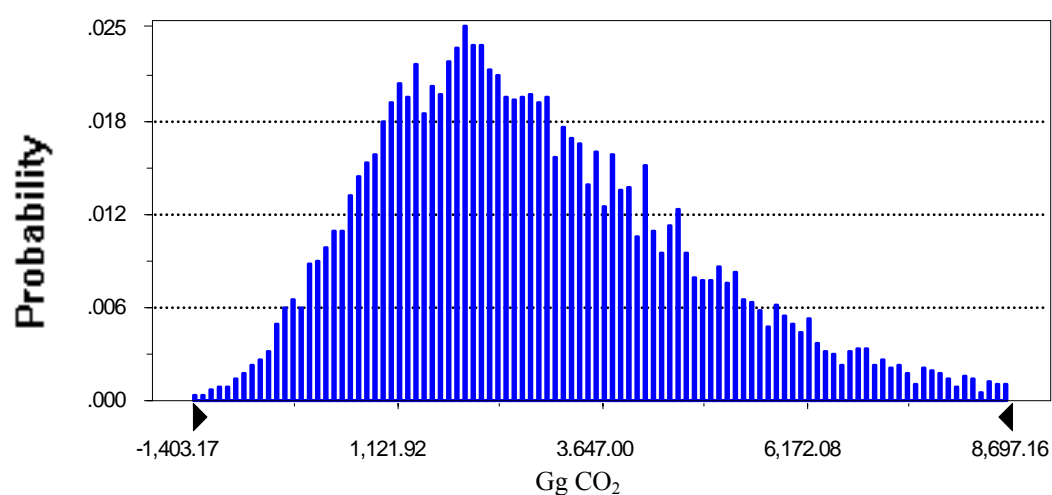


Figure A1.14 Probability density function resulting from Montecarlo analysis for the CO₂ emissions and removals from Cropland remaining Cropland, year 2009

LULUCF: CO₂ Land converting to Cropland

For CO₂ emissions and removals from Land converting to Cropland, Approach 2 has been carried out taking into account the *living biomass* and *soils* carbon pools, for the year 2009. In Table A1.32 a description of the statistics resulting from the Montecarlo analysis is shown.

Table A1.32 Statistics of the Montecarlo analysis for CO₂ emissions and removals from *Land converting to Cropland*, year 2009

	Value		
	<i>Living biomass</i>	<i>Soils</i>	total
Trials	5000	5000	5000
Mean	7	-112	-105
Median	4	-85	-79
Standard Deviation	11	119	118
Range Minimum	-7	-1,169	-1,097
Range Maximum	149	414	410
Uncertainty (%)	-150.7; 821.7	-384.1; 160.3	-408.2; 178.5

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.15.

5,000 Trials

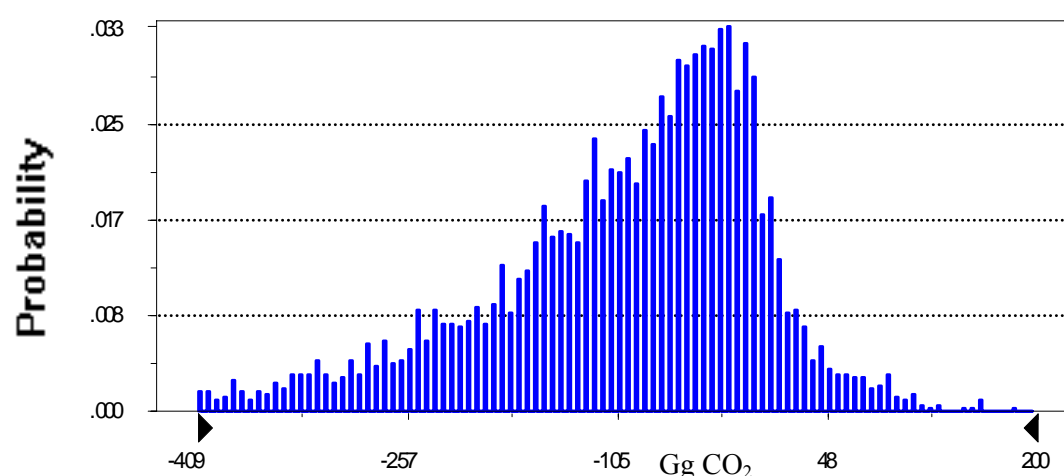


Figure A1.15 Probability density function resulting from Montecarlo analysis for CO₂ emissions and removals from *Land converting to Cropland*, year 2009

LULUCF: CO₂ Grassland remaining Grassland

For CO₂ emissions and removals from Grassland remaining grassland, Approach 2 has been carried out taking into account the different carbon pools, for the year 2009. In Table A1.33 a description of the statistics resulting from the Montecarlo analysis is shown.

Table A1.33 Statistics of the Montecarlo analysis for CO₂ emissions and removals from *Grassland remaining Grassland*, year 2009

	Value					
	<i>aboveground</i>	<i>belowground</i>	<i>litter</i>	<i>deadwood</i>	<i>soils</i>	total
Trials	10000	10000	10000	10000	10000	10000
Mean	26.59	11.05	9.66	3.63	82.86	133.79
Median	25.72	10.61	9.65	3.52	82.25	132.04
Standard Deviation	10.63	5.34	3.45	1.47	30.48	48.08
Range Minimum	-4.54	-3.88	-3.19	-0.69	-8.88	-9.27
Range Maximum	81.63	37.31	23.31	11.27	204.58	354.91
Uncertainty (%)	-68.6; 94.6	-82.6; 114.5	-70.4; 70.5	-69.9; 95.4	-70.6; 74.3	-67.7; 75.0

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.16.

10,000 Trials

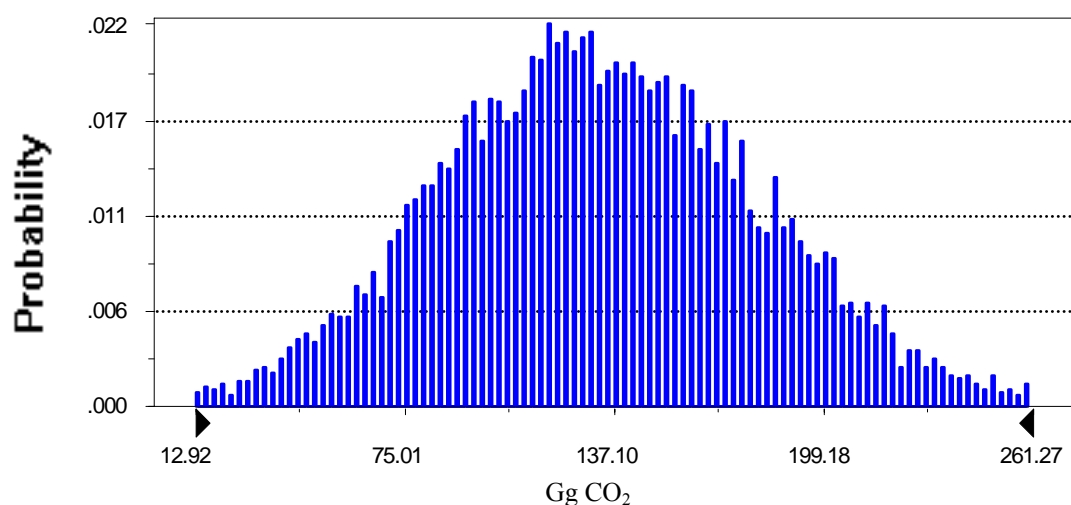


Figure A1.16 Probability density function resulting from Montecarlo analysis for CO₂ emissions and removals from Grassland remaining Grassland, year 2009

LULUCF: CO₂ Land converting to Grassland

For CO₂ emissions and removals from Land converting to Grassland, Approach 2 has been carried out taking into account the *living biomass* and *soils* carbon pools, for the year 2009. In Table A1.34 a description of the statistics resulting from the Montecarlo analysis is shown.

Table A1.34 Statistics of the Montecarlo analysis for CO₂ emissions and removals from Land converting to Grassland, year 2009

	Value		
	<i>Living biomass</i>	<i>Soils</i>	total
Trials	5000	5000	5000
Mean	-371.6	4,006	3,635
Median	-304.7	3,650	3,283
Standard Deviation	462.0	2,654	2,623
Range Minimum	-5,426	4,813	-6,794
Range Maximum	1,640	20,503	19,126
Uncertainty (%)	-383.8; 222.9	-106.1; 179.8	-119.3; 194.5

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.17.

5,000 Trials

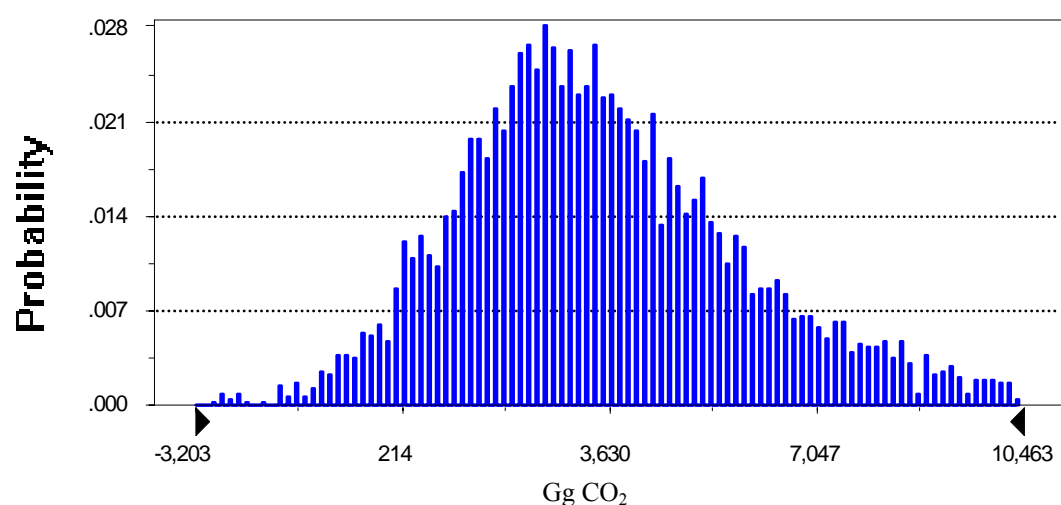


Figure A1.17 Probability density function resulting from Montecarlo analysis for the CO₂ emissions and removals from Land converting to Grassland, year 2009

LULUCF: CO₂ Land converting to Settlements

For CO₂ emissions from Land converting to Settlements, Approach 2 has been carried out taking into account the reporting subcategories (*annual crops converting to Settlements, woody crops converting to Settlements, Grassland converting to Settlement, Forest land converting to Settlements*), for the year 2009. In Table A1.35 a description of the statistics resulting from the Montecarlo analysis is shown.

Table A1.35 Statistics of the Montecarlo analysis for CO₂ emissions from Land converting to Settlements, year 2009

	Value				
	<i>Annual crops to SL</i>	<i>woody crops to SL</i>	<i>Grassland to SL</i>	<i>Forest land to SL</i>	total
Trials	10000	10000	10000	10000	10000
Mean	-450.9	-377.7	-274.7	-100.4	-4,428.4
Median	-362.8	-312.3	-240.7	-100.7	-4,116.9
Standard Deviation	323.9	262.3	175.8	23.68	1,693.4
Range Minimum	-3,739.5	-4,229.4	-2,423.8	-283.7	-18,736.0
Range Maximum	-22.0	-29.5	-2.3	-40.3	-1,073.8
Uncertainty (%)	-262.1; 72.0	-238.1; 70.8	-193.5; 82.9	-56.0; 35.1	-100.3; 49.2

In Table A1.36 the results of the uncertainty assessment for the different subcategories are reported, related to the year 2009.

Table A1.36 Uncertainties assessed for the different subcategories, year 2009

Uncertainty	living biomass %	dead organic matter %	Soils %	Total %
<i>annual crops to SL</i>	-300.9; 75.5	-	-267.1; 72.0	-262.1; 72.0
<i>woody crops to SL</i>	-288.8; 74.3	-	-235.5; 70.5	-238.1; 70.8
Cropland to SL	-288.8; 67.0	-	-187.0; 62.5	-193.5; 82.9
Grassland to SL	-	-	-193.5; 82.9	-193.5; 82.9
Forest land to SL	-115.9; 54.3	-56.9; 51.3	68.2; 40.0	-56.0; 35.1
Land to SL	-	-	-	-100.3; 49.2

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.18.

10,000 Trials

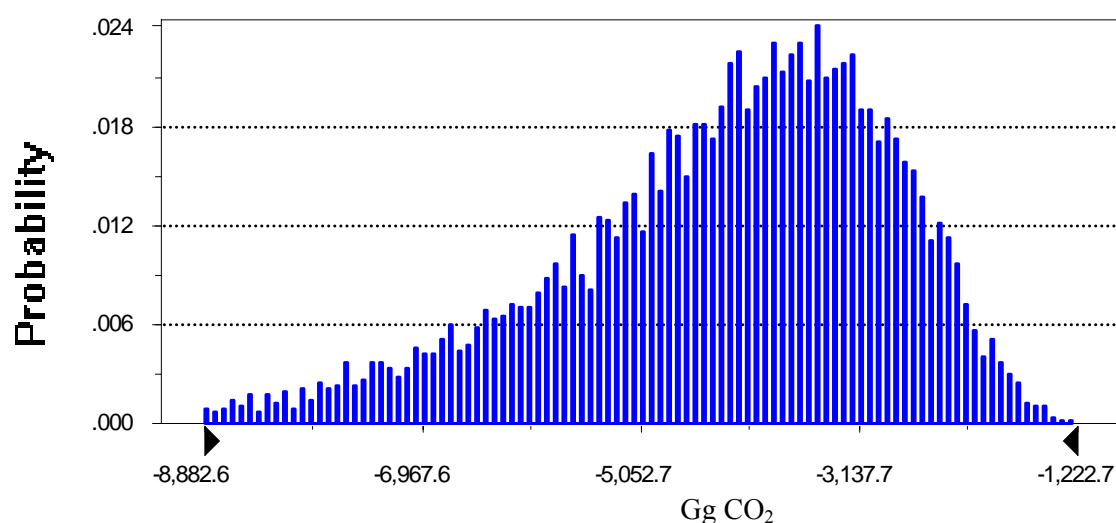


Figure A1.18 Probability density function resulting from Montecarlo analysis for the CO₂ emissions from Land converting to Settlements, year 2009

Waste: CH₄ from Solid waste Disposal Sites

Montecarlo analysis has been carried out for the CH₄ emissions from Solid waste disposal sites, for the reporting year 2009. In Table A1.37 a description of the statistics resulting from the Montecarlo analysis is shown.

Table A1.37 Statistics of the Montecarlo analysis for Solis waste disposal on land category, year 2009

	<u>Value</u>
Trials	5000
Mean	595,157
Median	595,893
Standard Deviation	37,423
Range Minimum	469,077
Range Maximum	728,751
Uncertainty (%)	12.58

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.19.

5,000 Trials

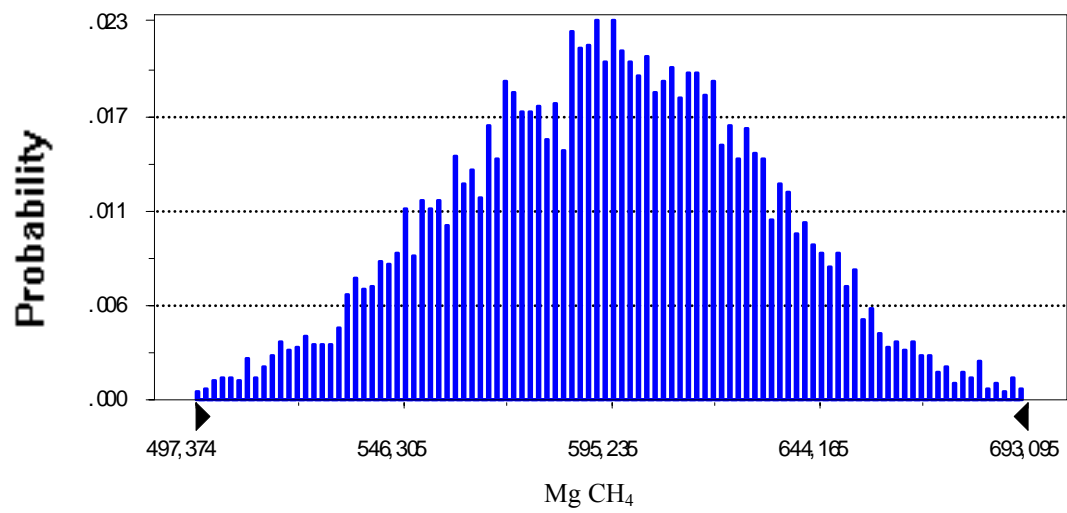


Figure A1.19 Probability density function resulting from Montecarlo analysis for the Solis waste disposal on land category, year 2009

ANNEX 2: ENERGY CONSUMPTION FOR POWER GENERATION

A2.1 Source category description

The main source of data on fuel consumption for electricity production 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 company that runs the high voltage transmission grid. For the period 1990-1998 the same data were published by ENEL (ENEL, several years), former monopolist of electricity distribution. The time series is available since 1963. In these publications, consumptions of all power plants are reported, either public or privately owned.

Detailed 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 largest 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 five groups that do not allow for a precise evaluation of the carbon content. In Table A2.1, the time series of fuel consumptions for power sector production is reported.

Table A2.1 Time series of power sector production by fuel, Gg or Mm³

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
national coal	58	-	Solids	Solids	Solids	Solids	Solids	Solids	Solids	Solids
imported coal	10,724	8,216	9,633	16,253	16,587	16,886	16,878	15,218	14,998	16,614
lignite	1,501	380								
Natural gas, m ³	9,731	11,277	22,334	30,544	31,381	33,957	33,706	28,634	29,630	27,857
BOF(steel converter) gas, m ³	509	633	Coal	Coal	Coal	Coal	Coal	Coal	Coal	Coal
Blast furnace gas, m ³	6,804	6,428	gases	gases	gases	gases	gases	gases	gases	Gases
Coke gas, m ³	693	540	8,690	12,104	13,131	11,353	10,648	6,661	8,822	10,016
Light distillate	5	6	oil products	oil products	oil products	oil products	oil products	oil products	oil products	oil products
Diesel oil	303	184								
Heavy fuel oil	21,798	25,355	19,352	7,941	7,629	5,292	4,366	3,715	2,152	1,802
Refinery gas	211	378								
Petroleum coke	186	189								
Orimulsion	-	-								
Gases from chemical processes	444	803	Others	Others	Others	Others	Others	Others	Others	Others
Tar	2	-		Mm ³ = 978	Mm ³ = 1,321	Mm ³ = 1,423	Mm ³ = 1,414	Mm ³ = 1,289	Mm ³ = 1,501	Mm ³ = 1,673
Heat recovered from Pyrite	146	3		Gg= 15,460	Gg= 16,253	Gg= 17,490	Gg= 16,520	Gg= 14,789	Gg= 18,160	Gg= 18,387
Other fuels	344	697	5,153							

Source: TERNA, several years

Figures reported in the table show that natural gas has substituted oil products, from 1990 to 2011, becoming the main fuel for electricity production while coal consumption has slightly increased in the last years as compared to 1990.

For the purpose of calculating GHG emissions, a detailed list of 25 fuels was delivered to ISPRA by TERNA for the years from 2000 to 2007. From 2008 the list of the fuels used to estimate emissions was expanded by TERNA, up to 40 different types in 2011. The list includes different variety of renewable sources according to their composition and origin, useful to estimate the percentage of renewable sources for electricity generation and to comply with national regulations of waste derived fuels. A list of different quantities of fuel oils used according to the sulphur content was also added. Energy data of previous years have not changed (see previous reports).

The detailed information is confidential and only the output of the simulation model applied to calculate emissions for the year 2011, at an aggregated level, is reported in Table A2.2. The consumption of municipal solid waste (MSW) / industrial wastes is separated from the biomass consumption, since the use of this fuel for electricity generation is expanding and EFs are different.

It has to be underlined that fuels used to cogenerate heat and electricity in some power plants are not included in TERNA data, where only the fuel used for electricity production is reported.

At national level, other statistics on the fuel used for electricity production exist, the most remarkable being the National Energy Balance (BEN), published annually (MSE, several years) and those published by Unione Petrolifera, the Oil companies association (UP, several years). In the past, also the association of the industrial electricity producers (UNAPACE, several years) up to the year 1998, and ENI, the former national oil company up to the year 2000, published production data with the associated fuel consumptions (ENI, several years).

A2.2 Methodological issues

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 publication 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 (point source evaluation) based on the physical quantities;
- the used fuel types are much more detailed in TERNA database, 40 fuels as above mentioned, whereas in BEN all 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;
- finally, the two data sets usually differ, even considering the total energy values of fuels or the produced electricity, there are always small differences, less than 1%, that increase the already sizable discrepancy between the reference approach and the detailed approach; the BEN adjust the physical quantities according to fixed low heating values and this process combined with the reduction of fuel types adds rounding errors and this may cause the small difference between the production of electricity of the two sources, 0.4% in 2011. The difference in the energy consumption value is equal to 0.04%.

Table A2.2 reports the differences between the national energy balance and TERNA data for 2011. For the other years, differences are explained in previous NIR reports. In Table A2.2, annual data from different sources are reported: detailed data reported by TERNA are compared with data available in the national energy balance.

For each source, three types of data are presented: electricity production, physical quantities of fuel consumptions and amount of energy used.

Table A2.2 Energy consumption for electricity production, year 2011

Fuels	TERNA			BEN		
	GWe, gross	Gg / Mm ³	Pj	GWe, gross	Gg / Mm ³	Pj
Coal	44,726.0	16,614	418.1	44,723.3	15,738	418.1
Coke oven gas	1,837.7	886	16.6	1,809.3	921	16.4
Blast furnace gas	3,504.1	8,952	30.7	3,505.8	8,160	30.7
Oxi converter gas	100.4	177	1.3	100.4		1.3
total derived gases	5,442.2	10,016	48.7	5,415.5	9,081	48.4
Coal	50,168.2		466.8	50,138.8		466.5
Light distillates	3.0	1	0.04	96.5	12	0.5
Light fuel oil	637.7	146	5.7	533.7	133	5.7
Fuel oil - high sulfur content	4,914.7	1,181	48.6	12,124.4	1,930	79.1
Fuel oil - low sulfur content	0.0		0.0	3,646.5	799	32.8
Refinery gas	2,224.5	318	14.9	2,176.7	291	14.6
Petroleum coke	693.7	157	5.4	695.3	157	5.5
Oriemulsion	0.0	0	0.0			
<i>total fuel oil</i>	<i>8,473.7</i>		<i>75.1</i>	<i>19,273.3</i>	<i>3,322</i>	<i>138.2</i>
Gas from chemical proc.	469.8	127	15.5	622.4	2,016	18.0
Heavy residuals/ tar	10,805.5	8,125	63.0			
Others	106.8		1.2			
<i>total residual</i>	<i>11,382.1</i>		<i>79.7</i>	<i>622.4</i>		<i>18.0</i>
Oil+residuals	19,855.8		154.8	19,895.7		156.2
Natural gas	144,539.2	27,857	966.8	144,544.2	28,213	966.8
Biofuels	2,697.5	567	20.7			0.0
Biogas	3,404.6	1,648	30.8			8.1
Biomass	2,512.4	2,810	45.7	8,593.0	9,287	89.0
Municipal waste	4,522.4	5,568	64.5	4,447.7	6,007	62.8
Grand total	227,700		1,750.1	228,507		1,749.5
TERNA /BEN differences				-0.4%		0.04%

Source: ISPRA elaborations

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 CO₂ emissions, and also N₂O and CH₄ emissions, a rather complex calculation sheet is used (APAT, 2003). 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. The main scope of the model is to estimate the emissions of pollutants different from CO₂ that are technology dependent. For each year, a run estimates the fuel consumed by each plant type, the pollutant emissions and GHG emissions.

The model has many possible outputs; some of which are built up in such a way to reproduce the data available from statistical source. The model is revised every year to mirror the changes occurred in the power plants. 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 other energy industries, Tables 1.A.1.b and 1.A.1.c of the CRF, and in the industrial sector section, Table 1.A.2 of the CRF.

The following Table A2.3 shows an intermediate step of the process, with all energy and emissions summarized by fuel and split in two main categories of producers: public services and industrial producers for the year 2011. Since 1998, expansion of industrial cogeneration of electricity and split of 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 of the CRF, according to the best information available.

Table A2.3 Power sector, Energy/CO₂ emissions in CRF format, year 2011

	TJ	C, Gg	CO₂, Gg
For Table 1.A.1, a. Public Electricity and Heat Production			
Liquid fuels	106,678	2,275	8,337
Solid fuels	418,112	10,459	38,322
Natural gas	866,806	13,136	48,130
Refinery gases	11,225	176	644
Coal gases	26,811	1,321	4,839
Biomass	129,588	3,528	12,928
Other fuels (incl.waste)	40,205	957	3,506
Total	1,599,424	28,323	103,778
Industrial producers (Table 1.A.1, a-b-c) and auto-producers, to table "1.A.2 Manufacturing Industries "			
Liquid fuels	5,237	115	421
Solid fuels	6	0	1
Natural gas	100,050	1,516	5,555
Refinery gases	3,715	58	213
Other refinery products	17,290	376	1,377
Coal gases	21,817	1,075	3,938
Biomass			
Other fuels (incl.waste)	2,524	35	128
Total	150,638	3,175	11,632
General total	1,750,062	31,497	115,409

Source: ISPRA elaborations

In conclusion, the main question of the accuracy of the underlying energy data of key sources is connected to the discrepancies between BEN and TERN 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 derive from the same source. On the basis of this consideration, we decided to base the inventory on TERN data that are expected to be more reliable. In particular because the emission factors used are based on the energy content of the fuel we have made an effort to reproduce with the model the TERN energy consumption figure and ignored discrepancies in the electricity production or in the physical quantities of fuel used.

A2.3 Uncertainty and time-series consistency

The combined uncertainty in CO₂ emissions from electricity production is estimated to be about 4.2% in annual emissions; a higher uncertainty, equal to 50.1%, is calculated for CH₄ and N₂O emissions on account of the uncertainty levels attributed to the related emission factors.

For the year 2009, Montecarlo analysis has been carried out to estimate uncertainty of CO₂ emissions from stationary combustion of solid, liquid and gaseous fuels emissions, resulting in 5.1%, 3.3% and 5.8%, respectively. Normal distributions have been assumed for all the parameters. A summary of the results is reported in Annex 1.

Estimates of fuel consumption for electricity generation in 2011 are reported in Table A2.3.

In Table A2.4, the time series of the total CO₂ emissions from electricity generation activities is reported, including total electricity produced and specific indicators of CO₂ emissions for the total energy production and for the thermoelectric production respectively, expressed in grams of CO₂ per kWh. The emission factors are reported excluding the electricity produced from pumped storage units using water that has previously been pumped uphill, as requested by Directive 2009/28/EC of the European Parliament and of the Council promoting the electricity renewable sources.

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 have raised till 2006 due to the even bigger increase of electricity production. The decreasing trend of 2007 and 2008 results from an increase in energy production from renewable sources, combined with a further reduction in the use of oil products for electricity production. In 2009, 2010 and 2011 the decrease is even more accentuated because of the economic recession.

Table A2.4 Time series of CO₂ emissions from electricity production

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Total electricity produced (gross), TWh	216.9	241.5	276.6	303.7	314.1	313.9	319.1	292.6	302.1	302.6
Total CO ₂ emitted, Mt	126.4	135.4	142.6	143.2	146.3	144.5	140.3	119.5	119.9	118.2
g CO ₂ / kwh of gross thermo-electric production	708.4	691.9	649.2	568.4	560.2	545.8	538.6	528.7	520.3	519.0
g CO ₂ / kwh of total gross* production	592.0	570.7	528.3	482.5	475.5	468.8	447.3	414.4	401.3	393.1

* excluding electricity production from pumped storage units using water that has previously been pumped uphill

Source: ISPRA elaborations

The trend of CO₂ emissions for thermoelectric production is the result of an increase of natural gas share due to the entry into service of more efficient combined cycle plants. The downward trend takes also into account the general increase in efficiency of the power plants.

A2.4 Source-specific QA/QC and verification

Basic activity data to estimate emissions from all operators are annually collected and reported by the national grid administrator (TERNA, several years). Other data are collected directly from operators for plants bigger than 20 MWh, with a yearly survey since 2005 and communicated at international level in the framework of the EU ETS scheme. Activity data and other parameters, as net calorific values, are compared every year at an aggregate level, by fuel; differences and problems have been identified, analysed in detail and solved with sectoral experts.

In addition, time series resulting from the recalculation have been presented to the national experts in the framework of an *ad hoc* working group on air emissions inventories. The group is chaired by ISPRA and includes participants from the local authorities responsible for the preparation of local inventories, sectoral experts, the Ministry of Environment, Land and Sea, and air quality model experts. Top-down and bottom-up approaches have been compared with the aim to identify the potential problems and future improvements to be addressed.

A2.5 Source-specific recalculations

Recalculations of the energy industry sector refer to CO₂ emission factors for the years 2005-2010 for coke oven gas and blast furnaces gas and 2009-2010 for natural gas. Bioliquid fuel consumptions for energy production, supplied by Terna, have been added from 2008 to 2010 resulting in a change of CH₄ and N₂O emissions. Coke oven gas and blast furnaces gas CO₂ emission factor has been updated on the basis of an in depth analysis of the information supplied by the plants in the framework of the EU ETS scheme. Natural gas CO₂ emission factor has been updated for change of imported gas parameters. The recalculations affected only slightly the time series from 2005 to 2009 with differences ranging from -0.07% to +0.05%, for CO₂, 1.3 for CH₄ and 0.7% for N₂O in 2010, with respect to the earlier submission.

A2.6 Source-specific planned improvements

No specific improvements are planned for the next submission.

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 gases are separately accounted for and reported in the electricity generation section.

Another specific national circumstance is the concentration of steel works, since the year 2005, 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 emission factor 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. According to the IPCC Good Practice Guidance (IPCC, 2000), the use of reductants is also included in this balance because no sufficient information to detail emissions between the energy and industrial processes sectors is available. The carbon balance methodology does not imply to separate off input between the energy and industrial sectors but ensures no double counting occurs.

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 emission factors to the energy carriers, trying to balance the carbon inputs with emissions. The exception mentioned refers to the recovered gases 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 gases 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 (TERNA, several years). The consideration of the BOF gases 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 2011, all the data mentioned can be found in “enclosures 1/a, 2/a and 3/a” of BEN, see also Annex 5 (MSE, several years)

In the first box from top of the table the quantities of coke, coke gas and blast furnace gas used by the different sectors are detailed. In the second box are reported the quantities of the same energy carriers that are self-used, used for the production of coke or 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 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.

Table A3.1 Energy balance, 2011, Tcal

coke	coke gas	blast furnace gas	NOTES
6,616			For blast furnace
0	3,914	7,344	For electricity production
25,722	0	119	For steel industries
129	0	0	For other industries use
0	0		For domestic use
32,467	3,913	7,463	Total consumption
385	136	7	Consumption for production of secondary fuels
0	1	0	Losses of transformation
32,852	4,051	7,470	Total consumption + losses and prod.
Energy balance, coke ovens		Energy balance, blast furnace gas	
-139		265.1	Difference in energy consumption
-0.4%		3.5%	Unbalance in %
39,005			Coke oven output
2,590			Transformation losses, coke ovens
1,539			non energy use
43,135			sub total
43,135			Coking coal input to coke ovens
14,516			Blast furnace coal input
-1,963			import + stock change

In Table A3.2, in the first two boxes from the top the same energy data of Table A3.1 valuated for their carbon content are reported, according to the standard emission factors reported in Table 3.12 of the NIR. In the coloured cells the balance of carbon inputs and outputs of two processes coke oven and blast furnaces are shown.

So in the end the methodology actually foresees as a first step the calculation of the total carbon inputs (imported fuels plus standard IPCC emission factors), 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, see 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 emission factors for coal produced CO₂, near to the natural gas emission factor, for the steel making process and quite high carbon emissions for the coal used to produce electricity.

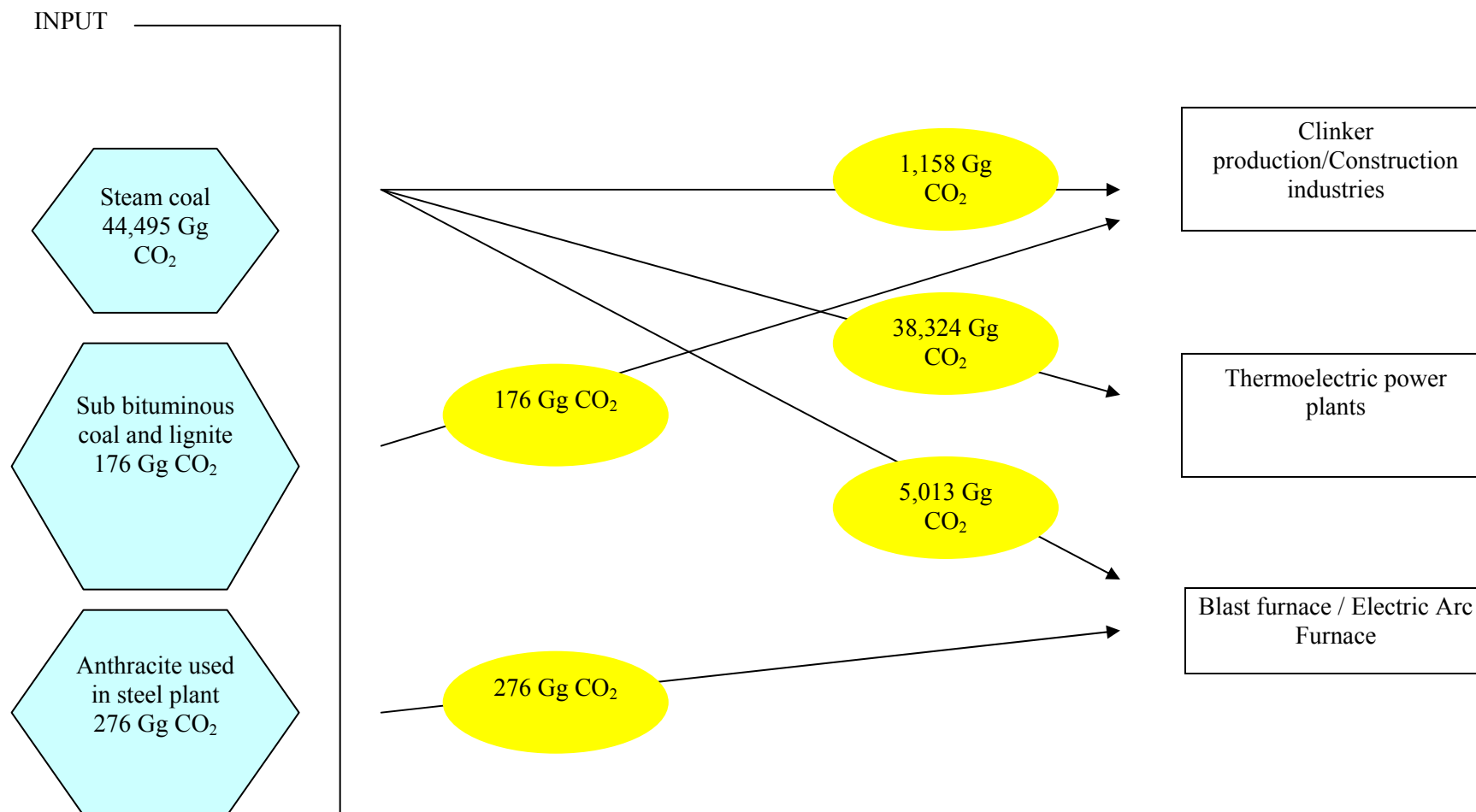
Additional information from the operators on fuel consumptions and average emission factors is submitted in the framework of the EU ETS scheme and it is used to verify our calculation and CO₂ emissions at plant level and to calculate average CO₂ emission factors for coal and derived gases from 2005.

Table A3.2 Carbon balance, 2011, Mt CO₂

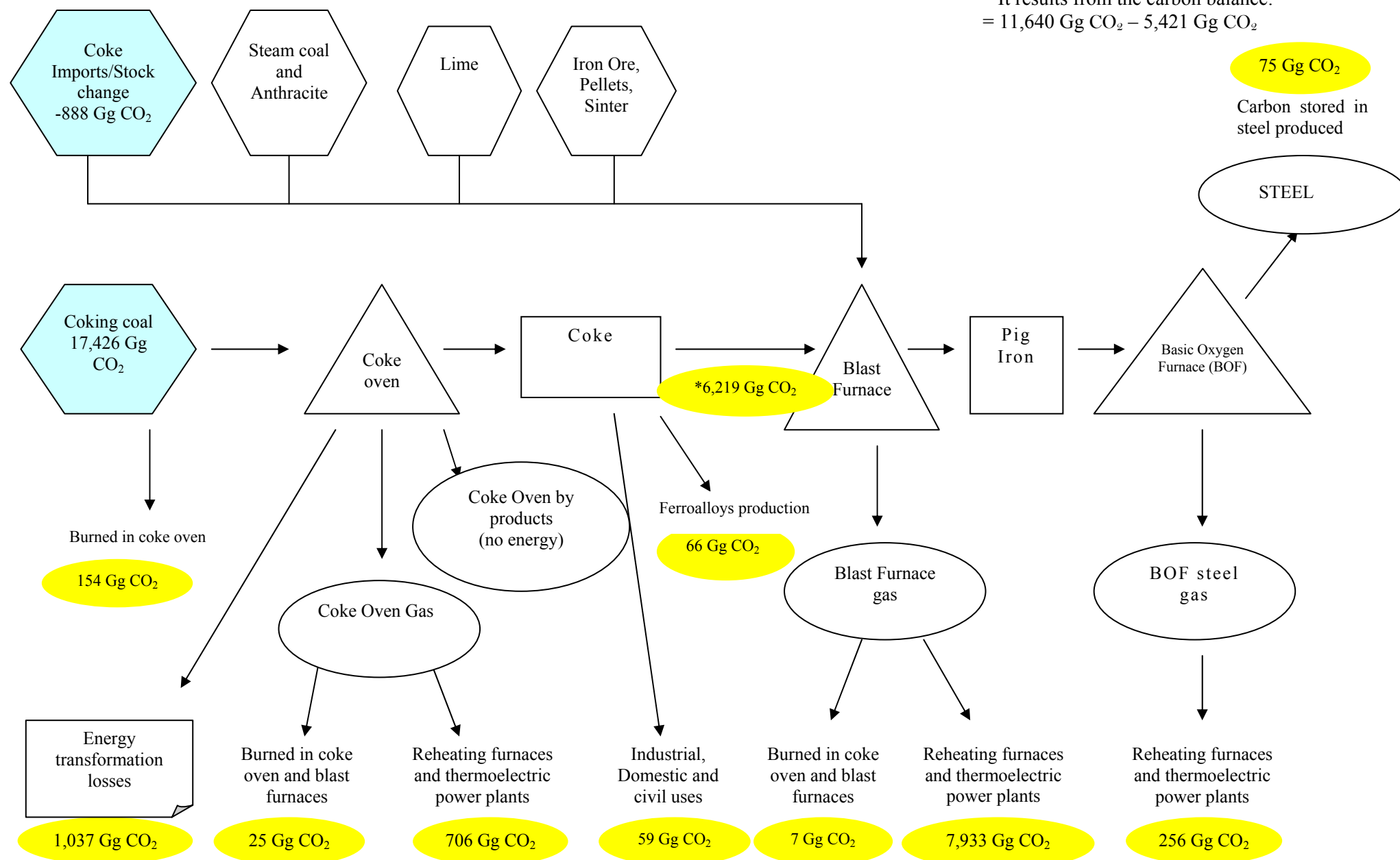
coke	coke gas	Blast furnace gas + oxi gas	NOTES	Total according to BEN	Total used for CRF
2.93			From blast furnace (no direct emissions, transformed in coal gasses)	2.93	
0.00	0.77	7.44	From electricity prod.	8.68	8.78
11.40	0.00	0.13	From steel industries	11.53	12.86
0.06	0.00	0.00	From other industries use	0.06	0.06
0.00	0.00		From domestic use	0.00	
14.39	0.77	7.57	Total emissions, final uses	23.21	21.70
0.15	0.03	0.01	Consumption for production of secondary fuels	0.18	
0.00	0.00	0.00	Losses of transformation	0.00	
14.54	0.80	7.58	Total consumption + losses and prod.	23.39	
Carbon balance, coke ovens		Carbon balance, blast furnace			
0.6		-0.4	Difference in physical emissions		
4%		-5%	Unbalance in %		
Emissions					
15.62			Carbon in produced coke		
1.04			Transformation losses		
0.62			non energy use	0.62	0.62
16.72			Coal input to coke ovens		
6.46			Coal input to blast furnace		
-0.87			Coke import + stock change		
22.31			Total carbon input		22.31

The flowchart of carbon - cycle for the year 2011 is reported below. CO₂ 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 2011. The amount of carbon stored in steel produced was estimated and subtracted from the balance to avoid the subsequent overestimation of CO₂. The amount of coke used for ferroalloys production has also been subtracted to avoid a double counting of emissions already estimated and reported in the industrial processes sector.

CO₂ emission calculation
Year 2011



* It results from the carbon balance:
 $= 11,640 \text{ Gg CO}_2 - 5,421 \text{ Gg CO}_2$



ANNEX 4: CO₂ 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 follows the IPCC Guidelines (IPCC, 1997); table 1.A(b) of the Common Reporting Format “Sectoral background data for energy - CO₂ 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 the Italian energy and emission factor data (ENEA, 2002 [a]), and these are described in the following. The BEN (MSE, several years [a]) reports the energy balances for all primary and secondary fuels, with data on imports, exports and production. See Annex 5, Tables A5.1-A5.10, for an example of the year 2011 and to the web site of the Ministry of Economic Development for the whole time series <http://dgerm.sviluppoeconomico.gov.it/dgerm/>.

Starting from those data and using the emission factors reported in chapter 3, Table 3.12, it is possible to estimate the total carbon entering in the national energy system. 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 3.8 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, we make reference to the BEN tables reported in Annex 5. In particular the following data are reported and used for the *Reference Approach*:

- 1) crude oil imports, exports and production;
- 2) natural gas liquids data;
- 3) import-export data of gasoline, aviation fuel, other kerosene, diesel, fuel oil, LPG and virgin naphta;
- 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, several years [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 2000 because it is explicitly excluded by the IPCC methodology. From 2001 onward a careful check with the team in charge to prepare the energy balances induced the inventory team to revise its position on this matter⁶⁴;

⁶⁴ Feedstock production refer to petrochemical feedstock and other fuel streams returning to the refineries from the internal market. Those quantities do not contain additional carbon inputs but as they are not properly subtracted to the final fuel consumption section of the energy balances they should be accounted for also 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 the Ministry of Economic Development has only a few details about the origin of those fuel streams returned to refineries. Since 2001 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 considers those fuels as “stock changes” of petrochemical input.

- 6) all coal data are available in BEN, coke import-export included;
- 7) natural gas import-export and production data;
- 8) waste production data;
- 9) Biomass fuel data.

The following additional information is needed to complete table 1.A(b) of CRF 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, several years), 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, while detailed data are available in BPT (MSE, several years [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 are equal to 9000 kcal/kg for bitumen and 9800 kcal/kg for motor oils. In the CRF those products are estimated with the OECD energy content and this could explain part of the unbalance between imported oil and used products.

For further information see 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 CO₂ emissions. The unaccounted sources are:

- Land use change and forestry
- Offshore flaring and well testing
- Non-Fuel industrial processes

First of all, the IPCC Reference total can be compared with the CRF Table 1A total. Results show the IPCC Reference totals are between 0-2.6 percent lower than the comparable 'bottom up' totals. The highest difference between the two approaches is observed in 1999 and is equal to 2.6%; input data have been checked in details, the difference could be attributed to higher thermo electric fuel input registered by ENEL/TERNA than the figure reported in the energy balance and higher quantities of pet coke calculated from cement production data than those reported in the energy balance. In addition, data on waste consumption reported in the energy balance are considerably lower than data from incinerations on waste for energy recovery used in the sectoral approach. Differences between emissions estimated by the reference and sectoral approach are reported in Table A4.1.

Table A4.1 Reference and sectoral approach CO₂ emission estimates 1990-2011 (Mt) and percentage differences

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Sectoral approach	400.7	413.8	433.6	457.2	452.6	444.1	435.1	391.6	401.2	390.4
Reference approach	396.2	406.5	422.9	448.9	446.3	436.2	431.4	391.0	399.5	389.4
Δ %	-1.14	-1.76	-2.47	-1.83	-1.40	-1.77	-0.85	-0.14	-0.44	-0.27

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, several years [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, whereas 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. In addition, waste consumption data reported in the BEN were not such accurate from 1990 up to 2002 as the subsequent years.
3. The 'bottom up' approach only includes emissions from the non-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 survey to improve the estimate of carbon content of liquid fuel is in progress.

A4.3 Comparison of the the sectoral approach with the reference approach and international statistics

A verification of national energy balance and CO₂ emissions with data communicated to the joint EUROSTAT/IEA/UNECE questionnaire was carried out in 2004 and results are reported in the document "Energy data harmonization for CO₂ emission calculations: the Italian case" (ENEA/MAP/APAT, 2004).

The analysis enhanced the main differences and the critical points to harmonize the data and their reporting. The most critical issues concerned the calorific value, EUROSTAT and MAP should apply the same calorific value; the distribution of fuel consumptions to the relevant sectors, e.g., in some cases EUROSTAT assigned "building materials industry" consumptions in "glass, pottery and building materials industry" consumptions, in other cases in "other industries"; the definition of coke, in particular, the distribution of consumptions between the iron and steel sector final consumption and transformation input; the definition of derived gases have to be harmonized, because differences in allocation of steelworks gases and gas from chemical processes were found.

In addition, "exchange and transfers, returns" and "statistical difference" rows were used in the national statistics to balance the energy resources with the energy uses whereas in the international statistics the two items, in some cases, were cancelled.

From 2004 some improvements were implemented both in the national and international statistics also through the revision of the questionnaire but difference in apparent consumptions still occur.

At European level, further examination is in progress. In the framework of the Monitoring Mechanism Decision jointly with EUROSTAT, a project which compares Eurostat energy data with energy data included in the CRF has been developed. The background of the project is the Energy Statistics Regulation (EC/1099/2008), which is the legal basis of the reporting of energy data to Eurostat, in particular Article 6, paragraph 2, of the regulation stipulating that: "Every reasonable effort shall be undertaken to ensure coherence between energy data declared in the energy statistics regulation, and data declared in accordance with Commission Decision No 280/2004/EC of the European Parliament and of the Council concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol".

Member States' reference approach data as submitted in CRF Table 1A(b) under the EU GHG Monitoring Mechanism (as available by 15 May 2011) were compared with Eurostat energy data as available in the Eurostat database in April 2011: <http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/database>. The comparison was carried out for the years 2009 and 2008. Specifically, for Italy, major discrepancies identified were only related to the consumption of refinery feedstocks which differs considerably between annual Eurostat data and the CRF: Annual Eurostat consumption is 30% and 40% lower than the CRF for 2008 and 2009 respectively. The same issue was identified during the last review process and corrected in this year submission.

In terms of CO₂ emissions, for Italy the preliminary comparison results in a difference in total equal to 2% in 2009, with higher differences for solid and other fuels. In the submission 2013, in response to the review process, waste data for energy recovery have been included in the reference approach resulting in a decrease of the differences especially for the last years.

ANNEX 5: NATIONAL ENERGY BALANCE, YEAR 2011

The official National Energy Balance (BEN) of the year 2011 is available, in Italian, on the website of the Italian Ministry of the Economic Development (MSE): <http://dgerm.sviluppoeconomico.gov.it/dgerm/>. Also, the time series from the year 1998 onwards are available at the same address.

The national energy balance consists of two “sets” of tables fuel consumptions expressed in physical quantities (Gg or Mm³) and in energy equivalents (10⁹ kcal). In the current annex, tables reproduce only figures expressed in amount of energy equivalents for the year 2011 (MSE, several years). Sectors and fuel definitions have been translated in English for the purposes of the NIR.

Reference is made here to the second set of tables because the reporting methodology of the BEN applies the same lower heat value to each primary fuel in various years, to take into account for the variable energy content of each shipment. 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 (not reported here) is an “adjusted” quantity of Gg or Mm³. This process is routinely applied to 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 it 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. Measurements of the actual energy content of fuels show minor variations from one year to another, 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 Italy used fuel from four main different sources: Russia, Netherlands, Algeria and national production. Since 2003-2004 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 market, the system changed. Since 2004, the price refers to the energy content of natural gas and the metered physical quantities of gas delivered to all final customers have been 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.

Therefore the physical quantities are the most reliable data for the estimations of liquid fuels used in the civil and transportation sector. This information is used to calculate emissions, using updated data for the emission factors which are estimated from samples of marketed fuels.

For this reason we attach also the copies of tables in physical quantities (see Tables A5.9-10), mirror sheet of the tables in energy equivalents, (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 2011, Primary fuels, 10⁹ kcal

BALANCE	PRIMARY SOURCES															
	Coking coal	Steam coal	Coal other uses	Lignite	Subproducts (a)	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy (e)	Geothermal Energy	Wind and Photovoltaic Energy	Waste	Wood	Biomass (f)	Biodiesel	TOTAL PRIMARY SOURCES
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Conversion factor (b)	7.400	6.350	7.400	2.500	2.500	8.190	10.000	10.000	2.200	2.200	2.200	2.500	2.500	2.500	8.900	
1. PRODUCTIONS (c)	0	584	0	0	6,560	69,167	52,840	24,920	100,810	12,439	45,435	15,017	23,393	23,218	5,260	379,673
2. IMPORTS	41,477	112,459	1,110	13	0	576,322	722,160	66,210	0	0	0	0	12,125	0	9,042	1,540,918
3. EXPORTS		0	22			1,016	4,400	9,850					148	0	1,415	16,851
4. Stock changes (d)	-2,035	-3,880	-74	0	0	6,364	-10,980	-8,330	0	0	0	0	0	0	-71	-19,006
5. TOTAL RESOURCES	43,512	116,923	1,162	13	6,560	638,140	781,580	89,610	100,810	12,439	45,435	15,017	35,370	23,218	12,958	1,922,747
6. Transformations (Enclosure 1/a)	43,127	99,934		0	6,560	231,063	871,190	0	100,810	12,439	45,435	15,017	130	23,218	0	1,448,923
7. Consumptions and Losses (Encl.2/a)	385	0	0	0	0	15,111	0	0	0	0	0	0	0	0	0	15,496
8. Final Consumptions (Enclosure 3/a)	0	16,989	1,162	13	0	391,966	0	0				0	35,240	0	12,958	458,328
a) Agriculture	0	0	0	0	0	1,302	0	0	0	0	0	0	1,410	0	0	2,712
b) Industry	0	16,989	1,118	13	0	126,733		0				0	2,468	0	0	147,321
c) Services						7,224							0	0	12,958	20,182
d) Domestic and civil uses			44	0		252,440		0					31,363	0	0	283,847
Total (a+b+c+d)	0	16,989	1,162	13	0	387,699		0				0	35,240	0	12,958	454,061
e) Non energy uses						4,267	0	0	0	0	0	0	0	0	0	4,267

BALANCE	PRIMARY SOURCES															
	Coking coal	Steam coal	Coal other uses	Lignite	Subproducts (a)	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy (e)	Geothermal Energy	Wind and Photovoltaic Energy	Waste	Wood	Biomass (f)	Biodiesel	TOTAL PRIMARY SOURCES
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Conversion factor (b)	7.400	6.350	7.400	2.500	2.500	8.190	10.000	10.000	2.200	2.200	2.200	2.500	2.500	2.500	8.900	
TOTAL ENERGY CONSUMPTIONS (7+8)	385	16,989	1,162	13	0	407,077	0	0	0	0		0	35,240	0	12,958	473,824
9. Non energy final uses																
10. BUNKERS																
12. TOTAL USES	43,512	116,923	1,162	13	6,560	638,140	871,190	0	100,810	12,439	45,435	15,017	35,370	23,218	12,958	1,922,747
(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 petrochemical industry, some reclassification of feedstocks and regeneration of lubricant oils																
(d) - In the "TOTAL RESOURCES", this entry is considered negative																
(e) - Pumping excluded																
(f) - Biomass production include: biomass used by electric energy production																

Table A5.2 -National Energy Balance, year 2011, Secondary fuels, 10⁹kcal

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	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
	17	18	19	20	22	23	21	24	25	26	27	28	29	30	31	32	33	34	35
Conversion factor (b)	0.860	7.500	7.246	4.250	0.900	7.400	4.250	11.000	12.000	10.400	10.500	10.400	10.300	10.200	9.800	9.800	8.300	6.513	
1. PRODUCTIONS (c)	258,547	32	34,431	4,050	7,470	1,191	0	23,155	36,924	39,406	197,621	31,834	5,799	372,728	(g) 52,881	50,068	14,384	39,810	1,170,331
2. IMPORTS	40,867	510	237					22,198	0	9,776	1,334	13,343	5,696	26,285	(h) 5,047	3,283	20,385	3,711	152,672
3. EXPORTS	1,538	8	1,963			200		4,334		12,449	88,431	2,132	3,615	95,278	14,190	13,259	1,992	17,074	256,463
4. Stock changes (d)		0	237					2,090		634	389	1,612	21	3,427	-774	4,106	183	1,322	13,247
5. TOTAL RESOURCES	297,876	534	32,468	4,050	7,470	991	0	38,929	36,924	36,099	110,135	41,433	7,859	300,308	44,512	35,986	32,594	25,125	1,053,293
6. Transformations (Encl.1/a)			6,616	3,913	(c) 7,344	0		0	3,489	123	0	0	0	1,360	18,913	7,830	1,301	0	50,889
7. Consumptions and Losses (Encl.2/a)	38,304	0	0	135	7	0	0	297	24,675	127		0	10	250	3,812	9,625	9,547	6	86,614
8. Final Consumptions (Encl.3/a)	259,572	534	25,852	0	119	992	0	38,632	8,760	35,849	110,136	41,433	7,849	292,496	4,146	8,565	21,746	3,381	881,528
a) Agriculture	5,080							660	0	0	95	0	0	21,583	0	0	0	0	27,418
b) Industry	104,760	105	25,852	0	119		0	2,849	5,892	0	252	166	10	3,622	2,941	7,546	21,746	3,381	179,241
c) Services	39,200							13,992			100,685	41,267	103	242,617	0	0	0	0	437,864

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	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
	17	18	19	20	22	23	21	24	25	26	27	28	29	30	31	32	33	34	35
Conversion factor (b)	0.860	7.500	7.246	4.250	0.900	7.400	4.250	11.000	12.000	10.400	10.500	10.400	10.300	10.200	9.800	9.800	8.300	6.513	
d) Domestic and civil uses	110,532	429	0				0	17,754	0	0	0		93	17,962	0	588	0	0	147,358
Total (a+b+c+d)	259,572	534	25,852	0	119	0	0	35,255	5,892	0	101,032	41,433	206	285,784	2,941	8,134	21,746	3,381	791,881
e) No energetic uses				0		992		3,377	2,868	35,849	9,104	0	7,643	6,712	1,205	431	0	21,466	89,647
TOTAL ENERGY CONSUMPTIONS (7+8)	297,876	534	25,852	135	126	992	0	38,929	33,435	35,976	110,135	41,433	7,859	292,746	7,958	18,190	31,293	3,387	946,856
9. Non energy final uses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21,465	21,465
10. BUNKERS	0	0	0	0	0	0	0	0	0	0	0	0	0	6,202	17,641	9,966	0	273	34,082
12. TOTAL USES	297,876	534	32,468	4,050	7,470	991	0	38,929	36,924	36,099	110,135	41,433	7,859	300,308	44,512	35,986	32,594	25,125	1,053,293

Table A5.3 -National Energy Balance, year 2011, Primary fuels used by transformation industries, "Enclosure 1/a", 10⁹kcal

TRANSFORMATIONS	PRIMARY SOURCES													
	Coking coal	Steam coal	Coal other uses	Lignite	Subproducts (a)	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy (e)	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	8.190	10.000	10.000	2.200	2.200	2.200	2.500	2.500	
1) INPUT QUANTITY														
a) Charcoal pit													130	130
b) Coking	43,135													43,135
c) Town gas Workshop														
d) Blast furnaces														
e) Petroleum refineries							871,190							871,190
f) Hydroelectric power plants									100,810					100,810
g) Geothermal power plants										12,439				12,439
h) Thermoelectric power plants		99,939			6,560	231,063						15,017	23,218	375,797
i) Wind / Photovoltaic power plants						-					45,435			45,435
TOTAL	43,135	99,939			6,560	231,063	871,190		100,810	12,439	45,435	15,017	23,348	1,448,936
2) OUTPUT QUANTITY														
A) Obtained sources														
a) Charcoal pit													65	65
b) Coking	39,005													39,005

TRANSFORMATIONS	PRIMARY SOURCES													
	Coking coal	Steam coal	Coal other uses	Lignite	Subproducts (a)	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy (e)	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	8.190	10.000	10.000	2.200	2.200	2.200	2.500	2.500	
c) Town gas Workshop														
d) Blast furnaces														
e) Petroleum refineries							824,800							824,800
f) Hydroelectric power plants									39,408					39,408
g) Geothermal power plants										4,863				4,863
h) Thermoelectric power plants		38,464			1,384	124,304						3,825	7,390	175,367
i) Wind / Photovoltaic power plants											17,761			17,761
Sub-Total A	39,005	38,464			1,384	124,304	824,800		39,408	4,863	17,761	3,825	7,455	1,101,269
B) Losses of transformation														
a) Charcoal pit													65	65
b) Coking	2,590													2,590
c) Town gas Workshop														
d) Blast furnaces														
e) Petroleum refineries							6,580							6,580
f) Hydroelectric power plants									61,402					61,402

TRANSFORMATIONS	PRIMARY SOURCES													
	Coking coal	Steam coal	Coal other uses	Lignite	Subproducts (a)	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy (e)	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	8.190	10.000	10.000	2.200	2.200	2.200	2.500	2.500	
g) Geothermal power plants										7,576				7,576
h) Thermoelectric power plants		61,475			5,176	106,759						11,192	15,828	200,430
i) Wind / Photovoltaic power plants											27,674			27,674
Sub-Total B	2,590	61,475			5,176	106,759	6,580		61,402	7,576	27,674	11,192	15,893	306,317
C) Non energy products														
a) Coke ovens (c)	1,540													1,540
b) Town Gas Workshop														
c) Petroleum refineries (d)							39,810							39,810
Sub-Total C	1,540						39,810							41,350
TOTAL A+B+C	43,135	99,939			6,560	231,063	871,190		100,810	12,439	45,435	15,017	23,348	1,448,936
(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 ammoniac sulphate														
(d) - Including solvent gasoline, turpentine, lubricants, white oils, insulating oils, vaseline, paraffin, bitumen and other products														
(e) - Pumping excluded														

Table A5.4 -National Energy Balance, year 2011, Secondary fuels used by transformation industries, "Enclosure 1/a", 10⁹kcal

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	7.513	4.250	0.900	7.400	4.250	11.000	12.000	10.400	10.500	10.400	10.300	10.200	9.800	9.800	8.300	6.170	
1) INPUT QUANTITY																			
a) Charcoal pit																			
b) Coking																			
c) Town gas Workshop																			
d) Blast furnaces			6,616																6,616
e) Petroleum refineries																			
f) Hydroelectr. power plants																			
g) Geothermal power plants																			
h) Thermoelectr. power plants				3,913	7,344				3,489	123				1,360	18,913	7,830	1,301		44,273
i) Wind / Photovoltaic power plants																			
TOTAL			6,616	3,913	7,344				3,489	123				1,360	18,913	7,830	1,301		50,889
2) OUTPUT QUANTITY																			
A) Obtained sources																			
a) Charcoal pit																			

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	7.513	4.250	0.900	7.400	4.250	11.000	12.000	10.400	10.500	10.400	10.300	10.200	9.800	9.800	8.300	6.170	
b) Coking																			
c) Town gas Workshop																			
d) Blast furnaces			6,616																6,616
e) Petroleum refineries																			
f) Hydroelectric power plants																			
g) Geothermal power plants																			
h) Thermoelectric power plants				1,555	3,014				1,870	87				464	10,431	3,132	597		21,150
i) Wind / Photovoltaic power plants																			
Sub-Total A			6,616	1,555	3,014				1,870	87				464	10,431	3,132	597		27,766
B) Losses of transformation																			
a) Charcoal pit																			
b) Coking																			
c) Town gas Workshop																			
d) Blast furnaces																			
e) Petroleum refineries																			
f) Hydroelectric																			

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	7.513	4.250	0.900	7.400	4.250	11.000	12.000	10.400	10.500	10.400	10.300	10.200	9.800	9.800	8.300	6.170	
power plants																			
g) Geothermal power plants																			
h) Thermoelectric power plants				2,358	4,330				1,619	36				896	8,482	4,698	704		23,123
i) Wind / Photovoltaic power plants																			
Sub-Total B				2,358	4,330				1,619	36				896	8,482	4,698	704		23,123
C) Non energy products																			
a) Coking																			
b) Town Gas Workshop																			
c) Petroleum refineries																			
Sub-Total C																			
TOTAL A+B+C			6,616	3,913	7,344				3,489	123				1,360	18,913	7,830	1,301		50,889

Table A5.5 -National Energy Balance, year 2011, Primary fuels losses, "Enclosure 2/a", 10⁹kcal

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	8.190	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						3,661								3,661
f) Natural gas liquids														
g) Crude oil														
h) Hydraulic Energy														
i) Geothermal Energy														
Sub-total						3,661								3,661
2) Consumptions for production														
of secondary sources (c)														
a) Charcoal pit														
b) Coke ovens	385													385
c) Town Gas Workshop														
d) Blast furnaces														
e) Petroleum refineries						8,026								8,026
f) Hydraulic power plants														

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	8.190	10.000	10.000	2.200	2.200			2.500	
g) Geothermal power plants														
h) Thermoelectric power plants														
i) Nuclear power plants														
Sub-total	385					8,026								8,411
3) Consumptions and Losses of														
transport and distribution						3,423								3,423
4) Differences :														
- Statistics														
- of conversion						1								1
TOTAL (1+2+3+4)	385					15,111								15,496
(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 2011, Secondary fuels losses, "Enclosure 2/a", 10⁹kcal

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	7.513	4.250	0.900	7.400	4.250	11.000	12.000	10.400	10.500	10.400	10.300	10.200	9.800	9.800	8.300	6.170	
1) Consumptions for production																			
of primary sources						1													1
a) Biomass																			
b) Coal	36																		36
c) Lignite	1																		1
d) Nuclear fuels	5																		5
e) Natural Gas	276																		276
f) Natural gas liquids																			
g) Crude oil																			
h) Hydraulic Energy	520	(d)																	520
i) Geothermal Energy	-																		
Sub-total	838					1													839
2) Consumptions for production																			
of secondary sources (c)																			
a) Charcoal pit																			
b) Coke ovens	177			134	7														318
c) Town Gas Workshop	235																		235

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	7.513	4.250	0.900	7.400	4.250	11.000	12.000	10.400	10.500	10.400	10.300	10.200	9.800	9.800	8.300	6.170	
d) Blast furnaces																			
e) Petroleum refineries	5,090							297	24,672	125			10	255	3,811	9,623	9,545	6	53,434
f) Hydraulic power plants	477																		477
g) Geothermal power plants	292																		292
h) Thermoelectric power plants	8,618																		8,618
i) Wind / Photovoltaic power plants	180																		
Sub-total	15,069			134	7			297	24,672	125			10	255	3,811	9,623	9,545	6	63,374
3) Consumptions and Losses of transport and distribution	22,397																		22,397
4) Differences :																			
- Statistics	-																		
- of conversion				1		-1			3	2	-1			-5	1	2	2		4
TOTAL (1+2+3+4)	38,304			135	7			297	24,675	127	-1		10	250	3,812	9,625	9,547	6	86,614

Table A5.7 -National Energy Balance, year 2011, Primary fuels used by end use sectors, "Enclosure 3/a", 10⁹kcal

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	Wood	Biodiesel	TOTAL PRIMARY SOURCES
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Conversion factor (a)	7.400	6.350	7.400	2.500	2.500	8.190	10.000	10.000	2.200	2.200	2.200	2.500	2.500	8.900	
1) AGRICULTURE AND FISHING															
I- Agriculture						1,302							1,410		2,712
II- Fishing															
Sub-Total						1,302							1,410		2,712
2) INDUSTRY															
I- Iron and steel industry		13,799	718			17,723									32,240
II- Other industry		3,190	401	13		109,010							2,468		115,082
a) Mining industry						369									369
b) Non-Ferrous Metals			37			4,136									4,173
c) Metal works factories						17,199									17,199
d) Food Processing, Beverages						14,365									14,365
e) Textile and clothing						6,183									6,183
f) Construction industries (cement, bricks)		3,190	349	13		6,069							2,468		12,089
g) Glass and pottery						18,133									18,133
h) Chemical			15			20,844									20,859
i) Petrochemical															
l) Pulp, paper and print						18,026									18,026

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	Wood	Biodiesel	TOTAL PRIMARY SOURCES
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Conversion factor (a)	7.400	6.350	7.400	2.500	2.500	8.190	10.000	10.000	2.200	2.200	2.200	2.500	2.500	8.900	
m) Other industries						3,686									
n) Building and civil works															
Sub-Total		16,989	1,119	13		126,733							2,468		147,322
3) SERVICES															
I - Railways															
II - Navigation															
III - Road transportation						7,224								12,958	20,182
IV - Civil aviation															
V - Other transportation															
VI - Public Service															
Sub-Total						7,224								12,958	20,182
4) DOMESTIC AND COMMERCIAL USES			44			252,440							31,363		283,847
TOTAL (1+2+3+4)		16,989	1,163	13		387,699							35,241	12,958	454,063
5) NON ENERGY USE (b)															
I - Chemical industry															
II - Petrochemical						4,267									4,267
III - Agriculture															
IV - Other sectors															
Sub-Total						4,267									4,267

FINAL CONSUMPTIONS	PRIMARY SOURCES														
	Coking coal	Steam coal	Coal other uses	Lignite	Subproduc ts	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy	Geotherma l Energy	Wind and Photovoltaic Energy	Waste	Wood	Biodiesel	TOTAL PRIMARY SOURCES
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Conversion factor (a)	7.400	6.350	7.400	2.500	2.500	8.190	10.000	10.000	2.200	2.200	2.200	2.500	2.500	8.900	
TOTAL (1+2+3+4+5)		16,989	1,163	13		391,965							35,241	12,958	458,329
	(a) - Lower heat value has been adopted for all fuels														
	(b) - Non energy uses of energetic sources														

Table A5.8-National Energy Balance, year 2011, Secondary fuels used by end use sectors, "Enclosure 3/a", 10⁹kcal

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
	16	17	18	19	21	22	20	23	24	25	26	27	28	29	30	31	32	33	34
Conversion factor	0.860	7.500	6.975	4.250	0.900	7.400	4.250	11.000	12.000	10.400	10.500	10.400	10.300	10.200	9.800	9.800	8.300	5.986	
1) AGRICULTURE AND FISHING																			
I- Agriculture	5,080							638			84			19,737					25,539
II- Fishing								22			11			1,846					1,879
Sub-Total	5,080							660			95			21,583					27,418
2) INDUSTRY																			
I- Iron and steel industry	17,750		25,722		119			187						163	412	245	8		44,606
II- Other industry	87,010	106	130					2,662	5,892		252	166	10	3,459	2,529	7,301	21,737	3,381	134,635
a) Mining industry	782							22						235	88	10			1,137
b) Non-Ferrous Metals	3,941		14					154						51	216				4,376
c) Metal works factories	21,702							594			252	166	10	1,061	666	941			25,392
d) Food Processing, Beverages	10,851	68						341						388	902	1,519			14,069
e) Textile and clothing	5,618							154						275	10	598			6,655
f) Construction industries (cement, bricks)	5,616		72					638						418	333	470	21,671	3,171	32,389
g) Glass and	4,251							517						143		1,558			6,469

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
	16	17	18	19	21	22	20	23	24	25	26	27	28	29	30	31	32	33	34
Conversion factor	0.860	7.500	6.975	4.250	0.900	7.400	4.250	11.000	12.000	10.400	10.500	10.400	10.300	10.200	9.800	9.800	8.300	5.986	
potter																			
h) Chemical	17,248	38	22					33						194		647	66		18,248
i) Petrochemical	1,329							77	5,892						98	1,019		210	8,625
l) Pulp, paper and print	8,253							66						184		402			8,905
m) Other industries	6,008		22					55						112	216	137			6,550
n) Building and civil works	1,411							11						398					1,820
Sub-Total	104,760	105	25,852		119			2,849	5,892		252	166	10	3,622	2,941	7,546	21,746	3,380	179,240
3) SERVICES																			
I - Railways	4,689													459					5,148
II - Navigation	48													2,203					2,251
III - Road transportation	4,356							13,937			100,443			237,895					356,631
IV - Civil aviation	189										74	40,123	103						40,489
V - Other transportation	20,295																		20,295
VI - Public Service	9,623							55			168	1,144		2,060					13,050
Sub-Total	39,200							13,992			100,685	41,267	103	242,617					437,864
4) DOMESTIC AND COMMERCIAL USES	110,532	429						17,754					93	17,962		588			147,358

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
	16	17	18	19	21	22	20	23	24	25	26	27	28	29	30	31	32	33	34
Conversion factor	0.860	7.500	6.975	4.250	0.900	7.400	4.250	11.000	12.000	10.400	10.500	10.400	10.300	10.200	9.800	9.800	8.300	5.986	
TOTAL (1+2+3+4)	259,572	534	25,852		119			35,255	5,892		101,032	41,433	206	285,784	2,941	8,134	21,746	3,380	791,880
5) NON ENERGY USE (b)																			
I - Chemical industry																			
II - Petrochemical								3,377	2,868	35,849	9,104		7,643	6,712	1,205	431		578	67,767
III - Agriculture						104													104
IV - Other sectors						888												20,888	21,776
Sub-Total						992		3,377	2,868	35,849	9,104		7,643	6,712	1,205	431		21,466	89,647
TOTAL (1+2+3+4+5)	259,572	534	25,852		119	992		38,632	8,760	35,849	110,136	41,433	7,849	292,496	4,146	8,565	21,746	24,846	881,527
(c) 490 10 ⁹ kcal of diesel and 22 10 ⁹ kcal of LPG used for heating for Public Service																			

Table A5.9 -National Energy Balance, year 2011, Primary fuels used by end use sectors, "Enclosure 3/a", quantity

Table A3.3 - National Energy Balance, year 2011, Primary fuels used by end use sectors, "Enclosure 3/a", quantity

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
Unit of measurement	kt	kt	kt	kt		Mmc	kt	kt	GWh	GWh	GWh	kt	kt	
1) AGRICULTURE AND FISHING														
I- Agriculture						159							564	
II- Fishing														
Sub-Total	0	0	0	0		159	0	0	0	0			564	
2) INDUSTRY														
I- Iron and steel industry		2,173	97			2,164								
II- Other industry	0	502	54	5		13,310	0		0	0		0	987	
a) Mining industry						45								
b) Non-Ferrous Metals			5			505								
c) Metal works factories						2,100								
d) Food Processing, Beverages						1,754								
e) Textile and clothing						755								
f) Construction industries (cement, bricks)		502	47	5		741							987	
g) Glass and pottery						2,214								
h) Chemical			2			2,545								
i) Petrochemical						0								
l) Pulp, paper and print						2,201								
m) Other industries						450								
n) Building and civil works														
Sub-Total	0	2,675	151	5	0	15,474	0	0	0	0		0	987	
3) SERVICES														
I - Railways														

FINAL CONSUMPTIONS	PRIMARY SOURCES													
	Coking coal	Steam coal	Coal other uses	Lignite	Subproduc ts	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy	Geotherma l Energy	Wind and Photovolta ic 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	
II - Navigation														
III - Road transportation						882							(b) 1,456	
IV - Civil aviation														
V - Other transportation														
VI - Public Service														
Sub-Total	0	0	0	0		882	0	0	0	0			1,456	
4) DOMESTIC AND COMMERCIAL USES			6			30,823							(b) 12,545	
TOTAL (1+2+3+4)	0	2,675	157	5		47,338	0	0	0	0			15,552	
5) NON ENERGY USE (a)														
I - Chemical industry														
II - Petrochemical						521								
III - Agriculture														
IV - Other sectors														
Sub-Total	0	0	0	0		521	0	0	0	0			-	
TOTAL (1+2+3+4+5)	0	2,675	157	5		47,859	0	0	0	0			15,552	
(a) - Non energy uses of energetic sources														
(b) - Biodiesel for road transport: 202 kt; biodiesel for domestic and commercial uses: 0 kt														

Table A5.10 -National Energy Balance, year 2011, Secondary fuels used by end use sectors, "Enclosure 3/a", quantity

FINAL CONSUMPTIONS	SECONDARY SOURCES																	
	Electric Energy	Char- coal	Coke	Coke oven gas	Blast furnace Gas	Non energy use of coal products	Gas works Gas	L. P. G.	Refinery gas	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
	15	16	17	18	20	21	19	22	23	24	25	26	27	28	29	30	31	32
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	5,907							58			8			1,935				
II- Fishing								2			1			181				
Sub-Total	5,907	0	0	0	0		0	60	0	0	9	0	0	2,116	0	0	0	0
2) INDUSTRY																		
I- Iron and steel industry	20,641		3,577		132			17						16	42	25	1	
II- Other industry	101,173	14	18	0	0	0	0	242	491	0	24	16	1	339	258	745	2,619	532
a) Mining industry	909							2						23	9	1		
b) Non-Ferrous Metals	4,582		2					14						5	22	0		
c) Metal works factories	25,235							54			24	16	1	104	68	96		
d) Food Processing, Beverages	12,617	9						31						38	92	155		
e) Textile and clothing	6,533							14						27	1	61		
f) Construction industries (cement, bricks)	6,530		10					58						41	34	48	2,611	499
g) Glass and pottery	4,943							47						14	0	159		
h) Chemical	20,056	5	3					3						19	0	66	8	
i) Petrochemical	1,545							7	491	0	0	0	0	0	10	104	0	33
l) Pulp, paper and	9,597							6						18	0	41		

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
	15	16	17	18	20	21	19	22	23	24	25	26	27	28	29	30	31	32
Unit of measurement	GWh	kt	kt	Mmc	Mmc	kt	Mmc	kt	kt	kt		kt	kt	kt	kt	kt	kt	kt
print																		
m) Other industries	6,986		3					5						11	22	14		
n) Building and civil works	1,640							1						39				
Sub-Total	121,814	14	3,595	0	132	0	0	259	491	0	24	16	1	355	300	770	2,620	532
3) SERVICES																		
I - Railways	5,452													45				
II - Navigation	56													216				
III - Road transportation	5,065							1,267			(b) 9,566			23,323				
IV - Civil aviation	220										7	3,858	10					
V - Other transportation	23,599																	
VI - Public Service	11,189							(a) 5			16	110		(a) 202				
Sub-Total	45,581	0	0	0	0	0	0	1,272	0	0	9,589	3,968	10	23,786	0	0	0	0
4) DOMESTIC AND COMMERCIAL USES	128,526	57						1,614					9	1,761		60		
TOTAL (1+2+3+4)	301,828	71	3,595	0	132	0	0	3,205	491	0	9,622	3,984	20	28,018	300	830	2,620	532
5) NON ENERGY USE																		
I - Chemical industry																		
II - Petrochemical								307	239	3,447	867	0	742	658	123	44	0	91

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
	15	16	17	18	20	21	19	22	23	24	25	26	27	28	29	30	31	32
Unit of measurement	GWh	kt	kt	Mmc	Mmc	kt	Mmc	kt	kt	kt		kt	kt	kt	kt	kt	kt	kt
III - Agriculture						14												
IV - Other sectors						120												3,287
Sub-Total	-	0	0	0	0	134	0	307	239	3,447	867	0	742	658	123	44	0	3,378
TOTAL (1+2+3+4+5)	301,828	71	3,595	0	132	134	0	3,512	730	3,447	10,489	3,984	762	28,676	423	874	2,620	3,910
(c) 48 kt of gas oil and 2 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 ISPRA. The purpose is to analyse regularly the chemical composition of the used fuel or relevant commercial statistics to estimate the carbon content / emission factor (EF) of the fuels. For each primary fuel (natural gas, oil, coal) a specific procedure has been established.

A6.1 Natural gas

The national market is characterized by the commercialisation of gases with different chemical composition in variable quantities from one year to the other. Since 1990 natural gas has been produced in Italy and imported by pipelines from Russia, Algeria and the 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, through new pipeline connections, and from 2008 a new NGL facility has entered into service, using mainly liquefied gas from Oman. There are also sizeable underground storage facilities and additional pipelines/NGL facilities are planned.

The estimation of an average EF for natural gas is the only way to calculate total emissions from this source in Italy, because the origin of the gas used by final consumers can not be tracked through the national statistics and it is subject to variations during the year, according to supply. Only the main industrial installations perform routine checks to estimate the average chemical composition / energy content of natural gas used.

Another task connected to the use of natural gases of different origin and composition is linked to the estimation of an average content of methane to estimate fugitive emissions of this gas from the transmission / distribution network. Since the beginning of the inventory estimations, the average EF of the used gas in Italy has been estimated by the inventory team and it changes every year.

From 2008 in the energy balance, BEN 2008, (MSE, several years [a]) some modifications have occurred; a new average lower heat value has been derived from Eurostat methodology. This new conversion factor did imply a methodological revision to estimate the average national EF. Additionally, the IPCC 2006 guidelines, see table A6.1, contain important information to consider: the recognition of a certain variability of the EF for this source; the estimation of a lower and upper bound for the EFs; the link between energy content and EF; the statement that, by converting to energy units all EFs, their variability can be reduced. Moreover default oxidation factor is estimated to be equal to 1 (full oxidation). The 2006 guidelines do not apply in the national inventory up to 2012, but some of the scientific information could and should be considered in the estimation of the national emission factors (IPCC, 2006).

Each of natural gases transmitted by the grid operator is regularly analysed at import gates, for budgetary reasons. Energy content for cubic meters, percentage of methane and other substances are calculated. For example, methane content can considerably vary: 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. Also carbon content varies significantly.

Natural gas properties are more stable referring to the country of origin, with small variations in chemical composition from year to year. Speciation of gas from each import manifold is regularly published by national transmission grid operator (Snam Rete Gas, several years). Other information is also available from the main final users (TERNA, several years).

So, for each year, the average methane and carbon content of the natural gas used in Italy are estimated, using 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.

In the 2013 submission, the average emission factors for the year 2009 and 2010 have been revised on account of updated information on energy conversion factor of imported fuels. As shown in the table, the ranges of national EFs are within the lower and upper threshold of the IPCC 2006 guidelines.

Table A6.1 Natural gas carbon emission factors

	t CO ₂ / TJ (stoichiometric)	t CO ₂ / TJ (with oxidation factor equal to 0.995)	t CO ₂ / 10 ³ std cubic mt	t CO ₂ / toe
Natural gas (dry) IPCC '96	56.061	55.780	1.925	2.334
Natural gas, IPCC '06 average	56.100			
lower	54.100			
upper	58.100			
National Emission Factors				
Natural gas , 1990	55.606	55.328	1.942	2.315
Natural gas, 1995	55.702	55.423	1.961	2.319
Natural gas , 2000	55.751	55.472	1.971	2.321
Natural gas , 2001	55.699	55.421	1.960	2.319
Natural gas , 2002	56.255	55.974	1.965	2.342
Natural gas, 2003	55.874	55.594	1.961	2.326
Natural gas, 2004	55.874	55.595	1.945	2.326
Natural gas, 2005	55.869	55.590	1.944	2.326
Natural gas, 2006	55.946	55.666	1.949	2.329
Natural gas, 2007	55.917	55.637	1.947	2.328
Natural gas, 2008	56.025	55.745	1.950	2.332
Natural gas, 2008, with 8190 lhv	57.196	56.910	1.950	2.381
Natural gas, 2009	56.050	55.769	1.958	2.333
Natural gas, 2009, with 8190 lhv	57.418	57.131	1.958	2.390
Natural gas, 2010	55.998	55.718	1.962	2.331
Natural gas, 2010, with 8190 lhv	57.527	57.239	1.961	2.395
Natural gas, 2011	55.804	55.525	1.955	2.323
Natural gas, 2011, with 8190 lhv	57.047	56.762	1.945	2.375

Source: ISPRA elaborations

The methodology used to estimate the EF is based on the available data. Each year the quantities of natural gas imported or produced in Italy are published on the web by the MSE <http://dgerm.sviluppoeconomico.gov.it/dgerm/bilanciogas.asp>. Those data are produced by the national grid operator and are concerned on all imported gas by point of entrance in the country and all natural gas produced. To compare quantities of different gases, the physical quantities of imported/produced gas are normalized to a higher heat value (hhv) equal to 9100 kcal/m³ and standard conditions. Other data input used in the estimation are the average chemical composition and the hhv of the gas at each import “gate” and for the national production. Those data are published by Snam Rete Gas in its yearly “Bilancio di Sostenibilità” (Snam Rete Gas, several years) and with them it is possible to estimate the average carbon content of the fuel. Those data are referred to the physical quantities of imported / produced gas.

So the total quantities of imported gas (normalized at the hhv of 9100) published by MSE are transformed back to the physical quantities of actually imported gas using the hhv ratio and then average carbon content of the total gas imported or produced in Italy can be estimated. Those data are then referred back to the normalized quantities of gas used in national statistics.

Data on final consumption of gas refers to the lower heat value (lhv). In particular the electricity production companies regularly estimate the actual lhv of the gas they are using and this figure is published yearly by TERNA. Operator’s data are used to verify the calculation results. Weighted average lhv of the imported / produced natural gas in 2011 is 8376 kcal/m³.

As mentioned above in the BEN 2008, the average lhv has been changed from 8250 kcal/m³ (historical value) to 8190 kcal/m³, to harmonize national data with Eurostat methodology. Eurostat consider the lhv as being 10% less than hhv, regardless of the actual value. As reported in table A6.1, this change influences the EF, if it is referred to the energy content (lhv) of the fuel, but it have no influence if the EF is referred to

cubic meters. The total amount of carbon emitted by natural gas in Italy from 2008 do not change using both EFs reported in the table because the total energy content of the natural gas use changes according to the statistical methodology used.

A6.2 Diesel oil, petrol and LPG

APAT (now ISPRA) has made an investigation of the carbon content of the main transportation fuels sold in Italy: petrol, diesel and LPG, with the aim of testing the average fuels sold in the year 2000 and collecting available information on previous year fuels. The goal of this work is the verification of CO₂ emission factors of Italian energy system, with a particular focus on the transportation sector. The results of analysis of fuel samples performed by “Stazione Sperimentale Combustibili” (APAT, 2003) were compared with emission factors used in Reference Approach of the Intergovernmental Panel for Climate Change (IPCC, 1997) and emission factors considered in the COPERT 4 programme (EMISIA SA, 2012).

These two methodologies are widely used to prepare data at the international level but, when applied to the Italian data set produce results with significant differences, around 2- 4%. The reason has been traced back to the emission factors that are referred to the energy content of the fuel for IPCC and to the physical quantities for the COPERT methodology.

The results of the study link the chemical composition of the fuel to the l_{h_v} 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 1996 emission factors for diesel fuels and IPCC-Europe for 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 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 the imported quantities.

Concerning petrol, instead, IPCC 1996 emission factors is quite low and it has to be updated, 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 l_{h_v} 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.

Table A6.2 Fuels, national production, carbon emission factors, with oxidation factor equal to 0.99

	t CO ₂ / TJ	t CO ₂ / t	t CO ₂ / toe
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 1990-1999	71.034	3.121	2.972
Petrol, experimental averages 2000-2011	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 2000-2011	73.153	3.138	3.061
Gas oil, heating, experimental averages 2000-2011	73.693	3.141	3.083
LPG, IPCC / OECD	62.392	2.952	2.610
LPG, IPCC / Europe	64.350	3.000	2.692
LPG, 1990 – 1999	64.350	3.000	2.692
LPG, experimental averages 2000-2011	64.936	2.994	2.717

Source: ISPRA elaborations

A6.3 Fuel oil

The main information available nationally of fuel oil EF is a sizable difference in carbon content between high sulphur and light sulphur brands. The data were elaborated from literature and from an extensive series of samples (more than 400) analysed by ENEL and made available to ISPRA. 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.

Table A6.3 Fuel oil, average of national and imported products, carbon emission factors

	t CO ₂ / TJ (stechiometric)	t CO ₂ / TJ (with oxidation factor equal to 0.99)	t CO ₂ / t	t CO ₂ / toe
Fuel oil , IPCC, 1996	77.310	76.539	3.148	3.202
Fuel oil , IPCC, 2006 average	77.400			
lower	75.200			
upper	79.600			
National emission factors				
Fuel oil, average 1990	77.339	76.565	3.111	3.203
Fuel oil, average 1995	77.425	76.650	3.127	3.207
Fuel oil, average 2000	76.665	75.898	3.124	3.176
Fuel oil, average 2001	76.665	75.889	3.122	3.175
Fuel oil, average 2002	76.709	75.942	3.125	3.177
Fuel oil, average 2003	76.921	76.151	3.131	3.186
Fuel oil, average 2004	76.939	76.170	3.132	3.187
Fuel oil, average 2005	75.875	75.116	3.110	3.143
Fuel oil, average 2006	75.952	75.193	3.111	3.146
Fuel oil, average 2007	76.326	75.562	3.113	3.162
Fuel oil, average 2008	76.393	75.629	3.111	3.164
Fuel oil, average 2009	76.449	75.684	3.112	3.167
Fuel oil, average 2010	76.424	75.660	3.110	3.166
Fuel oil, average 2011	76.391	75.627	3.111	3.164

Source: ISPRA elaborations

Data for all years are within IPCC 2006 ranges, but it can be noticed that are on the lower side from year 2000 onwards. The change from an average to a low EF is due to the harmful emissions limits and fuel regulations introduced in Italy between 1990 and 2000. Most of the fuel used from 2000 onwards is not heavy, high sulphur, fuel oil but light type, low sulphur.

A6.4 Coal

Italy has only negligible national production of coal; most part is imported from various countries and there are differences in carbon content of coal mined in different parts of the world. 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. Detailed data are available in BPT (MSE, several years [b]) supplied from the Ministry of Economic Development and reported for 2011 in Table A6.4.

Table A6.4 – Coal imported by country in 2011 (Mg)

Country	Coking coal	Coke	Steam coal	Lignite	Other	Total Coal	Petroleum-Coke
BELGIUM	0	0	0	0	25	25	0
CYPRUS	0	0	1,089,497	0	0	1,089,497	0
GERMANY	0	0	107	5,221	183	5,511	0
POLAND	0	25	0	0	0	25	0
SPAIN	0	0	723,754	0	0	723,754	0
TOTAL EU	0	25	1,813,358	5,221	208	1,818,812	0
AUSTRALIA	1,393,873	0	338,287	0	0	1,732,160	0
CANADA	905,660	0	0	0	0	905,660	0
CHINA	0	33,227	0	0	0	33,227	0
COLOMBIA	0	0	1,798,105	0	0	1,798,105	0
CROATIA	0	0	0	0	0	0	6,715
EGYPT	0	0	0	0	0	0	31,294
INDONESIA	0	0	6,366,045	0	0	6,366,045	0
Former SOVIET UNION	0	0	1,645,224	0	29,945	1,675,169	0
SINGAPORE	73,670	0	0	0	0	73,670	0
SOUTH AFRICA	0	0	3,917,470	0	0	3,917,470	0
UCRAINA	0	0	0	0	120,070	120,070	0
U.S.A.	3,128,364	0	1,730,938	0	0	4,859,302	1,458,622
VENEZUELA	104,000	0	101,495	0	0	205,495	100,407
TOTAL NON_EU	5,605,567	33,227	15,897,564	0	150,015	21,686,373	1,597,038
TOTAL	5,605,567	33,252	17,710,922	5,221	150,223	23,505,185	1,597,038

Source: MSE, several years [b]

Therefore an attempt was made to find out a methodology allowing 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 still unresolved problem is how to properly link statistical data, referred to the coal “as it is” without specifying moisture and ash content of the product, to the literature data, referring to sample coals.

We envisage improving the quality of the collected statistical data including moisture content of coals; currently 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 it 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, 2007);
- for each inventory year, it was 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, the estimate of carbon content of the average “as it is” coal reported in the statistics was possible.

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 average carbon EF for each year, see Table A6.4 for detailed data. The results do not show impressive changes yearly; anyway a noticeable difference in the emission factor is highlighted in the table. In Table A6.5 updated coal EFs from IPCC 2006 have been also reported. As can be seen, average values for steam coals have been slightly reduced in the updated methodology. National emission factors result in the range given by the old and new average values for “other bituminous coal”.

From the 2011 submission, with the aim to improve the estimation of the coal CO₂ emission factors an in depth analysis of data reported in the framework of the European emissions trading scheme has been carried out. In consideration that these data referring to emission factors and activity data are validated and the amount of fuel reported accounts for more than 90% of the national coal fuel consumption, the average coal CO₂ emission factors, resulting from ETS data, have been applied from 2005.

Table A6.5 – Coal, average carbon emission factors

	t CO ₂ / TJ (stoichiometric)	t CO ₂ / TJ (with oxidation factor 0.98)	t CO ₂ / t	t CO ₂ / toe
Sub bituminous coal, IPCC 1996	98.200	96.234	2.557	4.026
Other Bituminous coal, IPCC 2006, av	94.600			
lower	87.300			
upper	102.500			
National emission factors				
Steam coal, 1990	96.512	94.582	2.502	3.960
Steam coal, 1995	95.926	94.007	2.519	3.936
Steam coal, 2000	93.312	91.446	2.404	3.826
Steam coal, 2001	95.304	93.398	2.434	3.908
Steam coal, 2002	94.727	92.832	2.423	3.884
Steam coal, 2003	95.385	93.478	2.435	3.911
Steam coal, 2004	95.382	93.474	2.430	3.911
Steam coal, 2005	94.403	92.515	2.419	3.871
Steam coal, 2006	94.630	92.737	2.368	3.880
Steam coal, 2007	95.192	93.288	2.386	3.903
Steam coal, 2008	93.775	91.900	2.242	3.845
Steam coal, 2009	93.913	92.035	2.285	3.851
Steam coal, 2010	93.781	91.905	2.290	3.845
Steam coal, 2011	93.526	91.655	2.307	3.835

Source: ISPRA elaborations

A6.5 Other fuels

Country specific emission factors have been calculated for other fuels and included in the inventory on account of the analysis of data reported by plants in the framework of the European emissions trading scheme. In consideration that these data referring to emission factors and activity data are validated and the amount of fuels reported accounts for more than 90% of the national fuels consumption, the average CO₂ emission factors have been applied for the years 2005-2010.

In the following, values of CO₂ emission factors are specified for the different fuels. From 2005, figures result from a weighted average of ETS data; before that period, emission factors derive from literature data or other national data collection. In the 2013 submission an in depth analysis of data reported in the framework of the European emissions trading scheme has been carried out and the emissions factors for refinery gas, coke oven gas, and blast furnace gas have been revised starting from 2005.

Table A6.6 – Refinery gas, average carbon emission factors

<i>Refinery gas</i>	t CO ₂ / TJ (stoichiometric)	t CO ₂ / TJ (with oxidation factor 0.995)	t CO ₂ / t	t CO ₂ / toe
National emission factors				
Refinery gas, 1990-2004	62.392	62.080	3.117	2.597
Refinery gas, 2005	58.255	57.963	2.753	2.425
Refinery gas, 2006	57.173	56.889	2.637	2.380
Refinery gas, 2007	56.985	56.700	2.653	2.372
Refinery gas, 2008	58.187	57.896	2.702	2.422
Refinery gas, 2009	57.625	57.337	2.694	2.399
Refinery gas, 2010	57.622	57.331	2.711	2.399
Refinery gas, 2011	57.485	57.205	2.697	2.393

Source: ISPRA elaborations

Table A6.7 – Coke oven gas, average carbon emission factors

<i>Coke oven gas</i>	t CO ₂ / TJ (stechiometric)	t CO ₂ / 10 ³ std t CO ₂ / TJ cubic mt t CO ₂ / toe (with oxidation factor 0.995)		
National emission factors				
Coke oven gas, 1990-1999	47.200	46.964	0.835	1.965
Coke oven gas, 2000-2004	42.111	41.900	0.802	1.753
Coke oven gas, 2005	42.128	41.918	0.750	1.754
Coke oven gas, 2006	42.678	42.465	0.740	1.777
Coke oven gas, 2007	42.416	42.204	0.734	1.766
Coke oven gas, 2008	42.250	42.039	0.730	1.759
Coke oven gas, 2009	42.980	42.765	0.744	1.789
Coke oven gas, 2010	42.816	42.602	0.732	1.782
Coke oven gas, 2011	43.328	43.111	0.743	1.804

Source: ISPRA elaborations

Table A6.8 – Blast furnace gas, average carbon emission factors

<i>Blast furnace gas</i>	t CO ₂ / TJ (stechiometric)	t CO ₂ / 10 ³ std t CO ₂ / TJ cubic mt t CO ₂ / toe (with oxidation factor 0.995)		
National emission factors				
Blast furnace gas, 1990-1999	243.220	242.004	0.780	10.125
Blast furnace gas, 2000-2004	270.575	269.222	0.948	11.264
Blast furnace gas, 2005	263.653	262.334	0.924	10.976
Blast furnace gas, 2006	255.948	254.668	0.897	10.655
Blast furnace gas, 2007	261.469	260.162	0.916	10.885
Blast furnace gas, 2008	256.133	254.852	0.842	10.663
Blast furnace gas, 2009	259.560	258.263	0.854	10.806
Blast furnace gas, 2010	257.390	256.103	0.865	10.715
Blast furnace gas, 2011	255.351	254.074	0.880	10.630

Source: ISPRA elaborations

Table A6.9 – Oxygen furnace gas, average carbon emission factors

<i>Oxygen furnace gas</i>	t CO ₂ / TJ (stechiometric)	t CO ₂ / TJ t CO ₂ / 10 ³ std cubic mt (with oxidation factor 0.995)	t CO ₂ / toe	
National emission factors				
Oxygen furnace gas, 1990-2004	195.086	194.111	1.495	8.122
Oxygen furnace gas, 2005	197.579	196.591	1.514	8.225
Oxygen furnace gas, 2006	202.372	201.360	1.551	8.425
Oxygen furnace gas, 2007	195.871	194.892	1.501	8.154
Oxygen furnace gas, 2008	196.465	195.483	1.273	8.179
Oxygen furnace gas, 2009	196.970	195.986	1.277	8.200
Oxygen furnace gas, 2010	197.029	196.044	1.217	8.202

<i>Oxygen furnace gas</i>	t CO ₂ / TJ (stoichiometric)	t CO ₂ / TJ	t CO ₂ / 10 ³ std cubic mt (with oxidation factor 0.995)	t CO ₂ / toe
National emission factors				
Oxygen furnace gas, 2011	198.482	197.489	1.165	8.263

Source: ISPRA elaborations

Table A6.10 – Heavy residual fuels, average carbon emission factors

<i>Heavy residual fuels</i>	t CO ₂ / TJ (stoichiometric)	t CO ₂ / TJ	t CO ₂ / t (with oxidation factor 0.99)	t CO ₂ / toe
National emission factors				
Heavy residual fuels, 1999-2005	80.317	79.514	3.121	3.327
Heavy residual fuels, 2006	81.817	80.999	3.179	3.389
Heavy residual fuels, 2007	81.823	81.005	3.179	3.389
Heavy residual fuels, 2008	81.823	81.005	3.179	3.389
Heavy residual fuels, 2009	79.319	78.526	3.082	3.286
Heavy residual fuels, 2010	79.259	78.466	3.085	3.283
Heavy residual fuels, 2011	80.421	79.617	3.099	3.331

Source: ISPRA elaborations

Table A6.11 – Synthesis gas, average carbon emission factors

<i>Synthesis gas</i>	t CO ₂ / TJ (stoichiometric)	Oxidation factor	t CO ₂ / TJ	t CO ₂ / t	t CO ₂ / toe
National emission factors					
Synthesis gas, 1999-2004	96.800	1.000	96.800	0.895	4.050
Synthesis gas, 2005	98.103	0.994	97.527	0.927	4.080
Synthesis gas, 2006	98.566	0.994	97.958	1.032	4.099
Synthesis gas, 2007	98.321	0.992	97.545	0.899	4.081
Synthesis gas, 2008	98.860	0.992	98.085	0.961	4.104
Synthesis gas, 2009	97.555	0.990	96.579	0.947	4.041
Synthesis gas, 2010	101.930	0.990	100.911	0.902	4.222
Synthesis gas, 2011	100.627	0.990	99.620	0.883	4.168

Source: ISPRA elaborations

Table A6.12 – Residual gas of chemical processes, average carbon emission factors

<i>Residual gas of chemical processes</i>	t CO ₂ / TJ (stoichiometric)	Oxidation factor	t CO ₂ / TJ	t CO ₂ / t	t CO ₂ / toe
National emission factors					
Residuals gas of chemical processes, 1990-2007	51.500	0.995	51.243	2.276	2.144
Residuals gas of chemical processes, 2008	51.308	0.995	51.052	2.485	2.136
Residuals gas of chemical processes, 2009	50.588	0.995	50.342	2.515	2.106
Residuals gas of chemical processes, 2010	50.425	0.996	50.209	2.527	2.101
Residuals gas of chemical processes, 2011	50.886	0.995	50.651	2.388	2.119

Source: ISPRA elaborations

Table A6.13 – Petroleum coke, average carbon emission factors

<i>Petroleum coke</i>	t CO ₂ / TJ (stoichiometric)	Oxidation factor	t CO ₂ / TJ	t CO ₂ / t	t CO ₂ / toe
National emission factors					
Petroleum coke, 1990-2004	100.762	0.990	99.755	3.464	4.174
Petroleum coke, 2005	92.955	0.998	92.787	3.169	3.882
Petroleum coke, 2006	93.290	0.998	93.118	3.192	3.896
Petroleum coke, 2007	93.428	0.998	93.244	3.188	3.901
Petroleum coke, 2008	93.531	0.998	93.351	3.200	3.906
Petroleum coke, 2009	93.722	0.991	92.881	3.177	3.886
Petroleum coke, 2010	94.023	0.990	93.104	3.199	3.895
Petroleum coke, 2011	94.079	0.997	93.770	3.221	3.923

Source: ISPRA elaborations

ANNEX 7: AGRICULTURE SECTOR

Additional information used for estimating categories 4A and 4B from the agriculture sector is reported in this section.

A7.1 Enteric fermentation (4A)

The time series of the parameters used for estimating the Dairy Cattle EF using the Tier 2 approach, are reported in Table A.7.1. Information on the equations used for estimating the different net energy (NE_m , NE_g , etc.) is described in IPCC Good Practice (IPCC, 2000).

Table A.7.1 Parameters used for the Tier 2 approach - dairy cattle

	NE_m (MJ/day)	NE_a (MJ/day)	NE_g (MJ/day)	NE_l (MJ/day)	NE_w (MJ/day)	NE_p (MJ/day)	NE_{ma}/DE	NE_{ga}/DE	GE (MJ/day)
1990	40.75	0.35	0.99	33.52	0.00	3.97	0.51	0.31	240.23
1991	40.75	0.35	0.99	37.71	0.00	3.96	0.51	0.31	252.77
1992	40.75	0.35	0.99	40.42	0.00	3.91	0.51	0.31	260.76
1993	40.75	0.35	0.99	40.25	0.00	3.89	0.51	0.31	260.17
1994	40.75	0.35	0.99	42.53	0.00	3.92	0.51	0.31	267.10
1995	40.75	0.35	0.99	43.38	0.00	3.86	0.51	0.31	269.45
1996	40.75	0.35	0.99	45.11	0.00	3.86	0.51	0.31	274.63
1997	40.75	0.35	0.99	45.46	0.00	3.85	0.51	0.31	275.65
1998	40.75	0.35	0.99	45.25	0.00	3.79	0.51	0.31	274.86
1999	40.75	0.35	0.99	45.17	0.00	3.75	0.51	0.31	274.47
2000	40.75	0.35	0.99	44.31	0.00	3.78	0.51	0.31	271.99
2001	40.75	0.35	0.99	43.74	0.00	3.73	0.51	0.31	270.14
2002	40.75	0.35	0.99	47.60	0.00	3.72	0.51	0.31	281.66
2003	40.75	0.35	0.99	47.57	0.00	3.72	0.51	0.31	281.56
2004	40.75	0.35	0.99	49.68	0.00	3.66	0.51	0.31	287.72
2005	40.75	0.35	0.99	50.84	0.00	3.71	0.51	0.31	291.34
2006	40.75	0.35	0.99	51.17	0.00	3.67	0.51	0.31	292.23
2007	40.75	0.35	0.99	51.15	0.00	3.65	0.51	0.31	292.09
2008	40.75	0.35	0.99	52.43	0.00	3.65	0.51	0.31	295.94
2009	40.75	0.35	0.99	51.00	0.00	3.67	0.51	0.31	291.71
2010	40.75	0.35	0.99	55.30	0.00	3.67	0.51	0.31	304.57
2011	40.75	0.35	0.99	54.81	0.00	3.68	0.51	0.31	303.14

Source: ISPRA elaborations

A7.2 Manure management (4B)

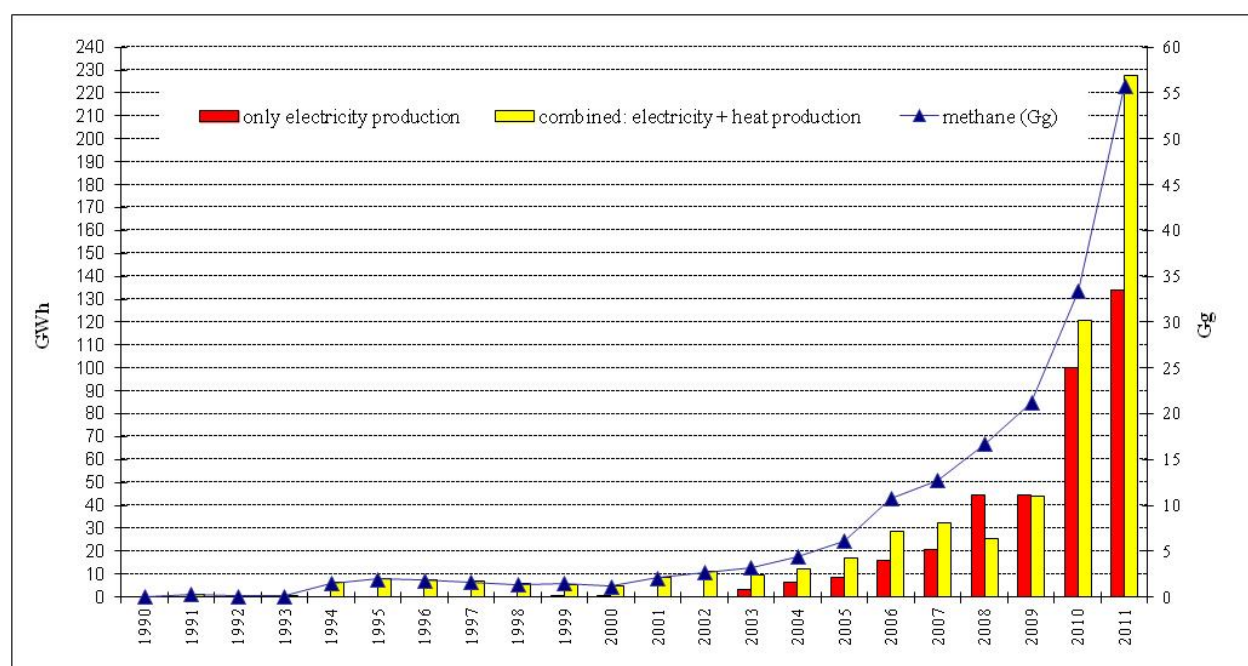
In this section the time series used to apply the methane emission reduction to the 4B Manure management category from the agriculture sector are reported. The source of information is the National Electric Network (TERNA, 2013). The total gross production of biogas produced from animal manure is used for the production of electricity and combined (electricity and heat) production. The conversion of this information (GWh) into methane (Gg) has assumed a 30% yield and a net caloric value of 50.038 Gg/TJ. For the last two years a higher efficiency and a higher net calorific value was assumed.

A representation of the time series is presented in the following Table A.7.2 and Figure A.7.1.

Table A.7.2 Time series of gross production of biogas from animal manure

Year	BIOGAS			
	Only for electricity production (GWh)	Combined: For electricity +heat production (GWh)	TOTAL Gross production (GWh)	Methane (Gg)
1990	0	0	0	0.00
1991	0	1.3	1.3	0.31
1992	0	0.5	0.5	0.12
1993	0	0.4	0.4	0.10
1994	0	6.3	6.3	1.51
1995	0	8.1	8.1	1.94
1996	0	7.6	7.6	1.82
1997	0	6.9	6.9	1.65
1998	0	5.7	5.7	1.37
1999	0.8	5.6	6.4	1.53
2000	0.2	4.7	4.9	1.18
2001	0	8.7	8.7	2.09
2002	0	11.3	11.3	2.71
2003	3.5	9.7	13.2	3.17
2004	6.3	12.2	18.5	4.44
2005	8.8	16.9	25.7	6.16
2006	16.2	28.5	44.7	10.72
2007	20.9	32.4	53.3	12.78
2008	44.3	25.5	69.8	16.74
2009	44.3	44.1	88.4	21.20
2010	100.3	120.7	221.0	33.33
2011	133.8	227.8	361.6	55.76

Source: ISPRA elaborations on TERNA data



Source: ISPRA elaborations

Figure A7.1 Time series of gross production of biogas from animal manure

In Table A.7.3 the percentages of animals in temperate zone based on data from the 2000 Agriculture Census, provided by ISTAT, and the average temperature at provincial level are shown.

A7.3 Agricultural soils (4D)

In this section parameters used for estimating direct and indirect N₂O emissions from sewage sludge applied to soils are presented.

Table A.7.4 Time series of sewage sludge activity data

Year	Total amount sewage sludge for agriculture (t dry matter)	N content (%)	N sewage sludge (t)
1990	98,164	5.2	5,071
1991	102,840	5.2	5,313
1992	94,675	5.2	4,891
1993	90,039	5.2	4,652
1994	127,505	5.2	6,587
1995	157,512	5.2	8,137
1996	174,505	5.2	9,015
1997	217,747	5.2	11,249
1998	194,314	5.3	10,292
1999	215,024	5.2	11,104
2000	217,424	5.0	10,954
2001	293,253	5.5	16,076
2002	302,112	5.1	15,339
2003	297,861	4.9	14,648
2004	195,161	4.1	8,055
2005	215,742	4.1	8,874
2006	189,555	4.1	7,778
2007	202,098	4.1	8,305
2008	194,666	4.5	8,841
2009	289,620	3.9	11,365
2010	286,463	3.9	11,241
2011	296,453	4.0	11,858

Source: ISPRA elaborations from MATTM (MATTM, 2010)

Table A.7.3 Distribution of animals in temperate zone

Percentage of animals in temperate zone based on data from the 2000 agriculture census (ISTAT)	Average temperature	Average temperature weighted by % animals for different altitudes (plain, hill, mountain)	Non-dairy cattle	Dairy cattle	Buffalo	Other swine	Sows	Sheep	Goats	Horses	Mules and asses	Broilers	hen	other poultry	Rabbits
(001) Torino	11.4	11.4	185,441	60,950	137	141,070	9,422	11,842	5,970	16,626	285	1,384,201	605,549	121,305	492,247
(002) Vercelli	11.4	11.4	6,139	3,361	0	19,046	3,023	4,530	3,037	378	177	240,844	90	367,320	39,791
(003) Novara	11.7	11.8	11,634	11,941	659	36,842	4,066	442	1,619	2,024	0	163,436	135,522	26,764	213,580
(004) Cuneo	11.4	11.5	360,266	79,864	0	731,388	51,882	24,890	8,155	353	7	1,906,594	513,460	794,541	1,585,288
(005) Asti	11.7	11.9	44,507	965	0	16,149	1,305	2,118	4,169	2,531	83	517,799	407,027	34,957	149,473
(006) Alessandria	11.5	11.6	37,346	3,671	0	24,325	1,120	3,109	4,344	277	80	73,144	216,432	360,226	44,509
(007) Aosta	11.5	11.6	17,379	22,332	0	26	0	2,586	3,692	116	32	9	2,602	98	1,894
(008) Imperia	11.1	11.1	2,372	353	0	3	0	843	2,970	53	0	26	557	4	7,535
(009) Savona	12.7	13.2	4,030	58	0	107	0	16,799	497	154	8	5,370	19,638	156	86,893
(010) Genova	12.4	12.9	5,357	1,551	0	134	39	4,984	3,611	2,844	149	12,259	46,343	5,251	30,704
(011) La Spezia	12.2	12.7	3,063	591	0	184	11	2,627	1,082	654	36	5,012	12,435	1,077	44,724
(012) Varese	11.4	11.5	13,632	5,249	7	2,161	88	5,275	2,936	3,128	465	50,165	344,100	175,959	23,006
(013) Como	12.1	12.4	11,270	7,743	2	844	178	5,475	10,203	3,616	591	135,711	29,395	13,744	91,334
(014) Sondrio	12.3	12.6	9,318	15,448	0	835	13	7,028	14,252	654	503	679,686	58,918	24	302
(015) Milano	12.2	12.5	62,266	36,960	1,782	105,277	7,399	2,833	1,715	2,431	122	97,755	710,011	59,622	5,511
(016) Bergamo	11.9	12	112,201	69,614	643	301,491	30,604	28,808	15,872	9,783	753	1,475,925	1,529,460	516,977	6,161
(017) Brescia	12.1	12.3	342,654	148,660	859	1,325,578	107,005	40,160	11,455	6,638	12	14,969,749	3,551,027	2,087,292	81,342
(018) Pavia	11.8	12	20,446	9,054	0	239,400	15,395	0	2,261	640	23	2,104	174,942	215,736	0
(019) Cremona	12.1	12.3	165,913	115,308	676	619,970	70,275	2,299	72	1,255	18	2,799,928	1,541,962	1,641,787	7,035
(020) Mantova	12.1	12.4	265,591	109,883	0	1,055,640	60,972	0	962	683	87	1,182,334	5,613,807	817,826	18,164
(021) Bolzano-Bozen	11.7	11.8	67,713	83,892	0	13,776	311	50,645	21,570	6,354	428	85	139,010	2,096	41,767
(022) Trento	10.8	11.3	17,303	29,737	0	7,206	171	29,731	10,811	3,313	571	1,182,144	397,493	34,367	180,203
(023) Verona	11.2	11.8	190,794	35,635	0	308,510	11,067	56	196	9,441	0	16,208,619	4,569,421	11,982,064	3,560,404

Percentage of animals in temperate zone based on data from the 2000 agriculture census (ISTAT)	Average temperature	Average temperature weighted by % animals for different altitudes (plain, hill, mountain)	Non-dairy cattle	Dairy cattle	Buffalo	Other swine	Sows	Sheep	Goats	Horses	Mules and asses	Broilers	hen	other poultry	Rabbits
(024) Vicenza	10.6	11.3	125,108	55,512	17	40,798	2,005	5,790	504	1,482	525	3,768,250	462,832	802,257	202,773
(025) Belluno	10.6	11.3	7,385	5,953	0	51,287	10,121	3,693	928	1,578	525	2,673	163	3,312	87,698
(026) Treviso	10.7	11.3	155,378	23,915	1,260	90,128	13,957	1	165	293	2	2,551,739	1,784,328	123,347	2,448,201
(027) Venezia	10.9	11.5	50,470	10,028	366	64,431	4,807	0	1,427	1,784	48	766,865	2,518,034	409,170	17,625
(028) Padova	10.7	11.3	157,703	35,518	916	116,304	12,043	3,763	95	3,291	41	1,988,851	1,801,912	1,194,511	3,735,627
(029) Rovigo	10.6	11.2	42,008	3,964	0	63,717	6,297	1,633	472	805	648	529,387	117,033	586,075	13,310
(030) Udine	10.8	11.4	28,891	32,597	0	61,912	2,591	2,065	2,013	1,717	202	2,801,700	5,597	284,658	901,263
(031) Gorizia	10.9	11.5	3,379	3,626	0	26,853	0	0	0	107	0	248,250	131,708	924,779	71,751
(032) Trieste	10.9	11.6	598	201	0	1,396	0	0	0	0	0	8,303	6,894	9,909	3,955
(033) Piacenza	10.7	11.2	46,684	31,700	13	73,976	4,598	44	8	2,589	273	84,174	173,053	0	158
(034) Parma	10.8	11.4	68,174	99,234	0	143,757	9,496	20	100	4,681	33	89,323	43,864	314	9,110
(035) Reggio nell'Emilia	10.8	11.4	66,270	79,949	247	458,348	21,186	607	802	3,827	243	361,411	76,942	42,922	3,126
(036) Modena	11.9	12.1	67,416	60,029	0	406,595	41,590	64	230	2,533	120	87,552	214,697	113,066	653,404
(037) Bologna	11.6	11.8	20,526	8,482	0	41,454	3,503	12,056	261	9,883	163	47,197	1,276,246	122,438	0
(038) Ferrara	11.7	12	45,143	10,999	0	23,215	3,623	0	109	4,385	91	0	102,049	57,109	7,380
(039) Ravenna	11.7	12	13,141	3,179	0	43,765	3,106	14,092	754	3,522	764	698,792	2,308,670	3,301,798	392,834
(040) Forlì-Cesena	11.8	12.1	18,275	2,382	1	93,487	15,742	26,716	1,246	3,380	12	16,350,182	7,581,497	7,795,705	251,700
(041) Pesaro e Urbino	12.4	12.7	30,155	2,429	0	12,424	623	100,473	1,829	3,286	64	39,984	311,955	51,308	308,246
(042) Ancona	12	12.3	9,137	1,141	0	14,310	1,415	11,661	538	137	25	1,382,625	67,488	19,237	112,653
(043) Macerata	13	13.3	13,794	1,378	0	9,895	738	46,279	998	589	102	1,167,510	67	0	388,050
(044) Ascoli Piceno	13.3	13.8	20,587	288	0	77,072	1,228	76,380	4,606	3,286	507	1,060,249	2,310,685	4,027	169,780
(045) Massa-Carrara	12.4	12.6	4,167	926	57	3,480	263	11,899	945	2,752	386	14,659	21,813	931	56,292
(046) Lucca	12.3	12.9	3,560	988	0	848	6	16,156	320	262	0	33,688	53,335	958	40,754
(047) Pistoia	12.5	13.2	8,092	86	0	673	38	5,605	429	4,210	804	0	516	0	1,701

Percentage of animals in temperate zone based on data from the 2000 agriculture census (ISTAT)	Average temperature	Average temperature weighted by % animals for different altitudes (plain, hill, mountain)	Non-dairy cattle	Dairy cattle	Buffalo	Other swine	Sows	Sheep	Goats	Horses	Mules and asses	Broilers	hen	other poultry	Rabbits
(048) Firenze	12	12.8	13,514	3,265	0	36,510	1,557	31,180	2,100	3,729	678	101,134	48,525	135,053	30,541
(049) Livorno	12.9	13.7	1,999	459	0	273	153	11,793	147	1,723	175	980	3,449	59,521	7,417
(050) Pisa	12.2	12.9	9,570	1,548	0	31,753	5,708	54,005	960	1,172	335	8,725	246,875	1,619	3,317
(051) Arezzo	12.2	12.7	9,710	246	22	76,408	8,336	33,407	4,035	1,144	491	187,271	105,848	1,436	292,761
(052) Siena	12.8	13	19,327	1,026	0	25,572	3,053	144,022	871	693	311	3,574	285,186	7,576	43,108
(053) Grosseto	13.8	14	24,968	5,363	395	30,966	2,853	375,071	1,788	7,262	241	6,741	16,471	8,498	70,470
(054) Perugia	13.2	13.3	41,054	11,904	0	223,089	4,769	145,178	7,205	7,151	251	2,786,387	1,035,490	310,913	151,039
(055) Terni	14	14.4	14,305	1,268	0	16,238	1,279	34,266	862	3,671	286	312,851	71,851	0	175,777
(056) Viterbo	14	14.1	21,859	10,870	921	14,190	1,027	290,585	459	2,287	641	509,739	124,450	80,398	246,566
(057) Rieti	14	14.1	26,425	7,172	868	3,745	204	92,899	5,257	9,425	861	362,698	126,234	1,552	53,653
(058) Roma	14.3	14.6	50,058	30,440	178	7,340	60	136,543	1,181	9,081	847	352,347	4,391	411	76,555
(059) Latina	14.6	15	37,987	31,533	28,647	13,183	96	62,152	22,999	2,925	509	39,081	292,776	1,160	654,434
(060) Frosinone	14	14	38,070	12,196	9,745	11,438	140	83,099	4,881	3,602	318	53,017	53,417	1,036	63,430
(061) Caserta	14.6	14.8	27,251	23,498	94,898	14,951	861	31,420	435	206	115	129,455	487,659	4,417	117,535
(062) Benevento	14.6	14.8	34,280	11,568	486	27,939	7,221	84,341	7,880	755	1,581	2,272,767	14,875	2,544	65,276
(063) Napoli	15	15.4	3,224	2,032	49	3,245	180	55	4,297	10	65	111,888	327,038	262,730	3,060
(064) Avellino	15	15.4	23,552	7,994	0	7,709	78	68,246	5,009	993	473	106,903	210,764	9,201	155,161
(065) Salerno	14.9	15.2	50,412	36,366	55,014	41,474	1,763	112,374	42,880	3,231	1,189	93,292	106,829	7,965	91,784
(066) L'Aquila	12.2	13.5	12,215	4,450	0	14,688	807	104,169	1,676	11,451	833	2,537	65,951	583	156,869
(067) Teramo	11.8	13.2	26,091	12,463	0	26,662	2,743	157,028	1,560	2,608	73	182,779	77,359	218,748	52,298
(068) Pescara	11.1	12.2	12,430	4,218	0	12,180	737	49,259	211	152	136	201,951	54,764	163	126,061
(069) Chieti	11.4	12.6	21,034	3,141	0	13,905	1,146	23,913	1,780	1,567	285	968,714	96,927	11,236	67,582
(070) Campobasso	13.9	14.3	18,793	13,149	229	27,235	1,345	60,164	3,650	1,482	29	7,067,027	144,105	923	3,335
(071) Foggia	13.6	14.1	27,297	6,128	4,543	10,280	61	100,938	26,029	2,851	1,403	699,034	14,783	102	6,453

Percentage of animals in temperate zone based on data from the 2000 agriculture census (ISTAT)	Average temperature	Average temperature weighted by % animals for different altitudes (plain, hill, mountain)	Non-dairy cattle	Dairy cattle	Buffalo	Other swine	Sows	Sheep	Goats	Horses	Mules and asses	Broilers	hen	other poultry	Rabbits
(072) Bari	13.7	14.2	35,866	31,546	199	5,149	752	64,117	4,353	3,065	32	4,673	306,370	1,409	121,201
(073) Taranto	13.9	14.5	22,345	25,796	0	12,845	178	24,980	7,310	3,611	93	1,163	211,415	60,027	83,456
(074) Brindisi	14	14.6	2,156	7,166	0	560	40	6,321	5,657	531	57	1,097	324,767	300	35,232
(075) Lecce	13.4	13.8	3,546	2,251	0	503	235	27,399	7,525	552	24	14	165,333	13	246
(076) Potenza	13.1	13.5	65,499	25,430	99	56,047	1,998	404,287	85,628	4,746	581	72,778	44,609	2,889	529,620
(077) Matera	13.5	13.8	15,452	9,590	515	7,642	293	102,658	41,129	2,988	103	3,752	74,191	5,249	325,003
(078) Cosenza	14.8	15.5	35,907	5,883	82	44,365	2,064	170,629	93,268	3,003	227	145,554	160,280	2,669	101,887
(079) Catanzaro	14.1	14.9	4,183	920	0	6,378	343	24,168	7,773	38	0	622	9,367	0	491
(080) Reggio di Calabria	14.5	15.5	19,585	1,807	0	14,072	1,037	50,802	42,664	253	0	13,029	48,974	253	42,367
(081) Trapani	14.4	15.3	3,430	888	0	186	69	57,240	1,178	3,544	73	129	31,954	34	3,771
(082) Palermo	14.5	15.4	46,032	4,790	0	2,679	875	132,035	13,759	1,562	63	32	316,059	0	300
(083) Messina	14.6	15.5	65,155	2,062	0	13,434	1,005	93,336	58,106	6,483	1,776	102	376,100	106	0
(084) Agrigento	14.4	15.2	3,567	1,073	0	2,436	237	46,636	1,473	19	20	0	26,829	0	36,773
(085) Caltanissetta	14.3	15.1	5,459	1,216	0	116	28	48,617	2,089	332	30	0	76,878	0	0
(086) Enna	15	15.6	48,664	1,489	0	4,228	440	110,030	5,739	594	172	5	65,692	0	0
(087) Catania	15.7	16.3	17,120	2,856	0	311	110	38,035	2,766	1,389	5	16	241,512	212	17,241
(088) Ragusa	15.7	16.3	49,505	26,664	0	4,968	315	18,496	0	903	90	392,370	721,491	0	580
(089) Siracusa	16	16.7	57,381	8,293	71	16,805	35	75,830	7,212	1,098	426	242,604	654,764	0	31,049
(090) Sassari	14.1	14.6	117,502	2,374	0	31,938	14,538	1,217,792	34,271	5,935	1,098	0	100,557	0	145,324
(091) Nuoro	15	15.4	64,036	5,800	0	35,443	13,568	918,328	94,019	10,951	687	42,136	211,093	282,830	281,681
(092) Cagliari	14.4	14.6	16,639	1,074	0	82,034	23,342	819,856	172,540	2,633	856	67,976	681,328	920,414	480
(093) Pordenone	11.3	11.3	26,760	14,452	0	147,452	40,071	997	0	665	10	1,303,096	262,413	138,240	81,438
(094) Isernia	11.5	11.4	16,093	7,221	131	11,787	174	45,531	3,452	1,008	35	641,701	1,511	0	15,247
(095) Oristano	11.5	11.4	37,907	24,089	0	11,761	7,127	455,419	11,914	3,026	556	14,240	6,134	767	26,143

Percentage of animals in temperate zone based on data from the 2000 agriculture census (ISTAT)	Average temperature	Average temperature weighted by % animals for different altitudes (plain, hill, mountain)	Non-dairy cattle	Dairy cattle	Buffalo	Other swine	Sows	Sheep	Goats	Horses	Mules and asses	Broilers	hen	other poultry	Rabbits
(096) Biella	11.4	11.4	8,850	3,617	0	16,084	5,709	13,521	3,009	606	240	222	765	97,447	0
(097) Lecco	11.5	11.6	4,335	1,634	0	2,461	339	1,924	1,315	1,908	277	288,301	5,001	1,219	8,219
(098) Lodi	12.2	12.5	53,611	46,294	353	358,631	25,804	0	6	745	0	16	1,257,958	92	0
(099) Rimini	11.7	12	4,523	166	0	22,086	1,454	7,946	0	1,077	150	184,953	145,785	621,136	0
(100) Prato	12	12.8	0	0	0	0	0	0	0	187	0	0	0	0	0
(101) Crotone	15.7	16.3	21,933	846	0	3,728	50	44,091	23,629	756	235	373,670	102,356	77	4,884
(102) Vibo Valentia	14.1	14.9	6,206	2,529	3	2,082	108	48,520	3,392	143	0	235	52,649	0	1,754
(103) Verbano-Cusio-Ossola	11.7	11.8	2,570	2,567	0	163	7	12,443	12,339	624	200	381	1,854	223	1,085
Total			4,409,921	1,842,004	205,093	8,479,430	721,843	7,954,167	1,045,898	278,471	30,254	97,532,025	52,692,584	38,370,412	21,199,217
N animals in temperate zone			552,951	140,747	83,864	208,379	21,948	2,046,930	421,088	38,047	6,040	1,560,813	3,971,390	567,236	1,424,974
% animals in temperate zone			12.50%	7.60%	40.90%	2.50%	3.00%	25.70%	40.30%	13.70%	20.00%	1.60%	7.50%	1.50%	6.70%
Based on temperature non weighted by % animals															
N animals in temperate zone			285,415	55,975	121	76,436	14,775	1,273,110	142,671	16,695	2,153	1,269,593	2,534,710	555,050	493,657
% animals in temperate zone			6.50%	3.00%	0.10%	0.90%	2.00%	16.00%	13.60%	6.00%	7.10%	1.30%	4.80%	1.40%	2.30%

ANNEX 8: Additional information to be considered as part of the annual inventory submission and the *supplementary information required under Article 7, paragraph 1*, of the Kyoto Protocol or other useful reference information

A8.1 Annual inventory submission

This appendix shows a copy of Tables 10s1-10s5 from the Common Reporting Format 2011, submitted in 2013, in which time series of emission estimates for the following gases are reported:

- CO₂
- CH₄
- N₂O
- HFCs, PFCs, SF₆
- All gases and sources categories

Table A8.1.1.1 CO₂ emissions trends, CRF year 2011 (years 1990 – 1999)

TABLE 10 EMISSION TRENDS

CO₂

(Part 1 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	404,072.23	404,004.24	403,166.60	399,823.23	393,701.63	416,988.58	412,954.68	416,863.11	428,077.16	433,320.38
A. Fuel Combustion (Sectoral Approach)	400,728.45	400,736.85	399,952.02	396,440.70	390,472.88	413,810.90	409,917.09	413,617.34	424,956.37	430,913.41
1. Energy Industries	136,502.92	130,586.47	130,325.22	124,848.67	127,316.71	139,841.41	135,043.26	137,027.71	148,064.92	145,892.04
2. Manufacturing Industries and Construction	85,275.97	82,962.46	81,547.47	82,062.29	83,187.62	85,037.31	83,121.67	85,776.21	79,398.27	81,263.19
3. Transport	101,268.85	103,786.58	108,033.55	109,632.46	109,239.86	111,445.03	112,669.95	114,359.93	118,142.99	119,687.91
4. Other Sectors	76,634.39	82,204.76	78,764.85	78,449.21	69,269.50	76,047.16	77,900.09	75,228.73	78,310.91	82,959.84
5. Other	1,046.34	1,196.59	1,280.93	1,448.07	1,459.19	1,439.99	1,182.11	1,224.77	1,039.27	1,110.43
B. Fugitive Emissions from Fuels	3,343.78	3,267.39	3,214.58	3,382.52	3,228.74	3,177.67	3,037.59	3,245.76	3,120.79	2,406.97
1. Solid Fuels	0.12	0.10	0.12	0.06	0.03	0.02	0.02	0.01	0.00	0.00
2. Oil and Natural Gas	3,343.66	3,267.28	3,214.46	3,382.46	3,228.71	3,177.65	3,037.57	3,245.75	3,120.79	2,406.97
2. Industrial Processes	28,434.49	27,992.04	28,539.49	25,278.77	24,204.52	26,037.93	23,490.76	23,616.25	23,645.56	23,775.07
A. Mineral Products	21,302.86	21,256.87	22,067.74	19,612.09	19,121.11	20,976.08	19,282.70	19,528.94	19,787.55	20,595.65
B. Chemical Industry	3,253.76	3,110.90	3,048.80	2,115.60	1,650.97	1,659.19	1,250.42	1,358.27	1,337.32	1,224.53
C. Metal Production	3,877.87	3,624.28	3,422.94	3,551.09	3,432.45	3,402.65	2,957.64	2,729.04	2,520.69	1,954.89
D. Other Production	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	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	1,642.40	1,628.27	1,630.15	1,576.93	1,503.51	1,463.28	1,404.34	1,414.68	1,331.18	1,335.90
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										

Table A8.1.1.1 CO₂ emissions trends, CRF year 2011 (years 1990 – 1999)

TABLE 10 EMISSION TRENDS

CO₂

(Part 1 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
G. Other										
5. Land Use, Land-Use Change and Forestry⁽²⁾	-13,035.17	-26,498.18	-25,075.91	-12,072.79	-24,298.18	-30,688.34	-30,693.82	-22,316.24	-19,474.44	-28,145.32
A. Forest Land	-17,281.73	-30,072.07	-28,815.52	-17,992.17	-29,045.25	-32,368.84	-31,879.76	-24,088.58	-22,664.20	-28,114.76
B. Cropland	-1,112.27	226.84	376.74	420.16	611.61	709.27	-426.65	-389.15	-321.01	-275.84
C. Grassland	2,842.83	837.09	851.93	2,988.26	1,623.55	-1,542.91	-848.79	-301.29	1,046.74	-2,220.47
D. Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
E. Settlements	2,515.99	2,509.96	2,510.93	2,510.96	2,511.91	2,514.14	2,461.38	2,462.78	2,464.04	2,465.76
F. Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	507.18	531.86	531.33	491.25	494.32	453.89	453.58	477.66	470.17	393.47
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
B. Waste-water Handling										
C. Waste Incineration	507.18	531.86	531.33	491.25	494.32	453.89	453.58	477.66	470.17	393.47
D. Other	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
Total CO₂ emissions including net CO₂ from LULUCF	421,621.13	407,658.24	408,791.66	415,097.38	395,605.80	414,255.34	407,609.55	420,055.46	434,049.64	430,679.50
Total CO₂ emissions excluding net CO₂ from LULUCF	434,656.30	434,156.41	433,867.57	427,170.18	419,903.98	444,943.68	438,303.36	442,371.70	453,524.08	458,824.82
Memo Items:										
International Bunkers	8,549.97	8,576.11	8,392.37	8,762.20	8,992.41	9,708.35	8,936.90	9,260.17	9,930.35	10,691.95
Aviation	4,160.77	4,993.23	4,940.81	5,082.84	5,353.48	5,673.52	6,081.29	6,200.46	6,737.93	7,392.96
Marine	4,389.20	3,582.88	3,451.56	3,679.36	3,638.93	4,034.83	2,855.61	3,059.71	3,192.42	3,298.98
Multilateral Operations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO₂ Emissions from Biomass	7,134.04	9,428.06	9,154.71	9,261.01	10,038.61	10,120.02	9,686.34	10,796.10	10,387.15	12,305.87

Table A8.1.1.1 CO₂ emissions trends, CRF year 2011 (years 2000 – 2009)

TABLE 10 EMISSION TRENDS

CO₂

(Part 2 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000 (Gg)	2001 (Gg)	2002 (Gg)	2003 (Gg)	2004 (Gg)	2005 (Gg)	2006 (Gg)	2007 (Gg)	2008 (Gg)	2009 (Gg)
1. Energy	436,230.37	441,387.14	443,693.34	458,529.73	460,499.38	459,366.61	454,781.02	446,236.48	437,402.51	393,750.39
A. Fuel Combustion (Sectoral Approach)	433,642.47	438,944.25	441,428.32	455,689.89	458,345.05	457,249.63	452,587.30	444,055.62	435,138.10	391,580.24
1. Energy Industries	151,893.98	154,498.04	161,400.59	161,982.20	159,962.44	159,829.28	160,983.71	160,769.41	156,105.92	131,166.74
2. Manufacturing Industries and Construction	82,245.45	80,543.88	76,727.06	82,314.52	83,113.04	78,551.02	77,490.30	74,221.73	70,904.64	54,580.15
3. Transport	120,100.81	122,177.89	124,138.08	125,097.19	127,081.10	125,824.54	127,145.29	127,209.41	122,272.57	117,896.84
4. Other Sectors	78,596.13	81,370.50	78,849.04	85,635.83	87,097.49	91,847.10	85,986.38	80,958.88	85,117.20	87,092.17
5. Other	806.10	353.94	313.56	660.15	1,090.98	1,197.69	981.61	896.19	737.77	844.34
B. Fugitive Emissions from Fuels	2,587.90	2,442.89	2,265.01	2,839.84	2,154.33	2,116.98	2,193.72	2,180.86	2,264.40	2,170.15
1. Solid Fuels	0.05	0.06	0.07	0.11	0.04	0.04	0.01	0.07	0.05	0.03
2. Oil and Natural Gas	2,587.84	2,442.83	2,264.94	2,839.73	2,154.29	2,116.94	2,193.71	2,180.79	2,264.35	2,170.12
2. Industrial Processes	24,570.91	25,391.76	25,380.25	26,542.68	27,404.60	27,186.45	27,205.40	27,710.92	25,092.58	19,950.52
A. Mineral Products	21,455.32	22,329.47	22,392.53	23,310.95	23,896.04	23,480.87	23,536.18	24,027.16	21,729.03	17,466.05
B. Chemical Industry	1,361.64	1,345.67	1,426.49	1,679.37	1,838.90	1,783.68	1,727.00	1,759.05	1,488.19	1,177.67
C. Metal Production	1,753.95	1,716.63	1,561.23	1,552.36	1,669.66	1,921.91	1,942.23	1,924.71	1,875.37	1,306.80
D. Other Production	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	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
3. Solvent and Other Product Use	1,274.84	1,282.80	1,286.40	1,290.46	1,282.91	1,299.41	1,317.39	1,287.04	1,226.46	1,145.71
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⁽²⁾	-26,325.89	-33,617.13	-38,585.66	-31,183.99	-36,688.87	-38,514.81	-39,378.59	-18,565.04	-36,967.66	-40,290.01
A. Forest Land	-26,988.94	-33,117.67	-36,981.99	-30,648.10	-35,369.26	-36,387.76	-36,761.62	-20,645.38	-33,541.09	-36,641.43
B. Cropland	-578.27	-1,179.42	-1,121.67	-1,061.98	-1,000.97	-975.53	-1,047.38	-850.66	-1,048.10	-1,151.23
C. Grassland	-1,227.17	-2,640.17	-3,809.17	-2,807.77	-3,659.67	-4,501.12	-4,932.85	-445.14	-5,794.60	-5,929.66
D. Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
E. Settlements	2,468.48	3,320.12	3,327.17	3,333.87	3,341.02	3,349.60	3,363.26	3,376.14	3,416.13	3,432.31
F. Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A8.1.1.1 CO₂ emissions trends, CRF year 2011 (years 2000 – 2009)

TABLE 10 EMISSION TRENDS

CO₂

(Part 2 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000 (Gg)	2001 (Gg)	2002 (Gg)	2003 (Gg)	2004 (Gg)	2005 (Gg)	2006 (Gg)	2007 (Gg)	2008 (Gg)	2009 (Gg)
6. Waste	201.57	222.26	170.87	196.81	180.11	225.56	238.76	206.76	200.03	242.31
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
B. Waste-water Handling										
C. Waste Incineration	201.57	222.26	170.87	196.81	180.11	225.56	238.76	206.76	200.03	242.31
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other (as specified in Summary I.A)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total CO₂ emissions including net CO₂ from LULUCF	435,951.80	434,666.84	431,945.20	455,375.68	452,678.14	449,563.22	444,163.98	456,876.15	426,953.92	374,798.92
Total CO₂ emissions excluding net CO₂ from LULUCF	462,277.69	468,283.97	470,530.86	486,559.68	489,367.01	488,078.03	483,542.57	475,441.19	463,921.58	415,088.93
Memo Items:										
International Bunkers	12,196.09	12,824.92	12,862.42	14,809.34	15,426.56	16,029.88	17,274.95	18,185.82	18,524.22	16,225.87
Aviation	8,015.50	8,011.06	7,312.69	8,526.80	8,620.09	9,110.86	9,833.14	10,430.30	10,087.15	8,968.33
Marine	4,180.59	4,813.86	5,549.73	6,282.54	6,806.47	6,919.02	7,441.81	7,755.53	8,437.07	7,257.54
Multilateral Operations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO₂ Emissions from Biomass	12,261.86	13,450.09	12,923.60	15,016.69	18,194.77	17,425.98	18,251.73	20,259.15	23,167.80	26,248.80

Table A8.1.1.1 CO₂ emissions trends, CRF year 2011 (years 2010 – 2011)

TABLE 10 EMISSION TRENDS

CO₂

(Part 3 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2010	2011	Change from base to latest reported year
	(Gg)	(Gg)	%
1. Energy	403,545.84	392,749.60	-2.80
A. Fuel Combustion (Sectoral Approach)	401,223.65	390,434.69	-2.57
1. Energy Industries	132,557.02	130,565.34	-4.35
2. Manufacturing Industries and Construction	60,015.12	59,853.91	-29.81
3. Transport	117,481.25	116,427.71	14.97
4. Other Sectors	90,542.78	83,092.77	8.43
5. Other	627.48	494.97	-52.70
B. Fugitive Emissions from Fuels	2,322.19	2,314.91	-30.77
1. Solid Fuels	0.05	0.04	-64.61
2. Oil and Natural Gas	2,322.14	2,314.87	-30.77
2. Industrial Processes	20,681.72	20,175.57	-29.05
A. Mineral Products	17,553.46	16,980.50	-20.29
B. Chemical Industry	1,662.94	1,584.84	-51.29
C. Metal Production	1,465.33	1,610.24	-58.48
D. Other Production	NA	NA	0.00
E. Production of Halocarbons and SF ₆			
F. Consumption of Halocarbons and SF ₆			
G. Other	NA	NA	0.00
3. Solvent and Other Product Use	1,050.27	1,079.53	-34.27
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			

Table A8.1.1.1 CO₂ emissions trends, CRF year 2011 (years 2010 – 2011)

TABLE 10 EMISSION TRENDS

CO₂

(Part 3 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2010	2011	Change from base to latest reported year
	(Gg)	(Gg)	%
G. Other			
5. Land Use, Land-Use Change and Forestry⁽²⁾	-43,559.81	-30,844.79	136.63
A. Forest Land	-38,247.44	-29,543.91	70.95
B. Cropland	-1,185.38	3,332.67	-399.63
C. Grassland	-7,549.23	-8,030.93	-382.50
D. Wetlands	NE,NO	NE,NO	0.00
E. Settlements	3,422.24	3,397.38	35.03
F. Other Land	NO	NO	0.00
G. Other	NA	NA	0.00
6. Waste	221.55	234.51	-53.76
A. Solid Waste Disposal on Land	NA,NO	NA,NO	0.00
B. Waste-water Handling			
C. Waste Incineration	221.55	234.51	-53.76
D. Other	NA	NA	0.00
7. Other (as specified in Summary 1.A)	NA	NA	0.00
Total CO₂ emissions including net CO₂ from LULUCF	381,939.57	383,394.43	-9.07
Total CO₂ emissions excluding net CO₂ from LULUCF	425,499.38	414,239.22	-4.70
Memo Items:			
International Bunkers	16,413.96	16,886.52	97.50
Aviation	9,440.35	9,725.54	133.74
Marine	6,973.61	7,160.99	63.15
Multilateral Operations	NE	NE	0.00
CO₂ Emissions from Biomass	26,526.65	31,395.60	340.08

Table A8.1.2.2 CH₄ emission trends, CRF year 2011 (years 1990 – 1999)

TABLE 10 EMISSION TRENDS

CH₄

(Part 1 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	430.23	437.40	439.90	435.18	425.69	415.63	407.22	407.46	408.69	400.83
A. Fuel Combustion (Sectoral Approach)	76.66	85.79	85.90	86.76	86.36	87.87	84.74	86.71	83.85	85.31
1. Energy Industries	9.27	8.93	8.59	8.14	8.39	8.63	8.41	8.60	8.52	8.26
2. Manufacturing Industries and Construction	6.82	6.67	6.49	6.62	6.59	7.02	6.48	6.69	6.44	6.06
3. Transport	39.15	41.71	43.77	45.27	43.89	43.48	42.79	41.02	39.31	37.01
4. Other Sectors	21.25	28.29	26.85	26.52	27.28	28.51	26.87	30.24	29.43	33.80
5. Other	0.17	0.19	0.20	0.22	0.21	0.22	0.19	0.17	0.16	0.18
B. Fugitive Emissions from Fuels	353.56	351.61	354.01	348.42	339.33	327.76	322.48	320.74	324.84	315.52
1. Solid Fuels	6.03	5.55	5.53	4.04	3.47	3.12	2.92	2.87	2.63	2.52
2. Oil and Natural Gas	347.54	346.06	348.48	344.38	335.86	324.64	319.56	317.87	322.20	313.00
2. Industrial Processes	5.16	4.95	4.83	4.87	5.07	5.36	2.99	3.23	3.10	3.05
A. Mineral Products	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
C. Metal Production	2.71	2.51	2.43	2.59	2.58	2.71	2.39	2.61	2.51	2.46
D. Other Production										
E. Production of Halocarbons and SF ₆										
F. Consumption of Halocarbons and SF ₆										
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use										
4. Agriculture	825.23	834.15	812.42	809.54	811.49	824.63	827.67	827.90	821.39	827.96
A. Enteric Fermentation	584.69	597.01	578.70	572.58	577.53	587.98	591.74	593.23	589.27	595.82
B. Manure Management	164.86	164.82	158.67	158.32	153.34	156.48	156.90	156.26	157.94	159.48
C. Rice Cultivation	75.06	71.64	74.39	78.00	79.98	79.56	78.37	77.82	73.50	72.00
D. Agricultural Soils	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

Table A8.1.2.2 CH₄ emission trends, CRF year 2011 (years 1990 – 1999)

TABLE 10 EMISSION TRENDS

CH₄

(Part 1 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
F. Field Burning of Agricultural Residues	0.62	0.68	0.66	0.64	0.64	0.62	0.65	0.59	0.67	0.66
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	28.48	16.88	16.43	27.84	22.37	7.57	9.47	15.44	23.22	10.01
A. Forest Land	8.70	2.66	3.95	10.01	4.16	1.87	1.79	5.55	6.38	3.54
B. Cropland	0.23	0.17	0.15	0.21	0.21	0.07	0.09	0.12	0.20	0.08
C. Grassland	19.54	14.05	12.34	17.62	17.99	5.62	7.59	9.77	16.64	6.40
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	823.24	869.72	822.03	819.83	845.79	865.61	904.86	929.66	931.47	943.44
A. Solid Waste Disposal on Land	726.38	768.40	717.80	712.65	737.49	757.56	795.95	819.36	820.62	832.10
B. Waste-water Handling	94.76	98.63	101.80	104.73	105.83	105.62	106.46	107.85	108.27	108.66
C. Waste Incineration	2.09	2.68	2.41	2.44	2.45	2.41	2.42	2.41	2.52	2.60
D. Other	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.05	0.06	0.08
7. Other (as specified in Summary I.A)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total CH₄ emissions including CH₄ from LULUCF	2,112.33	2,163.10	2,095.61	2,097.25	2,110.40	2,118.79	2,152.21	2,183.68	2,187.87	2,185.29
Total CH₄ emissions excluding CH₄ from LULUCF	2,083.85	2,146.22	2,079.18	2,069.41	2,088.03	2,111.22	2,142.74	2,168.24	2,164.65	2,175.28
Memo Items:										
International Bunkers	0.47	0.39	0.38	0.41	0.41	0.45	0.34	0.37	0.39	0.41
Aviation	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.08	0.09
Marine	0.42	0.34	0.33	0.35	0.35	0.39	0.27	0.29	0.31	0.32
Multilateral Operations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Table A8.1.2.2 CH₄ emission trends, CRF year 2011 (years 1990 – 1999)

TABLE 10 EMISSION TRENDS

CH₄

(Part 1 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
CO ₂ Emissions from Biomass										

Table A8.1.2.2 CH₄ emission trends, CRF year 2011 (years 2000 – 2009)

TABLE 10 EMISSION TRENDS

CH₄

(Part 2 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	384.61	366.65	359.57	353.20	348.59	342.77	316.67	312.82	315.66	309.77
A. Fuel Combustion (Sectoral Approach)	78.73	77.82	72.11	71.95	75.49	71.58	70.96	74.06	74.37	73.80
1. Energy Industries	6.85	5.95	5.92	6.14	6.21	6.34	6.17	5.72	5.65	5.19
2. Manufacturing Industries and Construction	5.72	5.79	5.69	5.83	5.76	6.28	6.24	6.53	6.24	4.18
3. Transport	33.29	31.42	29.02	26.70	23.92	21.72	19.96	18.15	16.88	15.98
4. Other Sectors	32.75	34.58	31.41	33.18	39.47	37.08	38.47	43.56	45.52	48.38
5. Other	0.13	0.09	0.07	0.10	0.14	0.16	0.13	0.11	0.07	0.07
B. Fugitive Emissions from Fuels	305.88	288.84	287.45	281.24	273.10	271.19	245.71	238.75	241.29	235.97
1. Solid Fuels	3.55	3.94	3.82	4.65	3.10	3.33	2.57	4.09	3.52	2.17
2. Oil and Natural Gas	302.32	284.90	283.64	276.59	269.99	267.86	243.14	234.66	237.77	233.81
2. Industrial Processes	3.01	2.83	2.71	2.77	2.91	3.06	3.14	3.08	2.91	1.82
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	0.40	0.33	0.33	0.31	0.33	0.33	0.32	0.34	0.30	0.28
C. Metal Production	2.61	2.50	2.38	2.46	2.58	2.72	2.81	2.75	2.61	1.54
D. Other Production										
E. Production of Halocarbons and SF ₆										
F. Consumption of Halocarbons and SF ₆										
G. Other	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
3. Solvent and Other Product Use										
4. Agriculture	806.11	769.91	753.51	755.67	743.31	740.44	724.56	746.78	731.28	736.09
A. Enteric Fermentation	583.14	543.96	528.92	530.19	519.41	519.73	509.48	528.51	523.60	524.14
B. Manure Management	156.10	159.19	155.42	154.89	150.14	149.93	144.20	145.43	140.99	136.79
C. Rice Cultivation	66.26	66.19	68.52	70.00	73.04	70.11	70.23	72.18	65.99	74.51
D. Agricultural Soils	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
F. Field Burning of Agricultural Residues	0.62	0.57	0.64	0.59	0.72	0.67	0.65	0.66	0.69	0.65

Table A8.1.2.2 CH₄ emission trends, CRF year 2011 (years 2000 – 2009)

TABLE 10 EMISSION TRENDS

CH₄

(Part 2 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	16.54	11.10	6.04	13.60	10.30	7.62	6.62	34.39	10.11	12.83
A. Forest Land	5.03	3.30	1.84	3.86	2.28	2.29	1.82	11.71	2.75	3.27
B. Cropland	0.13	0.09	0.05	0.11	0.09	0.06	0.06	0.26	0.09	0.09
C. Grassland	11.38	7.71	4.15	9.63	7.93	5.26	4.74	22.41	7.27	9.47
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	989.29	988.99	968.06	925.85	875.91	871.21	840.30	809.35	768.80	762.46
A. Solid Waste Disposal on Land	874.15	869.64	844.96	800.29	746.31	738.78	707.20	675.89	636.40	630.32
B. Waste-water Handling	112.73	116.97	120.53	123.05	126.55	129.67	130.40	130.77	129.62	129.43
C. Waste Incineration	2.32	2.26	2.41	2.33	2.87	2.56	2.48	2.47	2.57	2.50
D. Other	0.10	0.12	0.16	0.18	0.18	0.20	0.21	0.22	0.21	0.21
7. Other (as specified in Summary 1.A)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total CH₄ emissions including CH₄ from LULUCF	2,199.58	2,139.48	2,089.88	2,051.08	1,981.02	1,965.09	1,891.28	1,906.42	1,828.75	1,822.97
Total CH₄ emissions excluding CH₄ from LULUCF	2,183.04	2,128.38	2,083.84	2,037.48	1,970.72	1,957.47	1,884.66	1,872.03	1,818.65	1,810.14
Memo Items:										
International Bunkers	0.51	0.58	0.65	0.74	0.80	0.83	0.88	0.87	0.93	0.81
Aviation	0.11	0.12	0.12	0.14	0.15	0.17	0.17	0.13	0.12	0.12
Marine	0.40	0.46	0.53	0.60	0.65	0.66	0.71	0.74	0.81	0.69
Multilateral Operations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO₂ Emissions from Biomass										

Table A8.1.2.2 CH₄ emission trends, CRF year 2011 (years 2010 – 2011)

TABLE 10 EMISSION TRENDS

CH₄

(Part 3 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2010	2011	Change from base to latest reported year
	(Gg)	(Gg)	%
1. Energy	323.62	321.32	-25.31
A. Fuel Combustion (Sectoral Approach)	76.78	79.45	3.63
1. Energy Industries	5.02	5.59	-39.71
2. Manufacturing Industries and Construction	5.51	7.75	13.63
3. Transport	14.86	14.01	-64.21
4. Other Sectors	51.33	52.05	144.91
5. Other	0.06	0.05	-69.93
B. Fugitive Emissions from Fuels	246.83	241.87	-31.59
1. Solid Fuels	3.16	3.40	-43.55
2. Oil and Natural Gas	243.67	238.47	-31.38
2. Industrial Processes	2.50	2.76	-46.42
A. Mineral Products	NA	NA	0.00
B. Chemical Industry	0.33	0.30	-87.86
C. Metal Production	2.17	2.47	-8.92
D. Other Production			
E. Production of Halocarbons and SF ₆			
F. Consumption of Halocarbons and SF ₆			
G. Other	NA	NA	0.00
3. Solvent and Other Product Use			
4. Agriculture	708.47	687.55	-16.68
A. Enteric Fermentation	511.05	512.44	-12.36
B. Manure Management	122.25	100.67	-38.93
C. Rice Cultivation	74.54	73.80	-1.68
D. Agricultural Soils	NA	NA	0.00
E. Prescribed Burning of Savannas	NO	NO	0.00
F. Field Burning of Agricultural Residues	0.64	0.64	1.92
G. Other	NA	NA	0.00
5. Land Use, Land-Use Change and Forestry	7.74	8.98	-68.46
A. Forest Land	2.06	3.04	-65.04
B. Cropland	0.05	0.10	-54.65
C. Grassland	5.62	5.83	-70.15
D. Wetlands	NO	NO	0.00
E. Settlements	NO	NO	0.00
F. Other Land	NO	NO	0.00
G. Other	NA	NA	0.00

Table A8.1.2.2 CH₄ emission trends, CRF year 2011 (years 2010 – 2011)

TABLE 10 EMISSION TRENDS

CH₄

(Part 3 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2010	2011	Change from base to latest reported year
	(Gg)	(Gg)	%
6. Waste	741.13	729.69	-11.36
A. Solid Waste Disposal on Land	607.95	596.82	-17.84
B. Waste-water Handling	130.51	130.19	37.39
C. Waste Incineration	2.43	2.42	15.76
D. Other	0.25	0.26	2,337.84
7. Other (as specified in Summary 1.A)	NA	NA	0.00
Total CH₄ emissions including CH₄ from LULUCF	1,783.46	1,750.30	-17.14
Total CH₄ emissions excluding CH₄ from LULUCF	1,775.72	1,741.32	-16.44
Memo Items:			
International Bunkers	0.78	0.80	72.58
Aviation	0.12	0.12	158.97
Marine	0.67	0.68	62.99
Multilateral Operations	NE	NE	0.00
CO₂ Emissions from Biomass			

Table A8.1.3.2 N₂O emission trends, CRF year 2011 (years 1990 – 1999)

TABLE 10 EMISSION TRENDS

N₂O

(Part 1 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	14.93	15.11	15.33	15.38	15.90	17.40	18.43	19.48	20.39	21.33
A. Fuel Combustion (Sectoral Approach)	14.89	15.07	15.29	15.34	15.86	17.36	18.39	19.44	20.35	21.29
1. Energy Industries	1.67	1.58	1.55	1.47	1.49	1.67	1.61	1.61	1.64	1.58
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
3. Transport	3.27	3.41	3.65	3.84	4.56	5.62	6.85	7.79	8.63	9.41
4. Other Sectors	4.80	4.96	4.96	5.24	5.09	5.34	5.33	5.35	5.41	5.65
5. Other	0.23	0.24	0.24	0.28	0.25	0.21	0.18	0.21	0.17	0.14
B. Fugitive Emissions from Fuels	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
1. Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2. Oil and Natural Gas	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
2. Industrial Processes	21.54	22.81	21.11	21.65	20.36	23.35	22.66	22.78	23.06	23.56
A. Mineral Products	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
C. Metal Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other Production										
E. Production of Halocarbons and SF ₆										
F. Consumption of Halocarbons and SF ₆										
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	2.62	2.47	2.46	2.50	2.46	2.49	2.96	2.96	3.40	3.33
4. Agriculture	75.51	77.43	77.23	78.38	76.63	74.85	73.96	77.33	75.36	76.17
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
C. Rice Cultivation										
D. Agricultural Soils	62.85	64.79	65.12	66.39	64.68	62.64	61.61	64.87	62.65	63.27
E. Prescribed Burning of Savannas	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

Table A8.1.3.2 N₂O emission trends, CRF year 2011 (years 1990 – 1999)

TABLE 10 EMISSION TRENDS

N₂O

(Part 1 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	0.91	0.74	0.68	0.86	0.87	0.47	0.50	0.53	0.71	0.34
A. Forest Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B. Cropland	0.30	0.30	0.30	0.30	0.30	0.30	0.26	0.22	0.18	0.14
C. Grassland	0.61	0.44	0.39	0.55	0.57	0.18	0.24	0.31	0.52	0.20
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	6.03	6.12	6.06	5.90	5.91	5.85	6.00	5.98	6.14	6.27
A. Solid Waste Disposal on Land										
B. Waste-water Handling	5.91	5.98	5.92	5.78	5.78	5.73	5.89	5.85	6.02	6.15
C. Waste Incineration	0.13	0.15	0.14	0.13	0.13	0.12	0.12	0.12	0.12	0.12
D. Other	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
Total N₂O emissions including N₂O from LULUCF	121.55	124.69	122.87	124.67	122.13	124.42	124.51	129.05	129.06	131.01
Total N₂O emissions excluding N₂O from LULUCF	120.63	123.95	122.19	123.81	121.26	123.94	124.01	128.52	128.35	130.66
Memo Items:										
International Bunkers	0.23	0.21	0.22	0.24	0.24	0.26	0.25	0.27	0.29	0.31
Aviation	0.12	0.12	0.13	0.14	0.15	0.16	0.18	0.19	0.21	0.23
Marine	0.11	0.09	0.09	0.09	0.09	0.10	0.07	0.08	0.08	0.08
Multilateral Operations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO₂ Emissions from Biomass										

Table A8.1.3.2 N₂O emission trends, CRF year 2011 (years 2000 – 2009)

TABLE 10 EMISSION TRENDS

N₂O

(Part 2 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	17.35	17.62	17.54	17.87	18.45	17.22	17.36	17.29	16.68	15.92
A. Fuel Combustion (Sectoral Approach)	17.31	17.58	17.50	17.83	18.40	17.17	17.32	17.24	16.64	15.89
1. Energy Industries	1.67	1.75	1.82	1.84	1.91	1.90	1.89	1.87	1.88	1.68
2. Manufacturing Industries and Construction	4.66	4.74	4.77	4.93	5.03	5.02	5.05	4.98	4.64	3.98
3. Transport	5.30	5.29	5.28	5.06	5.03	3.81	4.06	4.02	3.71	3.57
4. Other Sectors	5.55	5.77	5.61	5.87	6.16	6.15	6.08	6.15	6.22	6.42
5. Other	0.14	0.03	0.02	0.13	0.28	0.29	0.24	0.23	0.20	0.24
B. Fugitive Emissions from Fuels	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
1. Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2. Oil and Natural Gas	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
2. Industrial Processes	25.54	26.55	25.49	24.38	27.24	25.03	8.54	6.10	3.44	3.64
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	25.54	26.55	25.49	24.38	27.24	25.03	8.54	6.10	3.44	3.64
C. Metal Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other Production										
E. Production of Halocarbons and SF ₆										
F. Consumption of Halocarbons and SF ₆										
G. Other	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
3. Solvent and Other Product Use	3.31	3.00	3.00	2.81	2.73	2.66	2.61	2.54	2.35	2.21
4. Agriculture	74.86	74.30	73.15	72.49	72.34	70.37	69.52	69.99	66.64	62.32
A. Enteric Fermentation										
B. Manure Management	12.46	12.91	12.42	12.33	11.98	11.96	11.61	12.19	12.18	12.30
C. Rice Cultivation										
D. Agricultural Soils	62.39	61.38	60.72	60.15	60.34	58.39	57.89	57.79	54.45	50.01
E. Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agricultural Residues	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01

Table A8.1.3.2 N₂O emission trends, CRF year 2011 (years 2000 – 2009)

TABLE 10 EMISSION TRENDS

N₂O

(Part 2 of 3)

Inventory
2011
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ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	0.46	0.35	0.23	0.41	0.35	0.27	0.23	0.78	0.27	0.32
A. Forest Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B. Cropland	0.11	0.10	0.10	0.10	0.10	0.10	0.08	0.07	0.05	0.03
C. Grassland	0.36	0.24	0.13	0.30	0.25	0.17	0.15	0.70	0.23	0.30
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	6.30	6.13	6.13	6.11	6.25	6.24	6.24	6.27	6.43	6.40
A. Solid Waste Disposal on Land										
B. Waste-water Handling	6.21	6.04	6.05	6.02	6.15	6.15	6.15	6.18	6.34	6.32
C. Waste Incineration	0.09	0.09	0.08	0.08	0.09	0.09	0.09	0.09	0.08	0.08
D. Other	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
Total N₂O emissions including N₂O from LULUCF	127.83	127.96	125.54	124.07	127.34	121.78	104.50	102.97	95.81	90.82
Total N₂O emissions excluding N₂O from LULUCF	127.37	127.62	125.31	123.66	126.99	121.51	104.26	102.19	95.53	90.49
Memo Items:										
International Bunkers	0.35	0.36	0.35	0.37	0.38	0.39	0.41	0.44	0.45	0.41
Aviation	0.25	0.24	0.21	0.21	0.21	0.21	0.22	0.24	0.24	0.22
Marine	0.11	0.12	0.14	0.16	0.17	0.18	0.19	0.20	0.21	0.18
Multilateral Operations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO₂ Emissions from Biomass										

Table A8.1.3.2 N₂O emission trends, CRF year 2011 (years 2010 – 2011)

TABLE 10 EMISSION TRENDS

N₂O

(Part 3 of 3)

Inventory
2011
Submission
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ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2010	2011	Change from base to latest reported year
	(Gg)	(Gg)	%
1. Energy	15.99	15.96	6.85
A. Fuel Combustion (Sectoral Approach)	15.95	15.92	6.88
1. Energy Industries	1.68	1.77	6.12
2. Manufacturing Industries and Construction	4.01	3.98	-19.25
3. Transport	3.61	3.64	11.32
4. Other Sectors	6.53	6.43	33.92
5. Other	0.13	0.10	-56.24
B. Fugitive Emissions from Fuels	0.04	0.04	-4.67
1. Solid Fuels	NA	NA	0.00
2. Oil and Natural Gas	0.04	0.04	-4.67
2. Industrial Processes	2.09	0.95	-95.58
A. Mineral Products	NA	NA	0.00
B. Chemical Industry	2.09	0.95	-95.58
C. Metal Production	NA	NA	0.00
D. Other Production			
E. Production of Halocarbons and SF ₆			
F. Consumption of Halocarbons and SF ₆			
G. Other	NA	NA	0.00
3. Solvent and Other Product Use	2.02	1.86	-28.99
4. Agriculture	60.79	61.59	-18.44
A. Enteric Fermentation			
B. Manure Management	11.94	11.99	-5.24
C. Rice Cultivation			
D. Agricultural Soils	48.84	49.59	-21.10
E. Prescribed Burning of Savannas	NO	NO	0.00
F. Field Burning of Agricultural Residues	0.01	0.01	6.99

Table A8.1.3.2 N₂O emission trends, CRF year 2011 (years 2010 – 2011)

TABLE 10 EMISSION TRENDS

N₂O

(Part 3 of 3)

Inventory
2011
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ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2010	2011	Change from base to latest reported year
	(Gg)	(Gg)	%
G. Other	NA	NA	0.00
5. Land Use, Land-Use Change and Forestry	0.18	0.21	-76.67
A. Forest Land	0.00	0.00	-65.04
B. Cropland	0.00	0.03	-90.24
C. Grassland	0.18	0.18	-70.15
D. Wetlands	NO	NO	0.00
E. Settlements	NO	NO	0.00
F. Other Land	NO	NO	0.00
G. Other	NA	NA	0.00
6. Waste	6.45	6.33	4.98
A. Solid Waste Disposal on Land			
B. Waste-water Handling	6.37	6.25	5.78
C. Waste Incineration	0.08	0.08	-32.54
D. Other	NA	NA	0.00
7. Other (as specified in Summary 1.A)	NA	NA	0.00
Total N₂O emissions including N₂O from LULUCF	87.52	86.90	-28.50
Total N₂O emissions excluding N₂O from LULUCF	87.34	86.69	-28.14
Memo Items:			
International Bunkers	0.40	0.41	77.77
Aviation	0.23	0.23	91.57
Marine	0.18	0.18	62.99
Multilateral Operations	NE	NE	0.00
CO₂ Emissions from Biomass			

Table A8.1.4.1 HFC, PFC and SF₆ emission trends, CRF year 2011 (1990 – 1999)

TABLE 10 EMISSION TRENDS

HFCs, PFCs and SF₆

(Part 1 of 3)

Inventory
2011
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ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(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
HFC-23	0.03	0.03	0.03	0.03	0.03	0.03	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
HFC-41	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
HFC-125	NA,NO	0.00	0.00	0.00	0.00	0.01	0.01	0.04	0.05	0.08
HFC-134	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
HFC-152a	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
HFC-143a	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.01	0.01	0.02	0.03	0.03
HFC-227ea	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.00	0.00	0.00	0.01
HFC-236fa	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
Unspecified mix of listed HFCs ⁽⁴⁾ - (Gg CO ₂ equivalent)	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)	2,486.74	2,149.93	1,567.24	1,444.45	1,233.11	1,266.38	1,038.26	1,066.25	1,103.90	1,110.77
CF ₄	0.32	0.28	0.21	0.20	0.17	0.17	0.15	0.15	0.16	0.16
C ₂ F ₆	0.05	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
C ₃ F ₈	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C ₄ F ₁₀	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
c-C ₄ F ₈	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.00	0.00
C ₅ F ₁₂	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C ₆ F ₁₄	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 CO ₂ equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO

Table A8.1.4.1 HFC, PFC and SF₆ emission trends, CRF year 2011 (1990 – 1999)

TABLE 10 EMISSION TRENDS

HFCs, PFCs and SF₆

(Part 1 of 3)

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GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Emissions of SF ₆ ⁽³⁾ - (Gg CO ₂ equivalent)	332.92	356.39	358.26	370.40	415.66	601.45	682.56	728.64	604.81	404.51
SF ₆	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.02

Table A8.1.4.2 HFC, PFC and SF₆ emission trends, CRF year 2011 (2000 – 2009)

TABLE 10 EMISSION TRENDS

HFCs, PFCs and SF₆

(Part 2 of 3)

Inventory
2011
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ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000 (Gg)	2001 (Gg)	2002 (Gg)	2003 (Gg)	2004 (Gg)	2005 (Gg)	2006 (Gg)	2007 (Gg)	2008 (Gg)	2009 (Gg)
Emissions of HFCs ⁽³⁾ - (Gg CO ₂ equivalent)	1,985.67	2,549.75	3,191.29	3,901.91	4,635.03	5,400.56	6,106.19	6,855.26	7,512.98	8,163.94
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32	0.08	0.12	0.17	0.23	0.29	0.36	0.43	0.49	0.55	0.60
HFC-41	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
HFC-125	0.13	0.20	0.28	0.38	0.48	0.59	0.69	0.79	0.89	0.98
HFC-134	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-134a	1.01	1.19	1.31	1.50	1.67	1.83	1.96	2.14	2.26	2.39
HFC-152a	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
HFC-143a	0.06	0.08	0.11	0.15	0.19	0.24	0.28	0.32	0.36	0.40
HFC-227ea	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.05	0.05
HFC-236fa	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
Unspecified mix of listed HFCs ⁽⁴⁾ - (Gg CO ₂ equivalent)	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 CO ₂ equivalent)	1,217.43	1,342.04	1,333.92	1,676.71	1,733.21	1,715.00	1,713.61	1,652.10	1,500.59	1,062.81
CF ₄	0.17	0.18	0.18	0.23	0.25	0.25	0.25	0.25	0.22	0.16
C ₂ F ₆	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
C ₃ F ₈	NA,NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C ₄ F ₁₀	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
c-C ₄ F ₈	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C ₅ F ₁₂	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C ₆ F ₁₄	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 CO ₂ equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO

Table A8.1.4.2 HFC, PFC and SF₆ emission trends, CRF year 2011 (2000 – 2009)

TABLE 10 EMISSION TRENDS

HFCs, PFCs and SF₆

(Part 2 of 3)

Inventory
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GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Emissions of SF ₆ ⁽³⁾ - (Gg CO ₂ equivalent)	493.43	795.34	739.72	467.56	502.14	465.39	405.87	427.55	435.53	398.02
SF ₆	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Table A8.1.4.2 HFC, PFC and SF₆ emission trends, CRF year 2011 (2010 – 2011)

TABLE 10 EMISSION TRENDS

HFCs, PFCs and SF₆

(Part 3 of 3)

Inventory
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ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2010	2011	Change from base to latest reported year
	(Gg)	(Gg)	%
Emissions of HFCs⁽³⁾ - (Gg CO₂ equivalent)	8,744.58	9,306.04	2,551.29
HFC-23	0.00	0.00	-89.75
HFC-32	0.66	0.71	100.00
HFC-41	NA,NO	NA,NO	0.00
HFC-43-10mee	NA,NO	NA,NO	0.00
HFC-125	1.08	1.17	100.00
HFC-134	NA,NO	NA,NO	0.00
HFC-134a	2.46	2.52	100.00
HFC-152a	NA,NO	NA,NO	0.00
HFC-143	NA,NO	NA,NO	0.00
HFC-143a	0.44	0.48	100.00
HFC-227ea	0.06	0.06	100.00
HFC-236fa	NA,NO	NA,NO	0.00
HFC-245ca	NA,NO	NA,NO	0.00
Unspecified mix of listed HFCs ⁽⁴⁾ - (Gg CO ₂ equivalent)	NA,NO	NA,NO	0.00
Emissions of PFCs⁽³⁾ - (Gg CO₂ equivalent)	1,330.83	1,454.54	-41.51
CF ₄	0.20	0.22	-32.25
C ₂ F ₆	0.00	0.00	-91.66
C ₃ F ₈	0.00	0.00	100.00
C ₄ F ₁₀	NA,NO	NA,NO	0.00
c-C ₄ F ₈	0.00	0.00	100.00
C ₅ F ₁₂	NA,NO	NA,NO	0.00
C ₆ F ₁₄	NA,NO	NA,NO	0.00
Unspecified mix of listed PFCs ⁽⁴⁾ - (Gg CO ₂ equivalent)	NA,NO	NA,NO	0.00

Table A8.1.4.2 HFC, PFC and SF₆ emission trends, CRF year 2011 (2010 – 2011)**TABLE 10 EMISSION TRENDS****HFCs, PFCs and SF₆****(Part 3 of 3)**Inventory
2011
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ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2010	2011	Change from base to latest reported year
	(Gg)	(Gg)	%
Emissions of SF ₆ ⁽³⁾ - (Gg CO ₂ equivalent)	373.27	351.38	5.54
SF ₆	0.02	0.01	5.54

Table A8.1.5.1 Total emission trends, CRF year 2011 (years 1990 – 1999)

TABLE 10 EMISSION TRENDS

SUMMARY

(Part 1 of 3)

Inventory
2011
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ITALY

GREENHOUSE GAS EMISSIONS	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO ₂ equivalen t (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalen t (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalen t (Gg)	CO ₂ equivalen t (Gg)
CO ₂ emissions including net CO ₂ from LULUCF	421,621.1 3	407,658.24	408,791.66	415,097.3 8	395,605.80	414,255.34	407,609.55	420,055.46	434,049.6 4	430,679.5 0
CO ₂ emissions excluding net CO ₂ from LULUCF	434,656.3 0	434,156.41	433,867.57	427,170.1 8	419,903.98	444,943.68	438,303.36	442,371.70	453,524.0 8	458,824.8 2
CH ₄ emissions including CH ₄ from LULUCF	44,358.93	45,425.08	44,007.80	44,042.26	44,318.37	44,494.56	45,196.39	45,857.38	45,945.33	45,891.14
CH ₄ emissions excluding CH ₄ from LULUCF	43,760.90	45,070.55	43,662.80	43,457.71	43,848.69	44,335.69	44,997.48	45,533.11	45,457.70	45,680.84
N ₂ O emissions including N ₂ O from LULUCF	37,679.71	38,653.65	38,090.63	38,646.75	37,860.19	38,568.73	38,597.95	40,005.82	40,008.42	40,611.92
N ₂ O emissions excluding N ₂ O from LULUCF	37,396.31	38,424.74	37,878.32	38,381.56	37,591.66	38,422.16	38,443.89	39,841.85	39,788.54	40,505.19
HFCs	351.00	355.43	358.78	355.42	481.90	671.29	450.33	755.74	1,181.72	1,523.65
PFCs	2,486.74	2,149.93	1,567.24	1,444.45	1,233.11	1,266.38	1,038.26	1,066.25	1,103.90	1,110.77
SF ₆	332.92	356.39	358.26	370.40	415.66	601.45	682.56	728.64	604.81	404.51
Total (including LULUCF)	506,830.4 3	494,598.72	493,174.37	499,956.6 6	479,915.04	499,857.76	493,575.03	508,469.28	522,893.8 2	520,221.4 9
Total (excluding LULUCF)	518,984.1 7	520,513.45	517,692.97	511,179.7 1	503,475.00	530,240.65	523,915.87	530,297.29	541,660.7 5	548,049.7 7

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO ₂ equivalen t (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalen t (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalen t (Gg)	CO ₂ equivalen t (Gg)
1. Energy	417,736.0 9	417,874.73	417,156.96	413,728.8 0	407,570.73	431,111.04	427,219.32	431,458.49	442,980.8 2	448,351.2 9
2. Industrial Processes	38,389.92	38,028.62	37,469.02	34,263.50	32,752.96	35,928.88	32,749.71	33,297.42	33,749.64	34,180.85
3. Solvent and Other Product Use	2,454.62	2,393.98	2,393.71	2,350.74	2,266.57	2,234.87	2,320.85	2,331.38	2,385.84	2,369.20
4. Agriculture	40,738.59	41,521.87	41,001.92	41,298.67	40,796.33	40,520.46	40,309.65	41,357.15	40,610.36	41,000.38
5. Land Use, Land-Use Change and Forestry ⁽⁵⁾	-12,153.74	-25,914.73	-24,518.61	-11,223.05	-23,559.96	-30,382.90	-30,340.85	-21,828.00	-18,766.93	-27,828.28
6. Waste	19,664.96	20,694.26	19,671.36	19,538.00	20,088.42	20,445.39	21,316.34	21,852.86	21,934.07	22,148.04

Table A8.1.5.1 Total emission trends, CRF year 2011 (years 1990 – 1999)

TABLE 10 EMISSION TRENDS

SUMMARY

(Part 1 of 3)

Inventory
2011
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ITALY

7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF) ⁽⁵⁾	506,830.4 3	494,598.72	493,174.37	499,956.6 6	479,915.04	499,857.76	493,575.03	508,469.28	522,893.8 2	520,221.4 9

Table A8.1.5.1 Total emission trends, CRF year 2011 (years 2000 – 2009)

TABLE 10 EMISSION TRENDS

SUMMARY

(Part 2 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS EMISSIONS	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)
CO ₂ emissions including net CO ₂ from LULUCF	435,951.80	434,666.84	431,945.20	455,375.68	452,678.14	449,563.22	444,163.98	456,876.15	426,953.92	374,798.92
CO ₂ emissions excluding net CO ₂ from LULUCF	462,277.69	468,283.97	470,530.86	486,559.68	489,367.01	488,078.03	483,542.57	475,441.19	463,921.58	415,088.93
CH ₄ emissions including CH ₄ from LULUCF	46,191.08	44,929.16	43,887.46	43,072.71	41,601.48	41,266.94	39,716.93	40,034.74	38,403.82	38,282.40
CH ₄ emissions excluding CH ₄ from LULUCF	45,843.74	44,695.99	43,760.64	42,787.18	41,385.21	41,106.94	39,577.86	39,312.65	38,191.59	38,013.00
N ₂ O emissions including N ₂ O from LULUCF	39,627.21	39,668.72	38,918.61	38,460.70	39,476.50	37,750.97	32,394.14	31,919.91	29,700.30	28,153.54
N ₂ O emissions excluding N ₂ O from LULUCF	39,483.23	39,561.04	38,846.20	38,334.08	39,366.79	37,667.51	32,321.92	31,678.64	29,615.20	28,052.98
HFCs	1,985.67	2,549.75	3,191.29	3,901.91	4,635.03	5,400.56	6,106.19	6,855.26	7,512.98	8,163.94
PFCs	1,217.43	1,342.04	1,333.92	1,676.71	1,733.21	1,715.00	1,713.61	1,652.10	1,500.59	1,062.81
SF ₆	493.43	795.34	739.72	467.56	502.14	465.39	405.87	427.55	435.53	398.02
Total (including LULUCF)	525,466.63	523,951.84	520,016.20	542,955.27	540,626.50	536,162.08	524,500.73	537,765.72	504,507.14	450,859.63
Total (excluding LULUCF)	551,301.20	557,228.13	558,402.63	573,727.11	576,989.40	574,433.42	563,668.03	555,367.39	541,177.47	490,779.67

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)
1. Energy	449,686.56	454,549.15	456,681.34	471,487.67	473,537.90	471,901.71	466,813.42	458,164.58	449,202.26	405,192.17
2. Industrial Processes	36,249.03	38,370.33	38,603.76	40,203.98	42,779.10	42,591.89	38,143.47	38,601.34	35,668.37	30,743.13
3. Solvent and Other Product Use	2,301.35	2,214.05	2,215.38	2,163.07	2,127.79	2,122.86	2,125.72	2,075.05	1,953.73	1,829.28
4. Agriculture	40,135.38	39,202.18	38,501.20	38,339.99	38,034.26	37,362.53	36,767.15	37,379.82	36,015.43	34,776.85
5. Land Use, Land-Use Change and Forestry ⁽⁵⁾	-25,834.57	-33,276.28	-38,386.43	-30,771.85	-36,362.90	-38,271.35	-39,167.30	-17,601.67	-36,670.33	-39,920.04
6. Waste	22,928.87	22,892.42	22,400.95	21,532.42	20,510.35	20,454.43	19,818.27	19,146.60	18,337.68	18,238.24
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)⁽⁵⁾	525,466.63	523,951.84	520,016.20	542,955.27	540,626.50	536,162.08	524,500.73	537,765.72	504,507.14	450,859.63

Table A8.1.5.1 Total emission trends, CRF year 2011 (years 2010 – 2011)

TABLE 10 EMISSION TRENDS

SUMMARY

(Part 3 of 3)

Inventory
2011
Submission
2013 v2.1
ITALY

GREENHOUSE GAS EMISSIONS	2010	2011	Change from base to latest reported year
	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	(%)
CO ₂ emissions including net CO ₂ from LULUCF	381,939.57	383,394.43	-9.07
CO ₂ emissions excluding net CO ₂ from LULUCF	425,499.38	414,239.22	-4.70
CH ₄ emissions including CH ₄ from LULUCF	37,452.63	36,756.26	-17.14
CH ₄ emissions excluding CH ₄ from LULUCF	37,290.20	36,567.66	-16.44
N ₂ O emissions including N ₂ O from LULUCF	27,132.14	26,939.29	-28.50
N ₂ O emissions excluding N ₂ O from LULUCF	27,075.62	26,873.17	-28.14
HFCs	8,744.58	9,306.04	2,551.29
PFCs	1,330.83	1,454.54	-41.51
SF ₆	373.27	351.38	5.54
Total (including LULUCF)	456,973.03	458,201.95	-9.59
Total (excluding LULUCF)	500,313.89	488,792.02	-5.82

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2010	2011	Change from base to latest reported year
	CO ₂ equivalent (Gg)	CO ₂ equivalent (Gg)	(%)
1. Energy	415,299.28	404,443.53	-3.18
2. Industrial Processes	31,829.82	31,640.92	-17.58
3. Solvent and Other Product Use	1,676.71	1,656.28	-32.52
4. Agriculture	33,722.59	33,530.43	-17.69
5. Land Use, Land-Use Change and Forestry ⁽⁵⁾	-43,340.86	-30,590.07	151.69
6. Waste	17,785.50	17,520.85	-10.90
7. Other	NA	NA	0.00
Total (including LULUCF)⁽⁵⁾	456,973.03	458,201.95	-9.59

A8.2 Supplementary information under Article 7, paragraph 1

A8.2.1 KP-LULUCF

Table A8.2.1.1 Table NIR1. Summary Table

Activity coverage and other information relating to activities under Article 3.3 and elected activities under Article 3.4

Activity		Change in carbon pool reported ⁽¹⁾					Greenhouse gas sources reported ⁽²⁾						
		Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil	Fertilization ⁽³⁾	Drainage of soils under forest management	Disturbance associated with land-use conversion to croplands	Liming	Biomass burning ⁽⁴⁾		
							N ₂ O				N ₂ O	N ₂ O	CO ₂
Article 3.3 activities	Afforestation and Reforestation	R	R	R	R	R	NO			NO	IE	R	R
	Deforestation	R	R	R	R	R			NO	NO	NO	NO	NO
Article 3.4 activities	Forest Management	R	R	R	R	NR	NO	NO		NO	IE	R	R
	Cropland Management	NA	NA	NA	NA	NA			NA	NA	NA	NA	NA
	Grazing Land Management	NA	NA	NA	NA	NA				NA	NA	NA	NA
	Revegetation	NA	NA	NA	NA	NA				NA	NA	NA	NA

Table A8.2.1.2 Table NIR2. Land Transition Matrix – 2008

Areas and changes in areas between the previous and the current inventory year ^{(1), (2), (3)}

To current inventory year <	
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Table A8.2.1.3 Table NIR2. Land Transition Matrix - 2009

Areas and changes in areas between the previous and the current inventory year ^{(1), (2), (3)}

To current inventory year From previous inventory year		Article 3.3 activities		Article 3.4 activities				Other ⁽⁵⁾	Total area at the beginning of the current inventory year ⁽⁶⁾
		Afforestation and Reforestation	Deforestatio n	Forest Managem ent (if elected)	Cropla nd Manag ement (if elected)	Grazing Land Managem ent (if elected)	Reve getat ion (if elect ed)		
		(kha)							
Article 3.3 activities	Afforestation and Reforestation	1,479.67	NO						1,479.67
	Deforestation		13.72						13.72
Article 3.4 activities	Forest Management (if elected)		0.72	7,358.47					7,359.19
	Cropland Management ⁽⁴⁾ (if elected)	NA	NA		NA	NA	NA		NA
	Grazing Land Management ⁽⁴⁾ (if elected)	NA	NA		NA	NA	NA		NA
	Revegetation ⁽⁴⁾ (if elected)	NA			NA	NA	NA		NA
Other ⁽⁵⁾		78.63	0.00	0.00	0.00	0.00	0.00	21,202.39	21,281.02
Total area at the end of the current inventory year		1,558.30	14.44	7,358.47	0.00	0.00	0.00	21,202.39	30,133.60

Table A8.2.1.4 Table NIR2. Land Transition Matrix - 2010

Areas and changes in areas between the previous and the current inventory year ^{(1), (2), (3)}

To current inventory year 	
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Table A8.2.1.4 Table NIR2. Land Transition Matrix - 2011

Areas and changes in areas between the previous and the current inventory year ^{(1), (2), (3)}

To current inventory year <	
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Table A8.2.1.5 Table NIR3. Summary overview for key categories for LULUCF activities under Kyoto Protocol

TABLE NIR 3. SUMMARY OVERVIEW FOR KEY CATEGORIES FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL

KEY CATEGORIES OF EMISSIONS AND REMOVALS	GAS	CRITERIA USED FOR KEY CATEGORY IDENTIFICATION			COMMENTS ⁽³⁾
		Associated category in UNFCCC inventory ⁽¹⁾ is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory ^{(1), (4)} (including LULUCF)	Other ⁽²⁾	
Specify key categories according to the national level of disaggregation used ⁽¹⁾					
Forest Management	CO2	Forest land remaining forest land	Yes	no	no
Afforestation and Reforestation	CO2	Conversion to forest land	Yes	no	category identified only for trend assessment with Tier2

Table A8.2.1.6 Table 5(KP). Report of supplementary information for LULUCF activities under Kyoto Protocol - 2008

TABLE 5(KP). REPORT OF SUPPLEMENTARY INFORMATION FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL ^{(1), (2)}

ITALY

Inventory 2008

Submission 2013 v2.1

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Net CO ₂ emissions/ removals ^{(3), (4)}	CH ₄ ⁽⁵⁾	N ₂ O ⁽⁶⁾	Net CO ₂ equivalent emissions/removals
	(Gg)			
A. Article 3.3 activities				-6,014.96
A.1. Afforestation and Reforestation ⁽⁷⁾	-6,410.85	0.97	0.00	-6,390.36
A.1.1. Units of land not harvested since the beginning of the commitment period	-6,410.85	0.97	0.00	-6,390.36
A.1.2. Units of land harvested since the beginning of the commitment period	NA	NA	NA	NA
A.2. Deforestation	375.40	NA	NA	375.40
B. Article 3.4 activities				-27,944.44
B.1. Forest Management (if elected)	-27,992.21	2.26	0.00	-27,944.44
B.2. Cropland Management (if elected)	NA	NA	NA	NA
B.3. Grazing Land Management (if elected)	NA	NA	NA	NA
B.4. Revegetation (if elected)	NA	NA	NA	NA
Information item:				
A.1.2. Units of land harvested since the beginning of the commitment period	NA	NA	NA	NA

Table A8.2.1.7 Table 5(KP). Report of supplementary information for LULUCF activities under Kyoto Protocol - 2009

TABLE 5(KP). REPORT OF SUPPLEMENTARY INFORMATION FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL ^{(1), (2)}

ITALY

Inventory 2009

Submission 2013 v2.1

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Net CO ₂ emissions/ removals ^{(3), (4)}	CH ₄ ⁽⁵⁾	N ₂ O ⁽⁶⁾	Net CO ₂ equivalent emissions/removals
	(Gg)			
A. Article 3.3 activities				-6,840.81
A.1. Afforestation and Reforestation ⁽⁷⁾	-7,238.50	0.98	0.00	-7,217.78
A.1.1. Units of land not harvested since the beginning of the commitment period	-7,238.50	0.98	0.00	-7,217.78
A.1.2. Units of land harvested since the beginning of the commitment period	NA	NA	NA	NA
A.2. Deforestation	376.97	NA	NA	376.97
B. Article 3.4 activities				-30,245.24
B.1. Forest Management (if elected)	-30,293.52	2.29	0.00	-30,245.24
B.2. Cropland Management (if elected)	NA	NA	NA	NA
B.3. Grazing Land Management (if elected)	NA	NA	NA	NA
B.4. Revegetation (if elected)	NA	NA	NA	NA
Information item:				
A.1.2. Units of land harvested since the beginning of the commitment period	NA	NA	NA	NA

Table A8.2.1.8 Table 5(KP). Report of supplementary information for LULUCF activities under Kyoto Protocol - 2010

TABLE 5(KP). REPORT OF SUPPLEMENTARY INFORMATION FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL (1), (2)

ITALY

Inventory 2010

Submission 2013 v2.1

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Net CO ₂ emissions/ removals ^{(3), (4)}	CH ₄ ⁽⁵⁾	N ₂ O ⁽⁶⁾	Net CO ₂ equivalent emissions/removals
	(Gg)			
A. Article 3.3 activities				-7,438.17
A.1. Afforestation and Reforestation ⁽⁷⁾	-7,830.13	0.62	0.00	-7,816.91
A.1.1. Units of land not harvested since the beginning of the commitment period	-7,830.13	0.62	0.00	-7,816.91
A.1.2. Units of land harvested since the beginning of the commitment period	NA	NA	NA	NA
A.2. Deforestation	378.74	NA	NA	378.74
B. Article 3.4 activities				-31,303.73
B.1. Forest Management (if elected)	-31,334.19	1.44	0.00	-31,303.73
B.2. Cropland Management (if elected)	NA	NA	NA	NA
B.3. Grazing Land Management (if elected)	NA	NA	NA	NA
B.4. Revegetation (if elected)	NA	NA	NA	NA
Information item:				
A.1.2. Units of land harvested since the beginning of the commitment period	NA	NA	NA	NA

Table A8.2.1.8 Table 5(KP). Report of supplementary information for LULUCF activities under Kyoto Protocol - 2011

TABLE 5(KP). REPORT OF SUPPLEMENTARY INFORMATION FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL ^{(1), (2)}

ITALY

Inventory 2011

Submission 2013 v2.1

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Net CO ₂ emissions/ removals ^{(3), (4)}	CH ₄ ⁽⁵⁾	N ₂ O ⁽⁶⁾	Net CO ₂ equivalent emissions/removals
	(Gg)			
A. Article 3.3 activities				-6,082.74
A.1. Afforestation and Reforestation ⁽⁷⁾	-6,481.98	0.91	0.00	-6,462.69
A.1.1. Units of land not harvested since the beginning of the commitment period	-6,481.98	0.91	0.00	-6,462.69
A.1.2. Units of land harvested since the beginning of the commitment period	NA	NA	NA	NA
A.2. Deforestation	379.95	NA	NA	379.95
B. Article 3.4 activities				-23,976.98
B.1. Forest Management (if elected)	-24,021.93	2.13	0.00	-23,976.98
B.2. Cropland Management (if elected)	NA	NA	NA	NA
B.3. Grazing Land Management (if elected)	NA	NA	NA	NA
B.4. Revegetation (if elected)	NA	NA	NA	NA
Information item:				
A.1.2. Units of land harvested since the beginning of the commitment period	NA	NA	NA	NA

A8.2.2 Standard electronic format

Table A8.2.2.1 Total quantities of Kyoto Protocol units by account type at beginning of reported year

Party Italy
 Submission year 2013
 Reported year 2012
 Commitment period 1

Table 1. Total quantities of Kyoto Protocol units by account type at beginning of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Party holding accounts	1602189698	NO	NO	NO	NO	NO
Entity holding accounts	213293289	2105194	NO	23852661	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	NO	NO	NO	NO	NO	NO
Retirement account	567758394	752006	NO	28577753	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
ICER replacement account for expiry	NO	NO	NO	NO		
ICER replacement account for reversal of storage	NO	NO	NO	NO		NO
ICER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	2383241381	2857200	NO	52430414	NO	NO

Table A8.2.2.2.a Annual internal transactions

Party Italy
 Submission year 2013
 Reported year 2012
 Commitment period 1

Table 2 (a). Annual internal transactions

Transaction type	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Article 6 issuance and conversion												
Party-verified projects		NO					NO		NO			
Independently verified projects		NO					NO		NO			
Article 3.3 and 3.4 issuance or cancellation												
3.3 Afforestation and reforestation			NO				NO	NO	NO	NO		
3.3 Deforestation			NO				NO	NO	NO	NO		
3.4 Forest management			NO				NO	NO	NO	NO		
3.4 Cropland management			NO				NO	NO	NO	NO		
3.4 Grazing land management			NO				NO	NO	NO	NO		
3.4 Revegetation			NO				NO	NO	NO	NO		
Article 12 afforestation and reforestation												
Replacement of expired tCERs							NO	NO	NO	NO	NO	
Replacement of expired ICERs							NO	NO	NO	NO		
Replacement for reversal of storage							NO	NO	NO	NO		NO
Replacement for non-submission of certification report							NO	NO	NO	NO		NO
Other cancellation							NO	NO	NO	NO	NO	NO
Sub-total		NO	NO				NO	NO	NO	NO	NO	NO

Transaction type	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Retirement	1.71E+08	4809456	NO	14793961	NO	NO

Table A8.2.2.2.b Annual external transactions

Party Italy
 Submission year 2013
 Reported year 2012
 Commitment period 1

Table 2 (b). Annual external transactions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Transfers and acquisitions												
BE	166942	NO	NO	NO	NO	NO	NO	26737	NO	194004	NO	NO
CZ	1000	NO	NO	6335	NO	NO	6335	NO	NO	NO	NO	NO
PT	55435	NO	NO	NO	NO	NO	11560	10000	NO	38875	NO	NO
SK	1976022	9355	NO	89335	NO	NO	179160	NO	NO	14032	NO	NO
PL	153995	50000	NO	NO	NO	NO	63995	80000	NO	60000	NO	NO
SE	NO	NO	NO	NO	NO	NO	35000	NO	NO	NO	NO	NO
DE	847551	31627	NO	990003	NO	NO	1928367	13000	NO	425695	NO	NO
ES	719973	1708821	NO	97666	NO	NO	282431	1104907	NO	916127	NO	NO
FI	NO	NO	NO	17196	NO	NO	NO	NO	NO	NO	NO	NO
GB	13743597	2731663	NO	7192309	NO	NO	8019295	15000	NO	2683313	NO	NO
NL	5606352	2148576	NO	3557966	NO	NO	12750400	NO	NO	317996	NO	NO
NO	NO	25716	NO	NO	NO	NO	25716	NO	NO	NO	NO	NO
LI	NO	NO	NO	416000	NO	NO	NO	NO	NO	NO	NO	NO
GR	NO	NO	NO	NO	NO	NO	NO	9265	NO	29786	NO	NO
HU	104775	NO	NO	NO	NO	NO	5938	NO	NO	NO	NO	NO
CH	NO	1288095	NO	1288828	NO	NO	NO	1	NO	168500	NO	NO
BG	1541644	NO	NO	NO	NO	NO	NO	134175	NO	431334	NO	NO
IE	4000	NO	NO	68500	NO	NO	18500	NO	NO	NO	NO	NO
EU	NO	970262	NO	3134513	NO	NO	NO	426396	NO	18216467	NO	NO
JP	NO	NO	NO	NO	NO	NO	NO	NO	NO	999999	NO	NO
FR	2181445	1519253	NO	1649811	NO	NO	8474367	813263	NO	2438128	NO	NO
AT	NO	NO	NO	NO	NO	NO	20000	NO	NO	NO	NO	NO
CDM	NO	NO	NO	13296280	54670	NO	NO	NO	NO	NO	NO	NO

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
SI	NO	3937	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sub-total	27102731	10487305	NO	31804742	54670	NO	31821064	2632744	NO	26934256	NO	NO

Additional information

Independently verified ERUs								NO				
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A8.2.2.2.c Total annual transactions

Table 2 (c). Total annual transactions

Total (Sum of tables 2a and 2b)	27102731	10487305	NO	31804742	54670	NO	31821064	2632744	NO	26934256	NO	NO
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Table A8.2.2.3 Expiry, cancellation and replacement

Party Italy
 Submission year 2013
 Reported year 2012
 Commitment period 1

Table 3. Expiry, cancellation and replacement

Transaction or event type	Expiry, cancellation and requirement to replace		Replacement					
	Unit type		Unit type					
	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Temporary CERs (tCERs)								
Expired in retirement and replacement accounts	NO							
Replacement of expired tCERs			NO	NO	NO	NO	NO	
Expired in holding accounts	NO							
Cancellation of tCERs expired in holding accounts	NO							
Long-term CERs (ICERs)								
Expired in retirement and replacement accounts		NO						
Replacement of expired ICERs			NO	NO	NO	NO		
Expired in holding accounts		NO						
Cancellation of ICERs expired in holding accounts		NO						
Subject to replacement for reversal of storage		NO						
Replacement for reversal of storage			NO	NO	NO	NO		NO
Subject to replacement for non-submission of certification report		NO						
Replacement for non-submission of certification report			NO	NO	NO	NO		NO
Total			NO	NO	NO	NO	NO	NO

Table A8.2.2.4 Total quantities of Kyoto Protocol units by account type at end of reported year

Party
Submission year
Reported year
Commitment period

Italy
2013
2012
1

Table 4. Total quantities of Kyoto Protocol units by account type at end of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Party holding accounts	1638291168	15815	NO	83759	NO	NO
Entity holding accounts	1970000	5134484	NO	13845427	54670	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	NO	NO	NO	NO	NO	NO
Retirement account	738261880	5561462	NO	43371714	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
ICER replacement account for expiry	NO	NO	NO	NO		
ICER replacement account for reversal of storage	NO	NO	NO	NO		NO
ICER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	2378523048	10711761	NO	57300900	54670	NO

Table A8.2.2.5.a Summary information on additions and subtractions

Party Italy
Submission year 2013
Reported year 2012
Commitment period 1

Table 5 (a). Summary information on additions and subtractions

		Additions						Subtractions					
		Unit type						Unit type					
Starting values		AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Issuance pursuant to Article 3.7 and 3.8		2.42E+09											
Non-compliance cancellation								NO	NO	NO	NO		
Carry-over		NO	NO		NO								
Sub-total		2.42E+09	NO		NO			NO	NO	NO	NO		
Annual transactions													
Year 0 (2007)		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 1 (2008)		20292957	NO	NO	19276322	NO	NO	3804703	NO	NO	9973920	NO	NO
Year 2 (2009)		20116642	NO	NO	22792461	NO	NO	26501513	NO	NO	4370667	NO	NO
Year 3 (2010)		1.83E+08	1340006	NO	20643648	NO	NO	1.93E+08	1050000	NO	13493232	NO	NO
Year 4 (2011)		40163828	3357194	NO	54089496	NO	NO	73259250	790000	NO	36533694	NO	NO
Year 5 (2012)		27102731	10487305	NO	31804742	54670	NO	31821064	2632744	NO	26934256	NO	NO
Year 6 (2013)		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sub-total		2.9E+08	15184505	NO	1.49E+08	54670	NO	3.28E+08	4472744	NO	91305769	NO	NO
Total		2.71E+09	15184505	NO	1.49E+08	54670	NO	3.28E+08	4472744	NO	91305769	NO	NO

Table A8.2.2.5.b Summary information on replacement

Table 5 (b). Summary information on replacement

	Requirement for replacement		Replacement					
	Unit type		Unit type					
	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Previous CPs			NO	NO	NO	NO	NO	NO
Year 1 (2008)		NO	NO	NO	NO	NO	NO	NO
Year 2 (2009)		NO	NO	NO	NO	NO	NO	NO
Year 3 (2010)		NO	NO	NO	NO	NO	NO	NO
Year 4 (2011)		NO	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO	NO	NO

Table A8.2.2.5.c Summary information on retirement

Table 5 (c). Summary information on retirement

Year	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Year 1 (2008)	NO	NO	NO	NO	NO	NO
Year 2 (2009)	NO	NO	NO	NO	NO	NO
Year 3 (2010)	NO	NO	NO	NO	NO	NO
Year 4 (2011)	5.68E+08	752006	NO	28577753	NO	NO
Year 5 (2012)	1.71E+08	4809456	NO	14793961	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO
Total	7.38E+08	5561462	NO	43371714	NO	NO

A8.2.3 National registry

A8.2.3.1 Changes to national registry

Changes to national registry are described in Chapter 13.

A8.2.3.2 Reports

- i) **list of discrepancies**
no discrepancies occurred during the reporting period
- ii) **notifications from EB of CDM**
no CDM notifications were received by the Registry during the reporting period
- iii) **non-replacements**
no non-replacements occurred during the reporting period
- iv) **invalid units**
no invalid units to list for the reporting period

A8.2.4 Adverse impacts under Article 3, paragraph 14 of the Kyoto Protocol

Chapter 14 presents information on the commitments to tackle adverse impacts under Article 3, paragraph 14, of the Kyoto Protocol. Additional information which can be added is the list of all registered CDM projects in which Italy is involved.

Table A8.2.3.1 Information of the 106 registered CDM projects where Italy is involved (as for 13/03/2013)

Title	Host Parties	Other Parties	Impacts assessment
Project for GHG emission reduction by thermal oxidation of HFC 23 in Gujarat, India.	India (b)	Switzerland, Japan, Netherlands, Italy , United Kingdom of Great Britain and Northern Ireland	-
La Esperanza Hydroelectric Project	Honduras (a)	Canada, Netherlands, Italy , Denmark, Finland, Austria, Luxembourg, Belgium, Sweden, Germany, Switzerland, Japan, Norway, Spain	Nussbaumer (2009) + CDCF (*)
Santa Rosa	Peru (a)	Canada, Netherlands, Italy , Denmark, Finland, Austria, Luxembourg, Belgium, Sweden, Germany, Switzerland, Japan, Norway, Spain	Nussbaumer (2009) + CDCF
DSL Biomass based Power Project at Pagara	India (a)	Italy , Germany, United Kingdom of Great Britain and Northern Ireland	Sirohi (2007)
GHG emission reduction by thermal oxidation of HFC 23 at refrigerant (HCFC-22) manufacturing facility of SRF Ltd	India (b)	Netherlands, Italy , France, Germany, United Kingdom of Great Britain and Northern Ireland, Switzerland	Sirohi (2007)
Biogas Support Program - Nepal (BSP-Nepal) Activity-1	Nepal (a)	Canada, Netherlands, Italy , Denmark, Finland, Sweden, Luxembourg, Switzerland, Austria, Germany, Belgium, Japan, Norway, Spain	Nussbaumer (2009) + CDCF
Biogas Support Program - Nepal (BSP-Nepal) Activity-2	Nepal (a)	Canada, Netherlands, Italy , Denmark, Finland, Sweden, Luxembourg, Switzerland, Austria, Germany, Belgium, Japan, Norway, Spain	Nussbaumer (2009) + CDCF
Olavarria Landfill Gas Recovery Project	Argentina (c)	Canada, Netherlands, Italy , Denmark, Finland, Sweden, Luxembourg, Switzerland, Austria, Germany, Belgium, Japan, Norway, Spain	Nussbaumer (2009) + CDCF
Moldova Biomass Heating in Rural Communities (Project Design Document No. 1)	Republic of Moldova (a)	Canada, Netherlands, Italy , Denmark, Finland, Austria, Luxembourg, Belgium, Sweden, Germany, Switzerland, Japan, Norway, Spain	Nussbaumer (2009) + CDCF
Moldova Biomass Heating in Rural Communities (Project Design Document No. 2)	Republic of Moldova (a)	Canada, Netherlands, Italy , Denmark, Finland, Sweden, Luxembourg, Switzerland, Austria, Germany, Belgium, Japan, Norway, Spain	Nussbaumer (2009) + CDCF
Moldova Energy Conservation and Greenhouse Gases Emissions Reduction	Republic of Moldova (a)	Canada, Netherlands, Italy , Denmark, Finland, Sweden, Luxembourg, Switzerland, Austria, Germany, Belgium, Japan, Norway, Spain	-
Aleo Manali 3 MW Small Hydroelectric Project, Himachal Pradesh, India	India (a)	Switzerland, Italy , United Kingdom of Great Britain and Northern Ireland	Nussbaumer (2009), Sirohi (2007)
5 MW Wind Power Project at Baramsar and Soda Mada, district Jaisalmer, Rajasthan, India.	India (a)	Italy	Nussbaumer (2009), Sirohi (2007)
Landfill gas recovery at the Norte III Landfill, Buenos Aires, Argentina.	Argentina (b)	Switzerland, Italy	-
Project for GHG Emission Reduction by Thermal Oxidation of HFC23 in Jiangsu Meilan Chemical CO.	China (b)	Canada, Netherlands, Italy , Denmark, Finland, France, Sweden, Germany, United Kingdom of Great Britain and Northern Ireland, Switzerland, Japan,	-

Title	Host Parties	Other Parties	Impacts assessment
Ltd., Jiangsu Province, China		Norway, Spain	
Project for HFC23 Decomposition at Changshu 3F Zhonghao New Chemical Materials Co. Ltd, Changshu, Jiangsu Province, China	China (b)	Canada, Netherlands, Italy , Denmark, Finland, France, Sweden, Germany, United Kingdom of Great Britain and Northern Ireland, Switzerland, Japan, Norway, Spain	-
Puente Gallego Landfill gas recovery project, Gallego, Rosario, Argentina.	Argentina (b)	Switzerland, Italy	-
Djebel Chekir Landfill Gas Recovery and Flaring Project – Tunisia	Tunisia (c)	Italy	-
Project for HFC23 Decomposition at Zhejiang Dongyang Chemical Co., Ltd., China	China (b)	Switzerland, Netherlands, Italy, United Kingdom of Great Britain and Northern Ireland	-
Project for HFC23 Decomposition at Limin Chemical Co., Ltd. Linhai, Zhejiang Province, China	China (b)	Switzerland, Netherlands, Italy , United Kingdom of Great Britain and Northern Ireland	-
Recovery of associated gas that would otherwise be flared at Kwale oil-gas processing plant, Nigeria	Nigeria (b)	Italy	-
Facilitating Reforestation for Guangxi Watershed Management in Pearl River Basin	China (d)	Canada, Italy , Luxembourg, France, Japan, Spain	Cóndor et al. (2010)
Landfill Gas Recovery and Flaring for 9 bundled landfills in Tunisia	Tunisia (c)	Italy	-
India-FaL-G Brick and Blocks Project No.1	India (a)	Canada, Netherlands, Italy , Denmark, Finland, Austria, Luxembourg, Belgium, Sweden, Germany, Switzerland, Japan, Norway, Spain	Nussbaumer (2009) + CDCF
Huadian Inner Mongolia Huitengxile 100.25MW Wind Farm Project	China (c)	Italy	Boyd et al. (2009)
Yunnan Whitewaters Hydropower Development Project	China (c)	Italy	Nussbaumer (2009)
Hebbakavadi Canal Based Mini Hydro Project in Karnataka, India	India (a)	Switzerland, Italy	-
Guangrun Hydropower Project in Hubei Province, P.R. China	China (c)	Canada, Netherlands, Italy , Finland, Austria, Luxembourg, Belgium, Sweden, Germany, Switzerland, Japan, Norway, Spain	Nussbaumer (2009) + CDCF
HFC23 Decomposition Project at Zhonghao Chenguang Research Institute of Chemical Industry, Zigong, SiChuan Province, China	China (b)	Switzerland, Netherlands, Italy , United Kingdom of Great Britain and Northern Ireland	-
Allain Duhangan Hydroelectric Project (ADHP)	India (c)	Italy	-
Rongcheng Dongchudao Wind Farm	China (a)	Italy	-
Landfill gas recovery and electricity generation at “Mtoni Dumpsite”, Dar Es Salaam, Tanzania	United Republic of Tanzania (c)	Italy	-
Laizhou Diaolongzui Wind Farm	China (c)	Italy	-
Quezon City Controlled Disposal Facility Biogas Emission Reduction Project	Philippines (a)	Switzerland, Sweden, Italy , Spain	-

Title	Host Parties	Other Parties	Impacts assessment
Laguna de Bay Community Waste Management Project: Avoidance of methane production from biomass decay through composting -I	Philippines (a)	Canada, Netherlands, Italy , Denmark, Finland, Austria, Luxembourg, Belgium, Sweden, Germany, Switzerland, Japan, Norway, Spain	-
Guyana Skeldon Bagasse Cogeneration Project	Guyana (c)	Canada, Netherlands, Italy , Denmark, Finland, Austria, Luxembourg, Belgium, Sweden, Germany, Switzerland, Japan, Norway, Spain	-
Guizhou Zhenyuan Putian Hydropower Station	China (a)	Italy	-
Kunming Dongjiao Baishuitang LFG Treatment and Power Generation Project	China (c)	Switzerland, Italy	-
Sichuan Shimian Xieluo Wanba River Hydropower Station	China (c,+)	Italy	-
Shenyang Laohuchong LFG Power Generation Project	China (c)	Switzerland, Italy	-
Expansion Project of Huadian Inner Mongolia Huitengxile Wind Farm	China (c)	Italy	-
Moldova Soil Conservation Project	Republic of Moldova (d)	Canada, Netherlands, Italy , Finland, Luxembourg, France, Sweden, United Kingdom of Great Britain and Northern Ireland, Japan, Norway, Spain	Cóndor et al. (2010)
Hubei Eco-Farming Biogas Project Phase I	China (a)	Canada, Netherlands, Italy , Denmark, Finland, Austria, Luxembourg, Switzerland, Sweden, Germany, Belgium, Japan, Norway, Spain	-
Salta Landfill Gas Capture Project	Argentina (a)	Canada, Netherlands, Italy , Denmark, Finland, Austria, Luxembourg, Switzerland, Sweden, Germany, Belgium, Japan, Norway, Spain	-
Coke Dry Quenching (CDQ) Waste Heat Recovery for Power Generation Project of Wugang No. 9 and 10 Coke Ovens	China (c)	Italy	-
Yingpeng HFC23 Decomposition Project	China (b)	France, Italy , Ireland, United Kingdom of Great Britain and Northern Ireland	-
Animal Manure Management System (AMMS) GHG Mitigation Project, Shandong Minhe Livestock Co. Ltd., Penglai, Shandong Province, P.R. of China	China (c)	Canada, Netherlands, Italy , Denmark, Finland, Austria, Luxembourg, Switzerland, Sweden, Germany, Belgium, Japan, Norway, Spain	-
Uganda Nile Basin Reforestation Project No.3	Uganda (d)	Canada, Italy , Luxembourg, France, Japan, Spain	-
Community-Based Renewable Energy Development in the Northern Areas and Chitral (NAC), Pakistan	Pakistan (a)	Canada, Netherlands, Italy , Denmark, Finland, Sweden, Luxembourg, Switzerland, Austria, Germany, Belgium, Japan, Norway, Spain	-
NISCO Converter Gas Recovery and Utilization for Power Generation Project	China (c)	Italy	-
Humbo Ethiopia Assisted Natural Regeneration Project	Ethiopia (d)	Canada, Italy , Luxembourg, France, Japan, Spain	CCB
Jinping Ladeng River Hydropower Station	China (c,+)	Italy	-
Assisted Natural Regeneration of Degraded Lands in Albania	Albania (d)	Canada, Italy , Luxembourg, France, Japan, Spain	Cóndor et al. (2010)
Sichuan Mabian Yi Minority Autonomous County Yonglexi Hydropower Station	China (a)	Italy	-

Title	Host Parties	Other Parties	Impacts assessment
Rwanda Electrogaz Compact Fluorescent Lamp (CFL) distribution project	Rwanda (a)	Canada, Netherlands, Italy , Denmark, Finland, Sweden, Luxembourg, Switzerland, Austria, Germany, Belgium, Japan, Norway, Spain	-
Reforestation as Renewable Source of Wood Supplies for Industrial Use in Brazil	Brazil (d,+)	Netherlands, Italy , Luxembourg, France, Ireland, Switzerland, Japan, Spain	-
Yunnan Maguan Mihu River 3rd Level Hydropower Station	China (c)	Italy	-
Jinping Maocaoping Hydropower Station	China (a)	Italy	-
Xianggelila Huajiaopo Hydropower Station	China (a)	Italy	-
Micro-hydro Promotion	Nepal (a,+)	Netherlands, Italy , Denmark, Finland, Austria, Luxembourg, Belgium, Sweden, Germany, Switzerland, Japan, Spain	-
Olkaria II Geothermal Expansion Project	Kenya (c)	Canada, Netherlands, Italy , Denmark, Finland, Sweden, Luxembourg, Switzerland, Austria, Germany, Belgium, Japan, Norway, Spain	-
Wugang Gas-Steam Combined Cycle Power Plant (CCPP) Project	China (c)	Italy	-
Wugang Waste Gas Recovery and Power Generation Project	China (c)	Italy	-
Chongqing Wanzhou Xiangjiuzui Hydropower Station	China (a)	Italy	-
Mungcharoen Green Power - 9.9 MW Rice Husk Fired Power Plant Project	Thailand (a)	Italy	-
AES Tietê Afforestation/Reforestation Project in the State of São Paulo, Brazil	Brazil (d)	Canada, Italy , Luxembourg, France, Japan, Spain	-
Landfill biogas extraction and combustion plant in El Inga I and II landfill (Quito, Ecuador)	Ecuador (c)	Italy	-
Jinping Maguo River Hydropower Station	China (a)	Italy	-
Improving Rural Livelihoods Through Carbon Sequestration By Adopting Environment Friendly Technology based Agroforestry Practices	India (d)	Canada, Italy , Luxembourg, France, Japan, Spain	-
Yunnan Yingjiang Zhina River 2nd Level Hydropower Station Phase 1 and Phase 2	China (c)	Italy	-
Yunnan Er'yan Misha River Longdi Hydropower Station	China (a)	Italy	-
Southern Nicaragua CDM Reforestation Project	Nicaragua (d)	Canada, Italy , Luxembourg, France, Japan, Spain	-
Yunnan Yingjiang Zhina River 1st Level Hydropower Station	China (a)	Italy	-
Shanxi Shuangliang Cement Company LTD. 4.5MW Waste Heat for Power Generation Project	China (c)	Italy	-
Aberdare Range/ Mt. Kenya Small Scale Reforestation Initiative Kamae-Kipipiri Small Scale A/R Project	Kenya (d)	Canada, Italy , Luxembourg, France, Japan, Spain	-

Title	Host Parties	Other Parties	Impacts assessment
India-FaL-G Brick and Blocks Project No.2.	India (a)	Netherlands, Italy , Denmark, Finland, Austria, Luxembourg, Sweden, Germany, Belgium, Japan, Norway, Spain	Nussbaumer (2009) + CDCF
Uganda Nile Basin Reforestation Project No.5	Uganda (d)	Japan, Italy , Spain, Luxembourg, France	-
Jiangsu Hantian Cement Waste Heat Recovery Power Generation Project	China (c)	Italy	-
Improving Kiln Efficiency in the Brick Making Industry in Bangladesh	Bangladesh (a,+)	Netherlands, Italy , Denmark, Finland, Austria, Luxembourg, Switzerland, Sweden, Germany, Belgium, Japan, Norway, Spain	-
Uganda Nile Basin Reforestation Project No 1	Uganda (d)	Japan, Italy , Spain, Luxembourg, France	-
Uganda Nile Basin Reforestation Project No 2	Uganda (d)	Japan, Italy , Spain, Luxembourg, France	-
Uganda Nile Basin Reforestation Project No 4	Uganda (d)	Japan, Italy , Spain, Luxembourg, France	-
Aberdare Range / Mt. Kenya Small Scale Reforestation Initiative Kirimara-Kithithina Small Scale A/R Project	Kenya (d,+)	Canada, Italy , Luxembourg, France, Japan, Spain	-
Tongdao County Laorongtan Hydropower Station Project	China (a,+)	Italy	-
Biogas Support Program - Nepal Activity-3	Nepal (a,+)	Netherlands, Italy , Finland, Luxembourg, Switzerland, Austria, Germany, Belgium, Spain	-
Fujian Shanghang Jiantou 9.8 MW hydropower Station Project	China (a,+)	Italy	-
Gas-Steam Combined Cycle Power Plant (CCPP) Project of Laiwu Iron & Steel Group Corp.	China (c,+)	Italy	-
India-FaL-G Brick and Blocks Project No.3	India (a,+)	Netherlands, Italy	-
Nam Mo Hydropower Project	Viet Nam (c,+)	Italy	-
Nam Non Hydropower Project	Viet Nam (c,+)	Italy	-
Yunnan Province Deqin County Chunduole Hydropower Station	China (c,+)	Italy	-
Sichuan Province Li County Luganqiao Hydropower Project	China (c,+)	Italy	-
Guodian Weifang Binhai Wind Farm Phase II Project	China (c,+)	Italy	-
Wushan Houxihe Hydropower Station Project	China (c,+)	Italy	-
Ningxia Taiyangshan Windfarm Shenpeng 49.5MW Project	China (c,+)	Italy	-
Xuanen County Shuangxi Hydropower Project	China (c,+)	Italy	-
Ningxia Helanshan Wind-farm (Touguan) Dalisi 49.5MW Wind Power Project	China (c,+)	Italy	-
Fujian Shanghang Huilong 9.9 MW hydropower Station Project	China (a,+)	Italy	-
Aeolis 2011 Wind Parks	Brazil (c,+)	Italy	-
Aeolis Beberibe Wind Park	Brazil (c,+)	Italy	-

Title	Host Parties	Other Parties	Impacts assessment
Yanyuan County Majingzi Hydropower Project	China (a,+)	Italy	-
WISCO 1234# Coke Dry Quenching (CDQ) Waste Heat Recovery for Cogeneration Project in Hubei Province	China (c,+)	Italy	-
Golden Jumping Group 12MWp Solar Power Project	China (a,+)	Italy	-
LFG Recovery and Electricity Production at the Bubanj Landfill Site, Nis, Serbia	Serbia (a,+)	Italy	-
Hydropower Plant Otilovici	Montenegro (a,+)	Italy	-
Shanxi Linfen 2×6MW Coke Oven Gas Power Generation Project	China (c,+)	Italy	-

(a)AMS, Small scale; (b) AM - Large scale; (c) ACM - Consolidated Methodologies; (d) Afforestation/reforestation; (*) project which is included in the UNEP Risoe Centre Database that also is classified as Gold Standard projects (validation); (**) New CDM projects respect to 2010 submission; (+) New CDM projects respect to 2011 submission; CCB= obtained the CCB standards (UNEP Risoe database); CDCF= Community Development Carbon Fund

ANNEX 9: METHODOLOGIES, DATA SOURCES AND EMISSION FACTORS

This appendix shows methodologies, data sources and emission factors used for the Italian greenhouse gas emission inventory.

Table A9.1 Methods, activity data and emission factors used for the Italian Inventory

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: Summary report for methods, activity data and emission factors used (Energy)

GREENHOUSE GAS SOURCE AND SINK	CO ₂				CH ₄				N ₂ O			
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												
Liquid fuels	Yes	T3	NS, PS	CS	Yes	T3	NS, PS	CR, D	Yes	T3	NS, PS	CR, D
Solid fuels	Yes	T3	NS, PS	CS	Yes	T3	NS, PS	CR, D	Yes	T3	NS, PS	CR, D
Gaseous fuels	Yes	T3	NS, PS	CS	Yes	T3	NS, PS	CR, D	Yes	T3	NS, PS	CR, D
Biomass	No				No				No			
Other fuels	Yes	T3	NS, PS	CS	Yes	T3	NS, PS	CR, D	Yes	T3	NS, PS	CR, D
b. Petroleum Refining												
Liquid fuels	Yes	T3	NS, PS	CS	Yes	T3	NS, PS	CR, D	Yes	T3	NS, PS	CR, D
Solid fuels	No				No				No			
Gaseous fuels	Yes	T3	NS, PS	CS	Yes	T3	NS, PS	CR, D	Yes	T3	NS, PS	CR, D
c. Manufacture of Solid Fuels and Other Energy Industries												
Liquid fuels	Yes	T3	NS, PS	CS	Yes	T3	NS, PS	CR, D	Yes	T3	NS, PS	CR, D
Solid fuels	Yes	T3	NS, PS	CS	Yes	T3	NS, PS	CR, D	Yes	T3	NS, PS	CR, D
Gaseous fuels	Yes	T3	NS, PS	CS	Yes	T3	NS, PS	CR, D	Yes	T3	NS, PS	CR, D
2. Manufacturing Industries and Construction												
a. Iron and Steel												

GREENHOUSE GAS SOURCE AND SINK	CO ₂				CH ₄				N ₂ O			
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⁾
Liquid fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
Solid fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
Gaseous fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
b. Non-Ferrous Metals												
Liquid fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
Solid fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
Gaseous fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
c. Chemicals												
Liquid fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
Solid fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
Gaseous fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
Biomass	No				No				No			
Other fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
d. Pulp, Paper and Print												
Liquid fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
Gaseous fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
Biomass	No				No				No			
e. Food Processing, Beverages and Tobacco												
Liquid fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
Gaseous fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
Biomass	No				No				No			
f. Other												
Liquid fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
Solid fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
Gaseous fuels	Yes	T2	NS, PS	CS	Yes	T2	NS, PS	CR, D	Yes	T2	NS, PS	CR, D
Biomass	No				No				No			
3. Transport												

GREENHOUSE GAS SOURCE AND SINK	CO ₂				CH ₄				N ₂ O			
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⁾
a. Civil Aviation												
Aviation gasoline	Yes	T1, T2	NS	CS	No				No			
Jet kerosene	Yes	T1, T2	NS	CS	No				No			
b. Road Transportation												
Gasoline	Yes	COPERT IV	NS, AS	CS	No				No			
Diesel oil	Yes	COPERT IV	NS, AS	CS	No				No			
LPG	Yes	COPERT IV	NS, AS	CS	No				No			
Gaseous fuel	Yes	COPERT IV	NS, AS	CS	No				No			
Biomass	No				No				No			
c. Railways												
Liquid fuels	No				No				No			
d. Navigation												
Gas/Diesel oil	Yes	T1, T2	NS	CS	No				No			
Residual Oil	Yes	T1, T2	NS	CS	No				No			
Gasoline	Yes	T1, T2	NS	CS	No				No			
e. Other Transportation												
Gaseous Fuels	No				No				No			
4. Other Sectors												
a. Commercial/Institutional												
Liquid fuels	Yes	T2	NS	CS	No				No			
Solid fuels	No				No				No			
Gaseous fuels	Yes	T2	NS	CS	No				No			
Biomass	No				No				No			
Other fuels	Yes	T2	NS	CS	No				No			
b. Residential												
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 ₂ O			
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			
Biomass	No				No				No			
c. Agriculture/Forestry /Fisheries												
Liquid fuels	Yes	T2	NS	CS	No				No			
Gaseous fuels	Yes	T2	NS	CS	No				No			
Biomass	No				No				No			
5. Other												
b. Mobile												
Liquid fuels	No				No				No			
B. Fugitive Emissions from Fuels												
1. Solid Fuels												
a. Coal Mining					No							
b. Solid Fuel Transformation					No							
2. Oil and Natural Gas												
a. Oil	Yes	T1, T2	NS	D, CS	No				No			
b. Natural Gas	No				Yes	T1, T2	NS	D, CS				
c. Venting and Flaring	Yes	T2	NS	CS	No				No			
d. Other	Yes	T2	NS	CS	No				No			

Table I -2: Summary report for methods, activity data and emission factors used (Industrial Processes)

GREENHOUSE GAS SOURCE AND SINK	CO ₂				CH ₄				N ₂ O				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																								
1. Cement Production	Yes	T2	NS	CS, PS	No				No															
2. Lime Production	Yes	T2	NS	CS, PS	No				No															
3. Limestone and Dolomite Use	Yes	T2	NS	D, CS, PS	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	No				No				No															
B. Chemical Industry																								
1. Ammonia Production	Yes	T2	NS, PS	PS	No				No															
2. Nitric Acid Production	No				No				Yes	T2	PS	D, PS												
3. Adipic Acid Production	No				No				Yes	T2	PS	D, PS												
4. Carbide Production	No				No				No															
5. Other					No																			
C. Metal Production																								
1. Iron and Steel Production	Yes	T2	NS	CR, CS, PS	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	No				No				No								No				No			

GREENHOUSE GAS SOURCE AND SINK	CO ₂				CH ₄				N ₂ O				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⁾
D. Other Production																								
1. Pulp and Paper	No																							
2. Food and Drink	No																							
E. Production of Halocarbons and SF ₆																								
1. By-product Emissions													No				No				No			
2. Fugitive Emissions													No				No				No			
3. Other													No				No				No			
F. Consumption of Halocarbons and SF ₆																								
1. Refrigeration and Air Conditioning Equipment													Yes	T2	AS	CS	No				No			
2. Foam Blowing													Yes	T2	AS	CS	No				No			
3. Fire Extinguishers													Yes	T2	AS	CS	No				No			
4. Aerosols/ Metered Dose Inhalers													Yes	T2	AS	CS	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													No				No				No			
G. Other													No											

Table I -3: 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 ₂ O			
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	Yes	CR, CS	NS, AS	CR, CS	No				No			
4. Agriculture												
A. Enteric Fermentation in Domestic Livestock					Yes	T1, T2	NS	D, CS				
B. Manure Management					Yes	T1, T2	NS	D, CS	Yes	T2	NS	D, CS
C. Rice Cultivation					No							
D. Agricultural Soils												
1. Direct Soil Emissions					No				Yes	T1, CS	NS	D, CS
2. Pasture, range and paddock manure					No				Yes	T1	NS	D, CS
3. Indirect Emissions					No				Yes	T1	NS	D, CS
F. Field Burning of Agricultural Residues					No				No			

Table I -4: 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 ₂ O			
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												
1. Forest Land remaining Forest Land	Yes	T1, T2, T3	NS	CS	No				No			
2. Land converted to Forest Land	Yes	T1, T2	NS	D, CS	No				No			
B. Cropland												
1. Cropland remaining Cropland	Yes	T1, T2, T3	NS	D, CS	No				No			
2. Land converted to Cropland	Yes	T1	NS	D	No				No			
C. Grassland												
1. Grassland remaining Grassland	Yes	T1, T2, T3	NS	CS	No				No			
2. Land converted to Grassland	Yes	T1	NS	D, CS	No				No			
D. Wetlands												
1. Wetlands remaining Wetlands												
2. Land converted to Wetlands												
E. Settlements												
1. Settlements remaining Settlements												
2. Land converted to Settlements	Yes	T1	NS	D, CS	No				No			
F. Other Land												
1. Other Land remaining Other Land												
2. Land converted to Other Land	No				No				No			
6. Waste												
A. Solid Waste Disposal on Land												
1. Managed Waste Disposal on Land	No				Yes	T2	NS	CS				
2. Unmanaged Waste Disposal Sites	No				Yes	T2	NS	CS				
B. Wastewater Handling												
1. Industrial Wastewater					No				No			
2. Domestic and Commercial Wastewater					Yes	D	NS	D	No			
C. Waste Incineration	No				No				No			

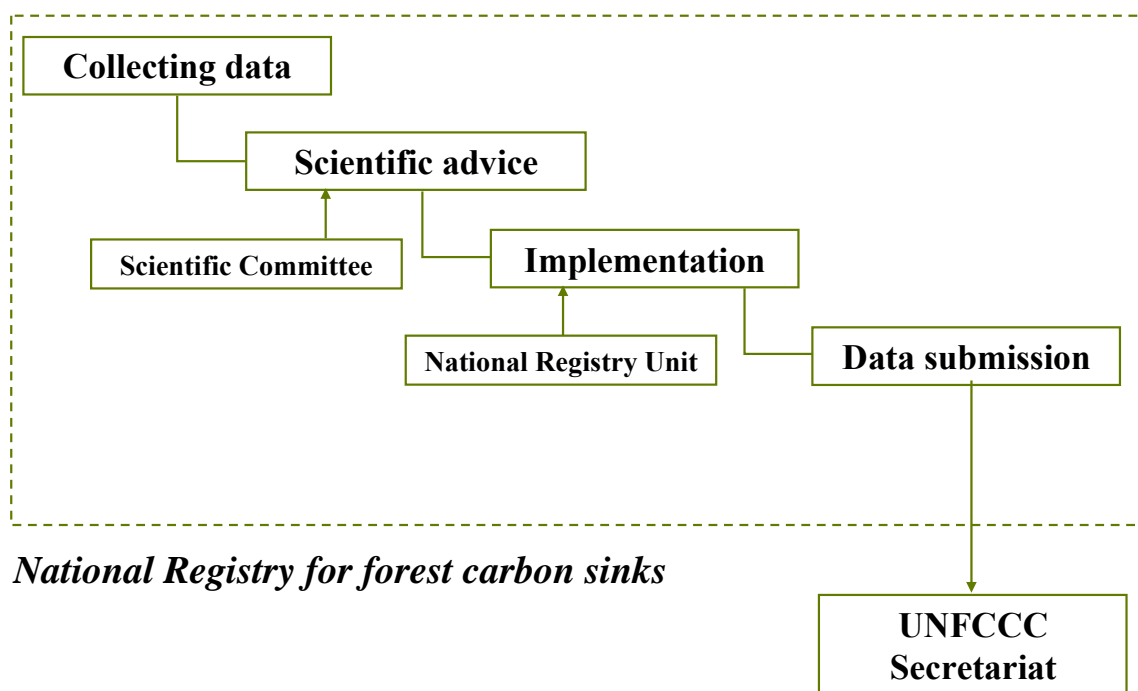
GREENHOUSE GAS SOURCE AND SINK	CO ₂				CH ₄				N ₂ O			
CATEGORIES	Key source ⁽¹⁾	Method applied ⁽²⁾	Activity data ⁽³⁾	Emission factor ⁽⁴⁾	Key source ⁽¹⁾	Method applied ⁽²⁾	Activity data ⁽³⁾	Emission factor ⁽⁴⁾	Key source ⁽¹⁾	Method applied ⁽²⁾	Activity data ⁽³⁾	Emission factor ⁽⁴⁾
D. Other					No							

Legend for tables I -1 to I -4

⁽¹⁾ Key categories of the Italian inventory.												
⁽²⁾ Method applied:												
D (IPCC default),		T1a, T1b, T1c (IPCC Tier 1a, Tier 1b and Tier 1c, respectively),						CR (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)				
⁽³⁾ Activity data used :												
NS (national statistics),				IS (International statistics),				AS (associations, business organizations)				
RS (regional statistics),				PS (Plant Specific data).				Q (specific questionnaires, surveys)				
⁽⁴⁾ Emission factor used:												
D (IPCC default),				CS (Country Specific),								
CR (CORINAIR),				PS (Plant Specific).								

ANNEX 10: THE NATIONAL REGISTRY FOR FOREST CARBON SINKS

The “National Registry for forest carbon sinks” is part of the Italian National System; it is the instrument to estimate, in accordance with the COP/MOP decisions, the IPCC Good Practice Guidance on LULUCF and every relevant IPCC guidelines, the greenhouse gases emissions by sources and removals by sinks in *forest land* and related land-use changes and to account for the net removals in order to allow the Italian Registry to issue the relevant amount of RMUs.



Italy has approved the National Plan for greenhouse gases reduction (PNR_{GHG}) with the CIPE (*Interministerial Economic Planning Committee*) decision n. 123, of 19 December 2002. The PNR_{GHG} sets policies and measures to act in order to achieve the national target of the Kyoto Protocol; Italy has committed to 6.5% reduction below 1990 greenhouse gases emission levels. The article 7.4 of CIPE decision (123/2002) states that Ministry for the Environment, Land and Sea (MATTM), in agreement with Ministry of Agriculture, Food and Forest Policies (MIPAAF) has to constitute, the National Registry for the forest carbon sinks to account for the net removals in the period 2008 – 2012, from *afforestation*, *reforestation* and *deforestation* activities (art. 3.3 KP) and from elected activities under article 3.4 of Kyoto Protocol (*forest management*). The National Registry for Carbon sinks, instituted by a Ministerial Decree on 1st April 2008, is part of National Greenhouse Gas Inventory System in Italy (ISPRA, 2011 [a]) and includes information on units of lands subject of activities under Article 3.3 and activities elected under Article 3.4 and related carbon stock changes. The National Registry for Carbon sinks is the instrument to estimate, in accordance with the COP/MOP decisions, the IPCC Good Practice Guidance on LULUCF and every relevant IPCC guidelines, the greenhouse gases emissions by sources and removals by sinks in forest land and related land-use changes and to account for the net removals in order to allow the Italian Registry to issue the relevant amount of RMUs. In 2009, a technical group, formed by experts from different institutions (ISPRA; Ministry of the Environment, Land and Sea; Ministry of Agriculture, Food and Forest Policies and University of Tuscia), set up the methodological plan of the activities necessary to implement the registry and defined the relative funding. Some of these activities (in particular IUTI, inventory of land use) have been completed, resulting in land use classification, for all national territory, for the years 1990, 2000 and 2008. A process of validation and verification of IUTI data has been put in place and is expected to supply data useful to update and improve the estimations.

Italy, in the “*Report on the determination of Italy’s assigned amount under Article 7, paragraph 4, of the Kyoto Protocol*” (Decision 13/CMP.1), has reported:

- the election of *forest management* as an activity under Article 3.4 of Kyoto Protocol and has adopted the forest definition in agreement with Food and Agriculture Organization of the United Nations definitions, with the following threshold values for tree crown cover, land area and tree height:
 - a. a minimum area of land of 0.5 hectares;
 - b. tree crown cover of 10 per cent;
 - c. minimum tree height of 5 meters.

Italy’s forest area eligible under *forest management* activity is the total forest area, since the entire Italian forest area has to be considered managed.

Following the Decision 8/CMP.2, credits from *forest management* are capped, in the first commitment period, to 2,78 Mt C (10.19 MtCO₂) per year, or 13.9 Mt C (50.97 MtCO₂) the whole commitment period per year.

Italy intends to account for Article 3.3 and 3.4 activities at the end of the commitment period.

Considering that the entire Italian forest area is subject to the *forest management* activity, under Kyoto Protocol, accounting for carbon stocks changes (and the related non-CO₂ emissions) on the national forest area, and on deforested areas, occurring in the first Commitments Period, is required.

The key elements of the accounting system in the National Registry for forest carbon sinks are:

National Land-Use Inventory (IUTI)

aimed at identifying and quantifying:

- *forest land* areas;
- land in conversion from *forest land* category since 31 December 1989;
- land in conversion to *forest land* category since 31 December 1989.

National Inventory of Carbon Stocks (ISCI)

aimed at quantifying:

- carbon stocks and carbon stock changes in any land-use category in the first Commitments Period.

National Census of Forest Fires (CIFI)

aimed at identifying and quantifying:

- *forest land* areas affected by fires.

National Inventory of non-CO₂ emissions from forest fires (IEIF)

aimed at quantifying:

- non-CO₂ emissions from *forest land* areas affected by fires.

National Land-Use Inventory (IUTI)

The National Land-Use Inventory (IUTI) is aimed at identifying the land uses and land-use changes over the national territory. IUTI will supply data concerning areas under *forest land* category (art. 3.4 of KP) and of land in conversion to and from *forest land* categories (art. 3.3 of KP). IUTI is based on a survey of sample points throughout Italian national territory considered as a population of points, and on the classification of the land use coupled with the sampling points. By using on-screen interpretation of digital orthophotos, land use is classified with a high degree of accuracy and precision, as required by IPCC standards. The following set of multi-temporal orthophotos was used as basis of photo-interpretation process:

- 1990, the black and white high resolution full national coverage aerial photography database of TerraItaly⁶⁵ was used to produce orthophotos in scale 1:75.000, spatial resolution of 1 m (the aerial photos, taken on 1988/89, have the same image acquisition standard adopted by USGS-National High Altitude Program at that time: panchromatic film, 400 lines per millimeter);
- 2000, TerraItaly⁶⁶ 2000 dataset, digital color aerial orthophotos with spatial resolution of 1 m;
- 2008, TerraItaly⁶⁷ 2008 dataset, digital color aerial orthophotos with spatial resolution of 0.5 m.

⁶⁵ http://www.cgrit.it/prodotti/voli_italia.html

⁶⁶ <http://www.terraitaly.it/>

⁶⁷ <http://www.terraitaly.it/>

Furthermore, visual interpretation was supported by ancillary information from available thematic forest and land use maps at regional and sub-regional scales.

Time:

IUTI adopts statistical sampling procedures to estimate the area covered by IPCC land use categories in Italy at three points in time (1990, 2008 and 2012). Annual estimates of land uses and land use changes are deduced to provide time-series of the areas devoted to any land-use category and any land-use change subcategory to and from *forest land* use, in the KP reporting. For the first Commitment Period accounting, the time series needed is related to the period 31/12/1989 - 1/1/2013; in particular the 31/12/1989 data are needed for identifying existing forest lands (*Forest Management*, art. 3.4) and setting land reference scenario for *Afforestation*, *Reforestation* and *Deforestation* (art. 3.3).

Space:

The sampling grid and the relative sample plots (1,206,000 sampling points) is uniformly distributed throughout the entire Italian national territory, using a non-aligned systematic sampling. The set of sample points was extracted using a 0.5 km square grid, for a total of about 1,206,000 geo-referenced points randomly located in each square cell and fully covering the Italian territory. A subset of the IUTI sample is represented by the 301,300 first phase sample points of the the national forest inventory (INFC).

Categories and subcategories:

Land use categories (Table A10.1) are defined according to IPCC Good Practice Guidance for LULUCF:

Table A10.1: IUTI classification system

IPCC Category Level I	IUTI Category Level II	IUTI Subcategory Level III	Code
1. Forest land	<i>Woodland</i>		1.1
	<i>Wooded land temporarily unstocked</i>		1.2
	<i>Arable land and other herbaceous cultivations</i>		2.1
2. Cropland		<i>Fruit orchards and plant nurseries</i>	2.2.1
	<i>Arboreal cultivations</i>	<i>Wood product plantations</i>	2.2.2
3. Grassland	<i>Grassland, pastures and uncultivated herbaceous areas</i>		3.1
	<i>Other wooded land</i>		3.2
4. Wetlands	<i>Marshlands and open waters</i>		4
5. Settlements	<i>Urban development</i>		5
6. Other land	<i>Non-productive areas or areas with scarce or absent vegetation</i>		6

Each sample point is photo-interpreted in order to classify the sample into IUTI land use classes at different points in time (1990, 2008 and 2012). For sample points where a land use change in the forest category is detected between 1990 and 2008, as a result of afforestation/reforestation/deforestation activities, the land use classification is performed also in an intermediate point in time (2000), in order to estimate by interpolation the annual gain/loss of forest area in different time periods (1990-2000 and 2000-2008)

Quality assurance/Quality control:

Data supplied by IUTI will be collected in the “*National Registry for the forest carbon sinks*” of Kyoto Protocol, and have to fulfil quality requirements as stated by the IPCC and UNFCCC guidelines. The photointerpreters have been trained through specific courses, in order to ensure a standard photointerpretation approach. In this phase, a particular attention was paid to the presence and distribution of forest formations. In cases of uncertain land use classification of the sample point, an internal expert panel classified the point.

The procedure of quality control has been carried out by an internal expert panel which led a new photointerpretation on a sub-sample of classified points (5%). The control activities have produced the same classification as carried out by the photointerpreters in more than of 95% of the cases.

Classification methodology

The adopted classification methodology ensures that any unit of land could be classified univocally (exclusion of multiple classification of the same unit of land) under a category (exclusion of the null case), by means of:

- a systematic sampling design to select classification points;
- a list of land-use definitions as reported in the IPCC GPG land-use classification;
- a list of land-use indicators able to indicate the presence of a certain use on the land;
- a classification hierarchy to facilitate land use classification (Table A10.2)

Concerning land use classification, the first step is related to a land classification, following artificial land level; the aim is to discriminate between land areas significantly modified by human activity, with an evolution strongly conditioned by prevalently residential and productive activities, and land areas characterized by a high degree of naturalness, in which natural evolution, although conditioned by human action, still exercises a predominant effect in the determination of the prevalent characteristics of the land.

Distinctions are therefore made between urbanized and agricultural territories, and natural and semi-natural territories (forest, pre-forest and herbaceous formations, open water, rocky areas).

At the subsequent levels, the classification process follows the prevalent use of land in the category of artificial territories, while the discriminating element for natural and semi-natural territories is essentially given by the vegetative cover degree, considering canopy, shrub and herbaceous cover.

Table A10.2: Classification hierarchy

A. LAND WITH ITS ORIGINAL CHARACTERISTICS OF PHYSIOGNOMY AND VEGETATION SIGNIFICANTLY MODIFIED BY HUMAN ACTION, CULTIVATED, CLEARED OR SUBJECT TO URBANIZATION WORK, AND DOMINATED BY ANTHROPIC ARTEFACTS DUE TO RESIDENTIAL, INDUSTRIAL, SOCIO-CULTURAL AND AGRICULTURAL ACTIVITIES.

AI. Land occupied by other agricultural cultivations

AI1. Herbaceous cultivations in open fields, subject to regular rotation, for the production of cereals, pulses, other food products or forage.

ARABLE

AI2. Arboreal cultivations not subject to regular rotation, destined permanently to the production of fruit or wood products.

AI2a. Arboreal cultivations destined prevalently to the production of fruit for nutritional purposes (apple orchards, vineyards, olive groves, etc) or for the production of arboreal or shrub species for ornamental purposes

ORCHARDS and NURSERIES

AI2b. Arboreal cultivations destined prevalently to the production of wood products or of woody biomass for energy generation purposes

ARBOREAL CULTIVATIONS FOR WOOD PRODUCTS

II. Areas with residential and industrial buildings and services, transport routes, infrastructures and urban green areas (parks and gardens)

SETTLEMENTS

B. NATURAL OR SEMI-NATURAL LAND NOT SIGNIFICANTLY MODIFIED BY HUMAN ACTION OR IN PHASE OF RENATURALIZATION.

BI. Formations constituted by trees able to reach the height on maturity *in situ* of 5 m, but temporarily lacking in canopy cover following accidental events or anthropic action.

WOODED LAND TEMPORARILY WITHOUT ABOVE-GROUND COVER

BII. Formations constituted by trees able to reach the height on maturity *in situ* of 5 m and procuring a degree of canopy cover on the terrain of $\geq 5\%$.

BII1. Formation with a degree of cover $< 10\%$

OTHER WOODED AREAS

BII2. Formation with a degree of cover $\geq 10\%$

WOODLAND

BIII. Formations never as above

BIII1. Formations constituted by shrubs or trees not able to reach a height on maturity *in situ* of 5 m, and procuring a degree of canopy cover on the terrain of $\geq 10\%$

OTHER WOODED LAND

BIII2. Formations constituted by shrubs or trees not able to reach a height on maturity *in situ* of 5 m and procuring a degree of canopy cover on the terrain of $< 10\%$, and silvi-pastoral formations with canopy cover from trees able to reach a height on maturity *in situ* of 5 m but with cover $< 5\%$

BIII2a. *Natural herbaceous formations of ground species with a degree of herbaceous cover of $\geq 40\%$.*

PASTURES, MEADOWS and UNCULTIVATED HERBACEOUS AREAS

BIII2b. *Natural herbaceous formations with a degree of herbaceous cover of $< 40\%$ or land completely lacking herbaceous cover*

BIII2b1. *Land without vegetation or with sporadic herbaceous vegetation. Rocky outcrops and beaches.*

OTHER LANDS

C. AREAS WITHOUT VEGETATION AND COVERED BY STILL OR FLOWING WATER OR AREAS OCCUPIED BY PARTICULAR ECOSYSTEMS OTHER THAN TERRESTRIAL ECOSYSTEMS (FLOATING VEGETATION, WET VEGETATION, SALTWATER VEGETATION, ETC).

MARSHLANDS AND OPEN WATERS

To achieve land use classification, a 0.5 ha neighbourhood of the sample plot is investigated. The operative procedure consists in digital orthophotos processing, considering sampling points: for each point identified on the territory by coordinates in a known reference system, the land use category, defined according to the classification system, must be established.

A grid, composed of 9 squares (3 x 3) of 2500 m² each, for an overall surface area of 22,500 m² is used. This graphic object, at the centre of which the sampling point must be situated, allows to assess whether area intercepted by the sampling point has an extension equal to or greater than the established threshold (equivalent to the surface area of 2 of the 9 cells displayed).

If the surface area value is very close to the threshold and the use of the cells still leaves doubts, a graphic tool for surface area measurement is used for the classification process. The contour of the polygon containing the sampling point is mapped, computing the extent of the area.

In Figures A10.1, A10.2 and A10.3, examples from land use classification system are reported. In particular, in figure 1 the sampling point is classified as 3.1 Grassland, given that trees covering the sampling point

have a surface area between 500 and 5000 m². In Figure A10.2, the sampling point is classified as 1.1 Woodland, while in Figure A10.3, the sampling point is classified as 3.1 Grassland.

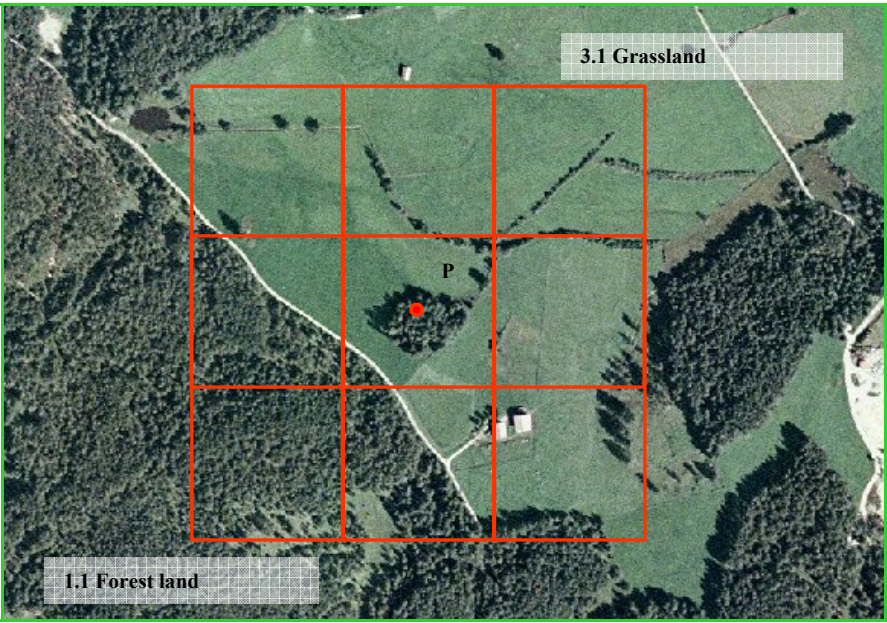


Figure A10.1: Land use classification system - grassland

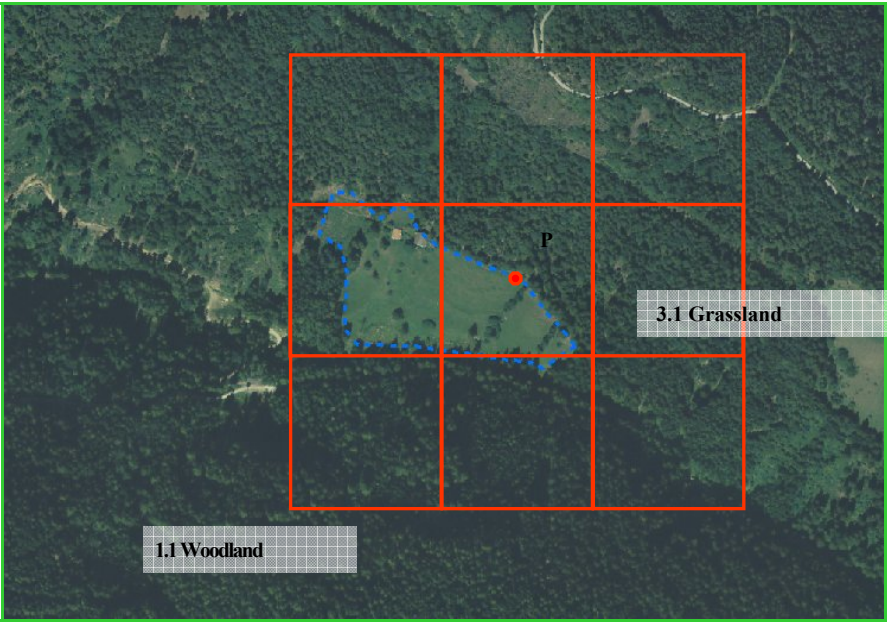


Figure A10.2: Land use classification system - Woodland

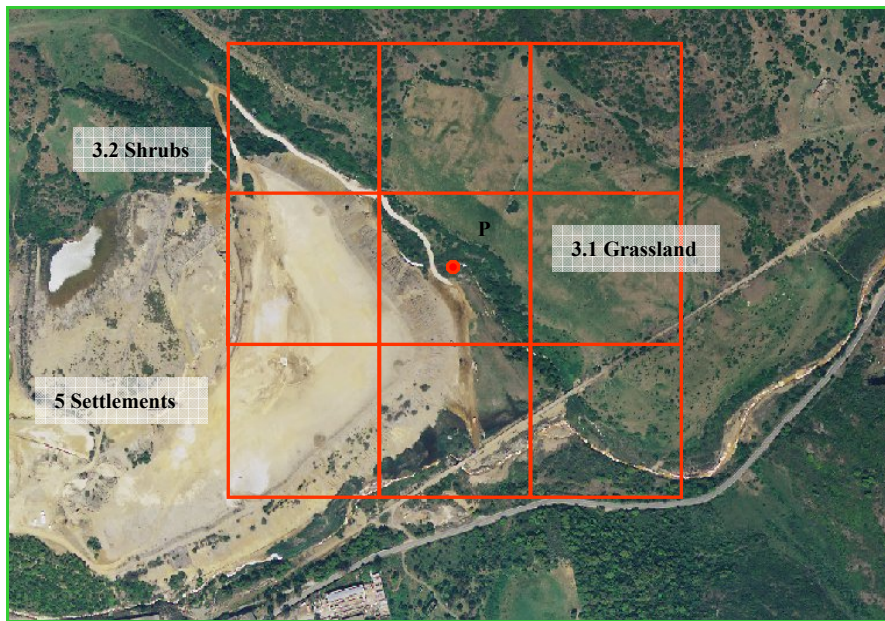


Figure A10.3: Land use classification system – grassland

National Inventory of Carbon Stocks (ISCI)

The National Inventory of the Carbon Stocks is a sampling of carbon stocks related to the different land-use categories.

The National Inventory of the Carbon Stocks includes:

- carbon stock changes in the land-use category forest land, the dataset is derived by the IFN data;
- carbon stock changes in the subcategories of the conversion to or from forest land to other predominant uses, the land in conversion to and from *forest land* to other uses require data integration with studies and additional surveys in order to estimate, at regional level, the C stock levels related to non-forest land uses (i.e. *settlements, cropland, grassland, wetlands*).

Time:

ISCI will annually provide time series of carbon stock levels and carbon stock changes for the category *forest land* and for the sub-categories land in conversion to and from *forest land* to other uses. For the Kyoto Protocol first Commitment Period accounting, the time series needed is related to the period 31/12/2007 - 1/1/2013.

Space:

Concerning the category *forest land* and any other category in conversion to and from *forest land*, the NFIs will assure the spatial coverage, providing carbon stocks data, at NUT2 level.

Quality assurance:

Data supplied by ISCI will be collected in the so-called “*National Registry for the forest carbon sinks*” of Kyoto Protocol, and have to fulfil quality requirements as stated by the IPCC and UNFCCC guidelines.

National Census of Forest Fires (CIFI)

The National Census of Forest Fires is a system aimed to detect, locate and classify *forest land* areas affected by fires; it will provide data on:

- forest areas affected by fires;
- forest typology and stand features;
- proxy parameters in order to estimate the initial C stock and losses by fire (e.g. vegetation height, altitude, slope, exposure).

Time:

CIFI will annually provide, from 01/01/2008, time series of forest areas affected by fires. For the Kyoto Protocol first Commitment Period accounting, the time series needed is related to the period 01/01/2008 - 31/12/2012 (because of the strong variability of the forest fires occurrence no interpolation of data is allowed).

Space:

CIFI will cover all the national territory and will provide geographically referenced data on burned *forest land remaining forest land* areas (art. 3.4) and on *land converted to forest land* burned areas (art. 3.3).

Key elements:

The key elements are:

- ground surveys that have to detect fires and record boundaries of burned areas. Additional data will concern collection of attributes as damage evaluation (percentage of oxidised biomass), forest typology (following NFI classification);
- remote sensed data will integrate data from ground surveys, in order to cross-check detected burned areas, at 0.5 ha spatial definition;
- digital terrain model;
- forest-non forest Boolean mask.

Quality assurance:

Data supplied by CIFI will be collected in the so-called “*National Registry for the forest carbon sinks*” of Kyoto Protocol, and have to fulfil quality requirements as stated by the IPCC and UNFCCC guidelines.

National Inventory of non-CO₂ emissions from forest fires (IEIF)

The Forest fires GHG emissions National Inventory is aimed at estimating non-CO₂ emissions from forest fires (CO₂ emissions are not taken into account, being already computed by National Inventory Carbon Stocks as decreases in carbon stocks). It will provide:

- emission figures of the land-use category *forest land*;
- emission figures of the land-use categories in conversion to or from *forest land* to other predominant uses.

Time:

The Forest fires GHG emissions National Inventory will annually provide time series of non-CO₂ emissions from forest fires. For the Kyoto Protocol first Commitment Period (CP) accounting, the needed time series is related to the period 01/01/2008 - 31/12/2012.

Space: IEIF will supply estimates of emissions released by fires detected by National Census of Forest Fires.

Key elements:

For any fire, once identified the prevalent forest typology and the damage of the stand (i.e. percentage of burned biomass) affected by fire, through the National Forest Service surveys, related carbon stocks are estimated by National Inventory Carbon Stocks. Emissions are calculated applying the damage coefficients and the emissions factors referenced or elaborated by research projects to the estimated carbon stocks.

Quality assurance:

Data supplied by IEIF will be collected in the so-called “*National Registry for the forest carbon sinks*” of Kyoto Protocol, and have to fulfil quality requirements as stated by the IPCC and UNFCCC guidelines.

ANNEX 11: THE NATIONAL REGISTRY

According to Article 7 of the Kyoto Protocol each Party included in Annex I shall incorporate in its annual greenhouse gas inventory the necessary supplementary information for the purposes of ensuring compliance with Article 3 of the Kyoto Protocol.

Supplementary information under article 7, paragraph 1, with regards to units holdings and transactions during the year 2012, is reported in the SEF submission (figures are also included in tables A8.2.2.1 - A8.2.2.5c of this document).

This annex reports supplementary information under article 7, paragraph 2, with regards to the national registry and in accordance with the guidelines set down in Annex I.II of UNFCCC's Decision 22/CP.8.

More detailed information can be found in the relevant annexes that have been submitted to UNFCCC along with this document.

(a) The name and contact information of the registry administrator designated by the Party to maintain the national registry

The Italian Registry is administrated by ISPRA (former APAT) under the supervision of the national Competent Authority for the implementation of the European directive 2003/87/CE, jointly established by the Ministry for Environment, Land and Sea and the Ministry for Economic Development. ISPRA, as Registry Administrator, is responsible for the management and functioning of the Registry, including Kyoto protocol obligations.

The contact person is: Mr Riccardo Liburdi
address: Via Vitaliano Brancati 48 – 00144 Rome – Italy
telephone: +390650072544
fax: +390650072657
e-mail: riccardo.liburdi@isprambiente.it

(b) The names of the other Parties with which the Party cooperates by maintaining their national registries in a consolidated system

As reported in chapter 13, the EU Member States who are also Parties to the Kyoto Protocol (25) plus Iceland, Liechtenstein and Norway decided to operate their registries in a consolidated manner in accordance with all relevant decisions applicable to the establishment of Party registries - in particular Decision 13/CMP.1 and decision 24/CP.8. The consolidated platform which implements the national registries in a consolidated manner (including the registry of EU) is called Consolidated System of EU registries (CSEUR).

(c) A description of the database structure and capacity of the national registry

In 2012, the EU registry has undergone a major redevelopment with a view to comply with the new requirements of Commission Regulation 920/2010 and Commission Regulation 1193/2011 in addition to implementing the Consolidated System of EU registries (CSEUR).

The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission.

During certification, the consolidated registry was notably subject to connectivity testing, connectivity reliability testing, distinctness testing and interoperability testing to demonstrate capacity and conformance to the Data Exchange Standard (DES). All tests were executed successfully and lead to successful certification on 1 June 2012.

(d) A description of how the national registry conforms to the technical standards for data exchange between registry systems for the purpose of ensuring the accurate, transparent and efficient exchange of

data between national registries, the clean development mechanism registry and the transaction log (decision 19/CP.7, paragraph 1)

The overall change to a Consolidated System of EU Registries triggered changes to the registry software and required new conformance testing. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission.

During certification, the consolidated registry was notably subject to connectivity testing, connectivity reliability testing, distinctness testing and interoperability testing to demonstrate capacity and conformance to the Data Exchange Standard (DES). All tests were executed successfully and lead to successful certification on 1 June 2012.

(e) A description of the procedures employed in the national registry to minimize discrepancies in the issuance, transfer, acquisition, cancellation and retirement of ERUs, CERs, tCERs, lCERs, AAUs and/or RMUs, and replacement of tCERs and lCERs, and of the steps taken to terminate transactions where a discrepancy is notified and to correct problems in the event of a failure to terminate the transactions

The overall change to a Consolidated System of EU Registries also triggered changes to discrepancies procedures, as reflected in the updated **manual intervention document** and the **operational plan**. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission.

(f) An overview of security measures employed in the national registry to prevent unauthorized manipulations and to prevent operator error and of how these measures are kept up to date

The overall change to a Consolidated System of EU Registries also triggered changes to security, as reflected in the updated **security plan**. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission.

(g) A list of the information publicly accessible by means of the user interface to the national registry

Non-confidential information required by Decision 13/CMP.1 annex II.E paragraphs 44-48, is publicly accessible through the public website <http://www.info-ets.isprambiente.it>

All required information is provided with the following exceptions:

- paragraph 45(e): representative name and contact information is deemed as confidential according to Annex XVI of the EU Registry Regulation No 916/2007/EC;
- paragraph 46: no Article 6 (Joint Implementation) project is reported as conversion to an ERU under an Article 6 project did not occur in the specified period;
- paragraph 47(a)(d)(f): holding and transaction information is provided on an account type level, due to more detailed information being declared confidential by article 75 of EC Regulation 920/2010 as amended by EC Regulation 1193/2011.

(h) The Internet address of the interface to its national registry

The Italian registry can be accessed at the following URL:

<https://ets-registry.webgate.ec.europa.eu/euregistry/IT/index.xhtml>

A support portal, with news, procedures, documentation, is also available for the public at:

<http://www.info-ets.isprambiente.it>

(i) A description of measures taken to safeguard, maintain and recover data in order to ensure the integrity of data storage and the recovery of registry services in the event of a disaster

The overall change to a Consolidated System of EU Registries also triggered changes to data integrity measures, as reflected in the updated **disaster recovery plan**. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission.

(j) The results of any test procedures that might be available or developed with the aim of testing the performance, procedures and security measures of the national registry undertaken pursuant to the provisions of decision 19/CP.7 relating to the technical standards for data exchange between registry systems.

On 2 October 2012 a new software release (called V4) including functionalities enabling the auctioning of phase 3 and aviation allowances, a new EU ETS account type (trading account) and a trusted account list went into Production. The trusted account list adds to the set of security measures available in the CSEUR. This measure prevents any transfer from a holding account to an account that is not trusted.

ANNEX 12: OVERVIEW OF THE CURRENT SUBMISSION IMPROVEMENTS

During the last UNFCCC review process, some issues were raised which have been taken into account to improve the current submission. Responses to the main recommendations are described in the following table.

Review report para	Subject	Description	Response
26	General Inventory preparation Transparency	<ul style="list-style-type: none"> – Improve the transparency in the energy sector regarding the reporting of fugitive emissions and in the industrial processes sector regarding the trends impacting emissions – Improve the transparency of the reporting on the LULUCF sector, especially the reporting under Article 3, paragraphs 3 and 4, of the Kyoto Protocol 	See response to review report paragraphs 33, 45, 52, 55, 87 and 70
33	Energy – Sector overview	Include the AD and EFs of all biomass fuel consumed in each category of the energy sector and provide more detailed explanations on the estimation of average EFs for biomass fuels in the NIR	Additional information have been supplied in the NIR in the relevant paragraphs, §3.3.3.1, §3.4.3, §3.6.2, §3.6.3.
34	Energy – Sector overview	Further enhance QA/QC efforts in the NIR, including correcting the share of the energy sector in national GHG emissions, clarifying the driver for recalculations, and correcting the trends in iron and steel production	Errors and description of trends have been checked and corrected in the NIR in §3.1, §3.3.3.3, §3.4.2.
35	Energy Reference and sectoral approaches Comparison and international statistics	<ul style="list-style-type: none"> – Include emissions from category other in the estimation of the reference approach manually in the CRF table 1.A(c) and update the difference between the reference approach and sectoral approach 	Waste production data have been included in the reference approach in the category other and differences have been updated (see §3.8.5 of the NIR)
37	Energy Reference and sectoral approaches Comparison and international statistics	<ul style="list-style-type: none"> – Include information on the treatment of refinery feedstocks in the national energy balance, and an explanation on the differences between the inventory data and the IEA data 	Refinery feedstocks exports have been properly included in the reference approach updating exports figure of other relevant liquid fuels (see §3.8.5 of the NIR).
39	Energy Reference and sectoral approaches International bunker fuels	<ul style="list-style-type: none"> – Document the split between domestic and international marine bunkers in the NIR 	Additional information have been included in the NIR (§3.5.4.2). Investigation on differences with IEA data are planned for the future.
40	Energy Reference and sectoral approaches Feedstocks and non-energy use of fuels	<ul style="list-style-type: none"> – Add a note in the CRF table 1A(d) explaining that the fuel quantity refers to the “net” fuel quantity and provide an explanation of what “net quantity” means. – Provide additional explanation in the NIR as to why the fractions of carbon stored in the NIR are different from those included in CRF table 1.A(d). 	Fractions of carbon stored based on gross fuel amount input have been calculated and reported in the CRF table 1.A.(d) (see §3.8.5 of the NIR).
41	Energy – Key categories	<ul style="list-style-type: none"> – Provide a description of the drivers behind the increasing trend of the CO₂ IEF for 	Additional information has been included in §3.3.2.2 of the NIR.

Review report para	Subject	Description	Response
	Stationary combustion:liquid fuels – CO ₂	consumption of liquid fuels in petroleum refining.	
42	Energy – Key categories – Stationary combustion:solid fuels –CH ₄	Provide in the NIR a rationale for the decreasing trend in the CH ₄ IEF in manufacture of solid fuels and other energy industries between 1990 and 2010.	Additional information has been included in §3.3.3.3 of the NIR
43	Energy – Key categories – Stationary combustion:solid fuels –CH ₄	Transparently document in the NIR the rationale for the relatively high CH ₄ IEF for solid fuels in the iron and steel subcategory	Additional information has been included in §3.4.3 of the NIR
44	Energy – Key categories – Stationary combustion:other fuels – CO ₂ , CH ₄ and N ₂ O	Include additional information on which other fuels are used, as well as the quantity of fuel used and their respective EFs in the NIR	Additional information has been included in §3.3.1.1, §3.4.3 , §3.6.2 of the NIR
45	Energy – Key categories - Oil and natural gas – CO ₂ , CH ₄ and N ₂ O	The ERT recommends that Italy further disaggregate oil and natural gas exploration and production, and oil transport and refining/storage, if higher-tier data allow.	The ERT recommendation has been fulfilled. Additional information has been provided in the NIR (§3.9.2).
46	Energy – Key categories -Oil and natural gas – CO ₂ , CH ₄ and N ₂ O	The ERT recommends that, in its next annual submission, Italy use the correct notation key and provide a description in the NIR and in CRF table 9(a).	The notation key has been corrected (§3.9.2 of the NIR).
47	Energy – Non-key categories - Fugitive emissions from solid fuels – CO ₂	The ERT encourages Italy to document the rationale for assuming emissions do not occur and clarify the use of the notation key “NA” for these categories in its next annual submission.	The CO ₂ emissions from mines have been estimated (§3.9.2 of the NIR).
52	Industrial processes - Cement production – CO ₂ - Transparency	The CO ₂ IEF for cement production was constant from 1990 to 2004 (0.54 t/t) and then fluctuated with an overall steady decrease by 1.1 per cent between 2005 and 2010 to 0.53 t/t in 2010. In response to a question raised by the ERT during the review about the decreasing trend, the Party responded that the national cement facilities association (Associazione Italiana Tecnico Economica Cemento) confirmed that for the last decade operators have been committed to the reduction of CO ₂ emissions from their production by producing the types of cement that have a lower clinker demand. The operators have achieved this by partially replacing clinker with different materials (e.g. fine ground carbonates and fly ash). In addition, Italy indicated that the IEF for each plant depends on the quality of the raw material input. The ERT noted that altering the fraction of clinker in cement, while reducing total CO ₂ emissions, should not have an impact on the decreasing IEF, which	Additional information about CO ₂ IEF fluctuations has been provided in the NIR in §4.2.2.

Review report para	Subject	Description	Response
		is based on emissions/t clinker produced. However, the ERT agrees that the quality of the raw material input (e.g. carbonate content) could result in a fluctuating IEF. Therefore, the ERT recommends that the Party further explore the fluctuating IEF and provide information thereon in its next annual submission.	
53	Industrial processes – Iron and steel production – CO ₂	Consistent with the IPCC good practice guidance, Italy provides the energy and carbon balance in the iron and steel category, with a detailed explanation (in annex 3 to the NIR). However, CO ₂ emissions due to the consumption of coke, coal and other reducing agents used in the iron and steel industry have been accounted for as fuel consumption and reported under the energy sector. The IPCC good practice guidance shows a preference for including these emissions under the industrial processes sector rather than the energy sector. Therefore, the ERT encourages Italy to disaggregate the process emissions from iron and steel production and report them under the industrial processes sector in its next annual submission in order to improve transparency.	Italy will consider this suggestion. More explanation has been included in §4.4.2.
54	Industrial processes Production of halocarbons SF6 – PFCs	However, because there is no methodology in the Revised 1996 IPCC Guidelines or the IPCC good practice guidance, the ERT encourages Italy to provide detailed information on the methodology applied for this category in its next annual submission.	Additional information has been provided in the NIR in §4.6.2.
55	Industrial processes Consumption of halocarbons SF6 – SF6	The ERT recommends that, in its next annual submission, the Party provide detailed information on the AD and EFs used for the estimation of emissions by each method, in order to increase transparency and demonstrate time-series consistency.	Additional information has been provided in the NIR in §4.7.2.
68	LULUCF Sector overview	... The ERT recommends that the Party use the new land-use matrix and present any related recalculations in the next annual submission..	As reported in the NIR (§7.1, §7.2.8, §10.3.1.6, Annex 10), the national land-use inventory (IUTI) has been completed for the years 1990, 2000 and 2008. A process of validation and verification of IUTI data is currently ongoing. The new data will be used, in the next submission, to derive land use matrices.
69	LULUCF Sector overview	... Therefore, the ERT agrees that the land use for energy crops should be allocated under cropland. The ERT recommends that Italy provide a clear description of the area	A detailed description related to energy crops included in cropland category is reported in the NIR (§7.2.2, §7.3.2).

Review report para	Subject	Description	Response
		plantations that are not for energy crops and that are reported under forest land in its next annual submission.	
70	LULUCF Forest remaining land - CO ₂	- land forest ... Italy refers in the NIR to the “For-est model”, with reference to an article by Federici et al. (2008). ... the ERT recommends that the Party improve the transparency of its reporting and assess whether values taken from the article should be updated or not and report on this assessment in its next annual submission.	Additional information has been reported in the NIR (§7.2.4, §10.3.1.1).
72	LULUCF Forest remaining land - CO ₂	- land forest Italy reports root-to-shoot ratio in NIR table 7.6, but did not provide documentation on these ratios. ...The ERT recommends that this improved documentation be included in the next annual submission.	Following the ERT’s recommendation, the dead wood mass has been estimated using country specific coefficients, calculated from outcomes of a survey conducted by the Italian national forest inventory (NIR, §7.2.4).
74	LULUCF Cropland remaining cropland – CO ₂	- ... The ERT welcomes this correction in the allocation of organic soils and recommends that the Party implements this correction in the next annual submission.	The ERT’s recommendation has been addressed and the organic soils have been allocated under annual crops subcategory.
75	LULUCF – Land converted to forest land - CO ₂	- ... The ERT recommends that Italy provide transparent documentation on the values used in applying equation 3.2.32 in its next annual submission and reiterates the recommendation in the previous review report that the Party develop a country-specific reference soil carbon content for forest land.	A detailed description of the methodology implemented to to assess carbon stock changes in land converted to forest land and the SOC’s used have been reported in the NIR (§7.2.4).
76	LULUCF – Land converted to cropland - CO ₂	- The ERT recommends that Italy review the 2010 values and provide an explanation for the finalization of the grassland conversion to cropland in 1996.	A detailed description of the land uses and land use changes assessment has been reported in the NIR (§7.1).
77	LULUCF – Land converted to settlements - CO ₂	- ... The ERT recommends that Italy, in its next annual submission improve the documentation on why there is only conversion from grassland for the period 1990-1995.	A detailed description of the land uses and land use changes assessment has been reported in the NIR (§7.1).
78	LULUCF Biomass burning – CH ₄ and N ₂ O	- ... The ERT recommends that Italy review its reporting on biomass burning for its next annual submission especially as another source indicates that about 40 per cent of wild fires occur on land with an agricultural land cover, 20 per cent on forest and other woody land, 35 per cent on nature land, while fewer than 1 per cent of wild fires occur in settlements.	Emissions from fires occurring in other land use categories (i.e. cropland, grassland and settlements) have been estimated (NIR, §7.12.1).
83	Waste – Solid waste disposal on land – CH ₄	- The ERT noted that information regarding the amount of waste disposed to managed and unmanaged landfill sites was included in this annual submission, consistent with recommendations in the previous review report. Italy has explained in the NIR that the amount of solid waste disposed to unmanaged landfills was estimated as a function of the waste disposed to managed	Additional information has been provided in the NIR (§ 8.2.2)

Review report para	Subject	Description	Response
		landfills on the basis of different studies; however, the ERT noted that the explanation does not include details about how this relationship was determined from these studies. The ERT also noted that the relationship is not constant over time: in 1990 the amount of waste disposed to unmanaged landfills represented 28.0 per cent of all non-hazardous waste disposed to landfills, while in 1995 this percentage was 18.8 per cent. The ERT recommends that Italy provide more information regarding these historical data in its next annual submission.	
84	Waste - Solid waste disposal on land – CH ₄	As noted in the previous review report, the methane generation constant (k), which is based on a foreign study and considered by Italian national experts to be representative of Italian conditions, does not result from experimental data in Italy, and the ERT noted that the NIR still does not provide sufficient documentation to support the application of these values to the Italian conditions. The ERT encourages Italy to provide more explanation and documentation to support the use of the chosen values for this parameter in its next annual submission. Further, the ERT noted that, on the basis of the foreign study, Italy used a different (k) value for 1990 (0.46) when compared with that used for the rest of the time series (0.36). In response to questions raised by the ERT during the review, Italy explained that the average (k) value is calculated on the basis of waste composition, so as waste composition changed the average (k) value changed over different time periods (1971–1990, 1991–2005 and 2006–2030). The ERT recommends that Italy include the explanation provided during the review in the NIR of its next annual submission.	Additional information has been provided in the NIR (§ 8.2.2).
85	Waste Wastewater handling – CH ₄ and N ₂ O	Italy calculated the CH ₄ emissions from wastewater handling using the IPCC tier 2 methodology, applying IPCC default EF values owing to the lack of country-specific data. Recalculations have been performed in the category as a result of updated AD. The ERT encourages Italy to further explore country-specific EFs to improve the accuracy of the inventory in its next annual submission.	Italy will consider this suggestion
86	Waste Wastewater handling – CH ₄ and N ₂ O	N ₂ O emissions from human sewage were calculated according to the IPCC good practice guidance methodology based on population and protein per capita intake. Italy has used protein consumption data from the Food and Agriculture Organization	Additional information has been provided in the NIR (§ 8.3.2).

Review report para	Subject	Description	Response
		of the United Nations (FAO). N ₂ O emissions from industrial wastewater were estimated using EFs from EMEP/CORINAIR (2007). The ERT encourages Italy to further explore country-specific EFs to increase the accuracy of the inventory in its next annual submission.	
87	Waste - Waste incineration – CO ₂ , CH ₄ and N ₂ O	The NIR does not clearly describe where the energy recovery from waste incineration was included under the energy sector (see para. 44 above). In the NIR it is stated that energy recovery is included under the energy sector in the category other sectors (commercial/institutional). In response to requests from the ERT during the review for further clarification, Italy explained that biogas emissions recovered from landfills and used for energy purposes were reported under the category other sectors (commercial/institutional) – biomass. The ERT noted that the value presented in NIR table 8.31 for CO ₂ emissions from waste incineration reported under the energy sector (4,651 Gg CO ₂ eq) matches the value reported under other fuels, not that reported in the category other sectors (commercial/institutional) – biomass. The ERT recommends that Italy improve the transparency of its reporting of the total amount of CO ₂ emissions from waste incineration used for energy purposes that is included under the energy sector in its next annual submission.	Additional information has been provided in the NIR (§ 8.2.2 and § 8.4.3).
88	Waste – Other waste – CH ₄	The CH ₄ emissions from composting in Italy have been estimated using an EF from international literature (0.029 g CH ₄ /kg waste); however, there is no explanation provided in the NIR to support the application of this EF to the Italian conditions. The ERT encourages Italy to include an explanation regarding the selection of the EF used to estimate CH ₄ emissions from composting in its next annual submission.	Additional information has been provided in the NIR (§ 8.5.2)
94	Supplementary information required under Article 7.1 of the KP – Overview	... the ERT recommends that Italy provide documentation in the NIR on the inclusion of forestry plantations under KP-LULUCF activities and explain why the information reported in the CRF tables is different from that reported to the FAO, as required by paragraph 16 of the annex to decision 16/CMP.1.	A description of the forest definition and its implementation in Italian context has been provided in the NIR (§10.1.1). Additional information is also reported in §7.2.2.
96	Supplementary information required under Article 7.1 of the KP - Activities under Article 3.3, of the	The ERT therefore recommends that, in its next annual submission, Italy provide better documentation to prove the areas of natural afforestation and reforestation activities on abandoned agricultural lands that are directly human-induced, or exclude the natural afforestation and reforestation on	A description of legislative Italian context and the consequent implications for the direct human induced afforestation and reforestation activities has been provided in the NIR (§10.4.1).

Review report para	Subject	Description	Response
	KP -Afforestation and reforestation - CO ₂	these lands from its accounting under Article 3, paragraph 3, of the Kyoto Protocol.	
98	Supplementary information required under Article 7.1 of the KP - Activities under Article 3.3, of the KP - Afforestation and reforestation - CO ₂	The ERT noted that Italy continues to estimate the carbon stock changes in mineral soils using a linear relationship with the aboveground biomass that is not clearly documented by the Party and has high uncertainty. The ERT reiterates the recommendation in the previous review report that the Party provide transparent documentation in its next annual submission.	In the NIR (§10.3.1.2) a detailed description of the methods and data used to estimate soils carbon stocks (and the consequent carbon stock changes) is reported. These SOC's have been used to assess the carbon stock changes in AR activities. For the next submission, the implementation of INFC data related to the soils survey to estimate litter and soils pools is foreseen.
99	Supplementary information required under Article 7.1 of the KP - Activities under Article 3.3, of the KP - Afforestation and reforestation - CO ₂	... The ERT therefore recommends that Italy estimate carbon stock changes in dead wood using country-specific methods and parameters, in line with the IPCC good practice guidance for LULUCF, and provide this information in its next annual submission.	The ERT's recommendation has been addressed and the dead wood mass has been estimated using country specific coefficients, calculated from outcomes of a survey conducted by the Italian national forest inventory (NIR, §10.3.1.6, §7.2.4).
100	Supplementary information required under Article 7.1 of the KP - Activities under Article 3.4 of the KP - Deforestation - CO ₂	The ERT recommends that Italy provide clear documentation on the emissions from deforested plantations that meet the forest definition in its next annual submission.	A description of the forest definition and its implementation in Italian context has been provided in the NIR (§10.1.1). Additional information is also reported in §7.2.2.
102	Supplementary information required under Article 7.1 of the KP - Activities under Article 3.4 of the KP - Forest management - CO ₂	...the ERT recommends that Italy develop country-specific methods and parameters to estimate carbon stock changes in dead wood in line with the IPCC good practice guidance for LULUCF and provide this information in its next annual submission.	The ERT's recommendation has been addressed and the dead wood mass has been estimated using country specific coefficients, calculated from outcomes of a survey conducted by the Italian national forest inventory (NIR, §10.3.1.6, §7.2.4).
103	Supplementary information required under Article 7.1 of the KP - Activities under Article 3.4 of the KP - Forest management - CO ₂	... the ERT recommends that Italy provide clear documentation on the inclusion of forestry plantations in the reporting on forest management in its next annual submission.	A description of the forest definition and its implementation in Italian context has been provided in the NIR (§10.1.1). Additional information is also reported in §7.2.2.