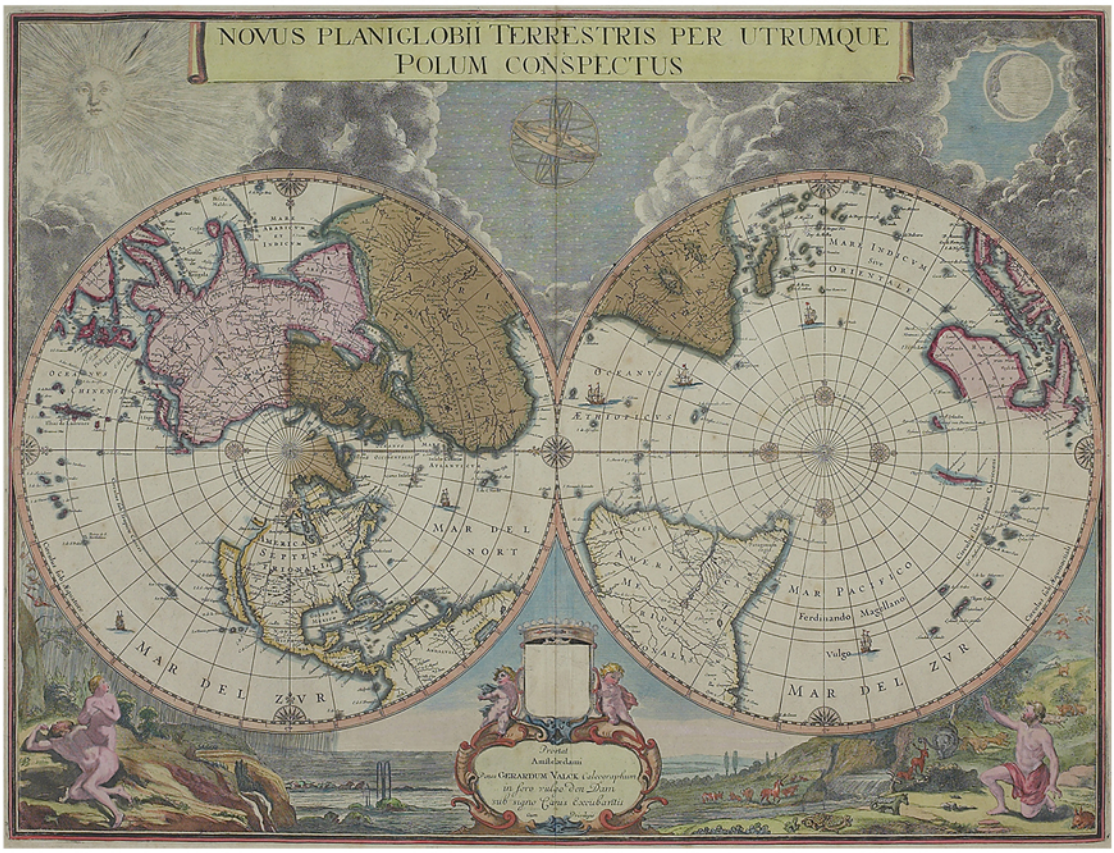
ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

Sistema Nazionale per la Protezione dell'Ambiente

RAPPORTI

Italian Greenhouse Gas Inventory 1990 - 2016

National Inventory Report 2018



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Rapporti 283/2018

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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-serra.

A garantire la predisposizione e l'aggiornamento annuale dell'inventario dei gas-serra secondo i formati richiesti, in Italia, è l'ISPRA 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.

In più, come è previsto dalla Convenzione-quadro sui cambiamenti climatici per tutti i Paesi industrializzati, l'ISPRA documenta in uno specifico rapporto, 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 a economia in transizione (JI).

Il presente documento rappresenta, inoltre, un riferimento fondamentale per la pianificazione e l'attuazione di tutte le politiche ambientali da parte delle istituzioni centrali e periferiche. Accanto all'inventario dei gas-serra, l'ISPRA realizza ogni anno l'inventario nazionale delle emissioni in atmosfera, richiesto dalla Convenzione di Ginevra sull'inquinamento atmosferico transfrontaliero (UNECE-CLRTAP) e dalle Direttive europee sulla limitazione delle emissioni. In più, tutto il territorio nazionale è attualmente coperto da inventari regionali sostanzialmente coerenti con l'inventario nazionale, realizzati principalmente dalle Agenzie Regionali e Provinciali per la Protezione dell'Ambiente.

Nonostante i progressi compiuti, l'attività di preparazione degli inventari affronta continuamente nuove sfide legate alla necessità di considerare nuove sorgenti e nuovi inquinanti e di armonizzare gli inventari prodotti per diverse finalità di *policy*. Il contesto internazionale al quale fa riferimento la preparazione dell'inventario nazionale costituisce una garanzia di qualità dei dati, per l'autorevolezza dei riferimenti metodologici, l'efficacia del processo internazionale di *review* e la flessibilità nell'adattamento alle nuove circostanze.

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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. The first commitment period ended in 2012, with an extension, for fulfilling commitments, to 18th November 2015, the so called *true-up period*. The evaluation of the Kyoto Protocol, together with the commitments fulfilled by each Party, has been finalized by the UNFCCC Secretariat.

A new global agreement was reached in Paris in December 2015, for the period after 2020. The agreement aims to strengthen the global response to the treat of climate change by holding the increase in the global temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impact of climate change. On 5 October 2016, the threshold for entry into force of the Paris Agreement was achieved and the Paris Agreement entered into force on 4 November 2016.
To fulfil the gap 2013-2020, the 'Doha Amendment to the Kyoto Protocol' was adopted on 8 December 2012.
The EU and its Member States have committed to this second phase of the Kyoto Protocol and established to reduce their collective emissions to 20% below their levels in 1990 or other chosen base years; this is also reflected in the Doha Amendment. The target will be fulfilled jointly with Iceland.

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, decision 24/CP.19, in FCCC/CP/2013/10/Add.3.
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 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 2018, including the update for the year 2016 and the revision of the entire time series 1990-2015.

Concerning the reporting and accounting requirements, under the KP CP2 each Party is required to submit a report, the initial report, to facilitate the calculation of its assigned amountand to demonstrate its capacity to account for its emissions and assigned amount (UNFCC Decision 2/CMP.8). The ratification decision allows a joint initial report of the EU, its Member States and Iceland, to be prepared by the European Commission, and individual initial reports of each Member States and Iceland. In its initial report, Italy describes the national assigned amount as well as the commitment period reserve.
The election of LULUCF activities under Article 3, paragraph 4, of the Kyoto Protocol for the commitment period 2013-2020 is also indicated in the same document; Italy has decided to elect cropland and grazing land management activities.
Emission estimates comprise the seven direct greenhouse gases under the Kyoto Protocol (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride, nitrogen trifluoride) 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/sia-ispra/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/10566.php.

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

Total greenhouse gas emissions, in CO_2 equivalent, excluding emissions and removals from land use, land use change and forestry, decreased by 17.5% between 1990 and 2016 (from 518 to 428 millions of CO_2 equivalent tons).
The most important greenhouse gas, CO_2, which accounted for 81.9% of total emissions in CO_2 equivalent in 2016, showed a decrease by 20.4% between 1990 and 2016. CH_4 and N_2O emissions were equal to 10.0% and 4.2%, respectively, of the total CO_2 equivalent greenhouse gas emissions in 2016. Both gases showed a decrease from 1990 to 2016, equal to 11.1% and 32.1% for CH_4 and N_2O, respectively.
Other greenhouse gases, HFCs, PFCs, SF_6 and NF_3, ranged from 0.01% to 3.4% of total emissions.
Table ES.1 illustrates the national trend of greenhouse gases for 1990-2016, expressed in CO_2 equivalent terms, by substance and category.

Table ES.1. Total greenhouse gas emissions and removals in CO_2 equivalent [Gg CO_2 eq]

GHG emissions	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
						Gg CO_2 equivalent					
CO_2 excluding net CO_2 from LULUCF	439,944	451,979	470,768	495,234	424,873	413,432	391,990	363,400	348,476	355,483	350,323
CO_2 including net CO_2 from LULUCF	434,595	429,231	453,502	466,752	393,234	387,139	372,256	329,721	314,121	319,310	319,245
CH_4 excluding CH_4 from LULUCF	48,236	50,311	50,737	48,206	46,769	45,123	45,724	44,046	43,132	43,133	42,870
CH_4 including CH_4 from LULUCF	49,719	50,657	51,669	48,565	47,126	45,693	46,936	44,236	43,475	43,424	43,266
N_2O excluding N_2O from LULUCF	26,423	27,231	28,374	27,799	19,057	18,450	19,066	18,145	17,627	17,636	17,954
N_2O including N_2O from LULUCF	27,246	28,059	29,053	28,413	19,699	19,124	19,826	18,703	18,213	18,192	18,710
HFCs	444	869	2,479	7,089	11,356	12,242	12,860	13,479	14,091	14,468	14,682
PFCs	2,907	1,492	1,488	1,940	1,520	1,661	1,499	1,705	1,564	1,688	1,629
SF_6	410	681	605	550	394	441	445	421	359	441	377
NF_3	NA,NO	77	13	33	20	28	25	26	28	28	28
Total (excluding LULUCF)	**518,363**	**532,640**	**554,464**	**580,851**	**503,989**	**491,378**	**471,609**	**441,222**	**425,277**	**432,878**	**427,862**
Total (including LULUCF)	**515,321**	**511,066**	**538,809**	**553,343**	**473,349**	**466,329**	**453,846**	**408,291**	**391,852**	**397,552**	**397,935**

GHG categories	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
						Gg CO_2 equivalent					
1. Energy	425,499	439,343	459,130	480,163	417,157	404,666	387,038	359,961	345,100	352,536	347,080
2. Industrial Processes and Product Use	40,473	38,292	39,161	46,710	36,357	36,613	33,771	32,825	32,399	32,282	32,098
3. Agriculture	35,078	34,992	34,259	32,083	30,065	30,329	30,916	29,747	29,243	29,435	30,394
4. LULUCF	-3,043	-21,574	-15,655	-27,509	-30,640	-25,049	-17,763	-32,930	-33,425	-35,326	-29,927
5. Waste	17,313	20,013	21,914	21,895	20,410	19,769	19,883	18,689	18,535	18,625	18,290
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

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 2016, of 81.1%. Emissions from this sector decreased by 18.4% from 1990 to 2016. Substances with decrease rates were CO_2, whose levels reduced by 18.2% from 1990 to 2016 and accounts for 96.5% of the total in the energy sector, and CH_4 which showed a reduction of 32.2% but its share out of the sectoral total is only 2.2%; N_2O, also, showed a decrease of 2.6% from 1990 to 2016, accounting for 1.3%. Specifically, in terms of total CO_2 equivalent, an increase in emissions was observed in the transport sector, about 2.4%, from 1990 to 2016; in 2016 this sector accounted for 30.1% of total energy sector emissions.
For the industrial processes sector, emissions showed a decrease of 20.7% from 1990 to 2016. Specifically, by substance, CO_2 emissions account for 46.0% and showed a decrease by 49.8%, CH_4 decreased by 63.1%, but it accounts only for 0.1%, while N_2O, whose levels share 1.8% of total industrial emissions, decreased by 92.0%. 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 mineral and metal production emissions. A considerable increase was observed in F-gases emissions (about 344.5%), whose level on total sectoral emissions is 52.1%. 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 years.
For agriculture, emissions refer mainly to CH_4 and N_2O levels, which account for 62.1% and 36.1% of the sectoral total, respectively; CO_2, on the other hand, shares only 1.8% of the total. The decrease observed in the total emissions (-13.4%) is mostly due to the decrease of CH_4 emissions from enteric fermentation (-9.4%), which account for 46.2% of sectoral emissions and to the decrease of N_2O from agricultural soils (-14.8%), which accounts for 29.1% of sectoral emissions.
As regards land use, land-use change and forestry, from 1990 to 2016 total removals in CO_2 equivalent increased considerably; CO_2 accounts for almost the total emissions and removals of the sector (96.4%).
Finally, emissions from the waste sector increased by 5.6% from 1990 to 2016, mainly due to an increase in the emissions from solid waste disposal on land (11.6%), which account for 74.5% of waste emissions. The most important greenhouse gas in this sector is CH_4 which accounts for 89.1% of the sectoral emissions and shows an increase of 5.2% from 1990 to 2016. N_2O emission levels increased by 43.9%, whereas CO_2 decreased by 81.3%; these gases account for 10.4% and 0.5% in the sector, respectively.
Table ES.2 provides an overview of the CO_2 equivalent emission trends by IPCC source category.

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

Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
						Gg CO_2 equivalent					
1A. Energy: fuel combustion	**412,622**	**427,216**	**448,312**	**470,783**	**408,316**	**395,954**	**378,452**	**351,440**	**337,049**	**344,986**	**339,860**
CO_2: 1. Energy Industries	136,447	140,989	148,817	160,591	133,397	132,015	127,678	108,208	99,602	105,199	103,785
CO_2: 2. Manufacturing Industries and Construction	91,713	90,001	90,762	82,313	61,372	60,264	54,555	50,544	51,544	49,876	46,955
CO_2: 3. Transport	100,240	111,418	121,297	126,446	113,872	112,849	105,298	102,645	107,449	104,837	103,379
CO_2: 4. Other Sectors	76,101	75,799	79,182	92,595	90,659	83,297	82,782	81,663	70,594	77,005	77,809
CO_2: 5. Other	1,071	1,496	837	1,233	652	515	335	585	573	459	515
CH_4	2,449	2,716	2,471	2,290	3,153	2,382	3,033	3,104	2,803	3,010	2,931
N_2O	4,600	4,797	4,945	5,315	5,211	4,633	4,772	4,690	4,484	4,599	4,485
1B2. Energy: fugitives from oil & gas	**12,877**	**12,127**	**10,818**	**9,381**	**8,841**	**8,712**	**8,586**	**8,521**	**8,052**	**7,551**	**7,221**
CO_2	4,014	3,971	3,236	2,537	2,622	2,615	2,528	2,702	2,501	2,574	2,483
CH_4	8,852	8,144	7,570	6,830	6,207	6,086	6,047	5,810	5,541	4,967	4,728
N_2O	12	12	12	13	12	11	11	10	9	10	9
2. Industrial processes	**40,473**	**38,292**	**39,161**	**46,710**	**36,357**	**36,613**	**33,771**	**32,825**	**32,399**	**32,282**	**32,098**
CO_2	29,385	27,338	25,904	28,772	21,783	21,336	18,052	16,370	15,678	15,000	14,761
CH_4	129	134	73	74	60	66	63	51	48	42	48
N_2O	7,199	7,701	8,599	8,251	1,224	838	827	773	631	613	574
HFCs	444	869	2,479	7,089	11,356	12,242	12,860	13,479	14,091	14,468	14,682
PFCs	2,907	1,492	1,488	1,940	1,520	1,661	1,499	1,705	1,564	1,688	1,629
SF_6	410	681	605	550	394	441	445	421	359	441	377
NF_3	NA,NO	77	13	33	20	28	25	26	28	28	28
3. Agriculture	**35,078**	**34,992**	**34,259**	**32,083**	**30,065**	**30,329**	**30,916**	**29,747**	**29,243**	**29,435**	**30,394**
CO_2: Liming	1	1	2	14	18	25	16	14	12	14	12
CO_2: Urea application	465	512	525	507	335	351	551	450	411	425	527
CH_4: Enteric fermentation	15,497	15,319	15,048	13,709	13,530	13,542	13,521	13,684	13,577	13,696	14,039
CH_4: Manure management	3,934	3,749	3,733	3,612	3,603	3,458	3,424	3,161	3,063	3,095	3,106
CH_4: Rice Cultivation	1,876	1,989	1,656	1,752	1,822	1,805	1,789	1,661	1,613	1,668	1,710
CH_4: Field Burning of Agricultural Residues	15	15	15	16	15	15	16	15	15	16	17
N_2O: Manure management	2,889	2,690	2,641	2,443	2,384	2,300	2,278	2,134	2,062	2,084	2,122
N_2O: Agriculture soils	10,396	10,713	10,636	10,026	8,352	8,829	9,318	8,623	8,486	8,434	8,857
N_2O: Field Burning of Agricultural Residues	4	4	4	4	4	4	4	4	4	4	4
4A. Land-use change and forestry	**-3,043**	**-21,574**	**-15,655**	**-27,509**	**-30,640**	**-25,049**	**-17,763**	**-32,930**	**-33,425**	**-35,326**	**-29,927**
CO_2	-5,349	-22,748	-17,266	-28,482	-31,639	-26,292	-19,735	-33,679	-34,355	-36,173	-31,078
CH_4	1,483	346	933	359	357	570	1,212	190	344	291	396
N_2O	823	828	679	614	642	674	760	558	586	556	756

Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
						Gg CO_2 equivalent					
6. Waste	**17,313**	**20,013**	**21,914**	**21,895**	**20,410**	**19,769**	**19,883**	**18,689**	**18,535**	**18,625**	**18,290**
CO_2	507	454	204	226	162	165	197	219	112	94	95
CH_4	15,483	18,244	20,171	19,922	18,379	17,769	17,831	16,560	16,471	16,639	16,292
N_2O	1,323	1,315	1,538	1,746	1,869	1,836	1,856	1,911	1,952	1,892	1,903
Total emissions (with LULUCF)	***515,321***	***511,066***	***538,809***	***553,343***	***473,349***	***466,329***	***453,846***	***408,291***	***391,852***	***397,552***	***397,935***
Total emissions (without LULUCF)	***518,363***	***532,640***	***554,464***	***580,851***	***503,989***	***491,378***	***471,609***	***441,222***	***425,277***	***432,878***	***427,862***

ES.4. Other information

In Table ES.3 NO_X, CO, NMVOC and SO_2 emission trends from 1990 to 2016 are summarised.
All gases showed a significant reduction in 2016 as compared to 1990 levels. The highest reduction is observed for SO_2 (-93.5%), while CO and NO_X emissions reduced by about 68.0% and 63.1% respectively; NMVOC levels showed a decrease by 54.7%.

Table ES.3. Total emissions of indirect greenhouse gases and SO_2 (1990-2016) [Gg]

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
						Gg					
NO_X	2,072	1,947	1,495	1,286	979	940	882	823	808	786	764
CO	7,209	7,256	4,854	3,448	3,076	2,436	2,671	2,502	2,268	2,377	2,309
NMVOC	1,996	2,028	1,590	1,338	1,117	1,027	1,019	992	926	918	904
SO_2	1,784	1,323	756	410	218	196	178	147	132	124	116

Sommario (Italian)

Nel documento “Italian Greenhouse Gas Inventory 1990-2016. National Inventory Report 2018” 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, i rapporti *National Inventory Report*, 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/10566.php.

La serie storica nazionale delle emissioni è anche disponibile sul sito web all’indirizzo: http://www.sinanet.isprambiente.it/it/sia-ispra/serie-storiche-emissioni .

Da un’analisi di sintesi della serie storica dei dati di emissione dal 1990 al 2016, si evidenzia che le emissioni nazionali totali dei sei gas serra, espresse in CO_2 equivalente, sono diminuite del 17.5% nel 2016 rispetto al 1990. In particolare, le emissioni complessive di CO_2 sono pari all’81.9% del totale e risultano nel 2016 inferiori del 20.4% rispetto al 1990. Le emissioni di metano e di protossido di azoto sono pari a circa il 10.0% e 4.2% del totale, rispettivamente, e presentano andamenti in diminuzione sia per il metano (-11.1%) che per il protossido di azoto (-32.1%). Gli altri gas serra, HFC, PFC, SF_6 e NF_3, hanno un peso complessivo sul totale delle emissioni che varia tra lo 0.01% e il 3.4%; le emissioni degli HFC evidenziano una forte crescita, mentre le emissioni di PFC decrescono e quelle di SF_6 e NF_3 mostrano un lieve incremento. Sebbene tali variazioni non sono risultate 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 (UNFCC) which was approved in New York on 9th May 1992 and signed during the summit of the Earth in Rio the Janeiro in June 1992. Parties to the Convention are committed to develop, publish and regularly update national emission inventories of greenhouse gases (GHGs) as well as formulate and implement programmes addressing anthropogenic GHG emissions. Specifically, Italy ratified the convention through law no.65 of 15/1/1994.
On 11/12/1997, Parties to the Convention adopted the Kyoto Protocol, which establishes emission reduction objectives for Annex B Parties (i.e. industrialised countries and countries with economy in transition) in the period 2008-2012. In particular, the European Union as a whole was 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, 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.
The first commitment period ended in 2012, with an extension, for fulfilling commitments, to 18th November 2015, the so called *true-up period*. The evaluation of the Kyoto Protocol, together with the commitments fulfilled by each Party, has been finalized by the UNFCCC Secretariat.

A new global agreement was reached in Paris in December 2015, for the period after 2020. The agreement aims to strengthen the global response to the treat of climate change by holding the increase in the global temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impact of climate change. In order to achieve this long-term temperature goal, Parties aim to reach global peaking of GHG emissions as soon as possible and undertake rapid reductions so as to achieve a balance between antropogenic emissions by sources and removals by sinks in the second half of this century. Each Party shall prepare, communicate and mantain successive nationally determined contributions that it intends to achieve. On 5 October 2016, the threshold for entry into force of the Paris Agreement was achieved (at least 55 Parties to the Convention accounting in total for at least an estimated 55 percent of the total global greenhouse gas emissions, where "total global greenhouse gas emissions" means the most up-to-date amount communicated on or before the date of adoption of the Agreement). The Paris Agreement entered into force on 4 November 2016.

To fulfil the gap 2013-2020, the 'Doha Amendment to the Kyoto Protocol' was adopted on 8 December 2012. The amendment includes:

- New commitments for Annex I Parties to the Kyoto Protocol who agreed to take on commitments in a second commitment period from 1 January 2013 to 31 December 2020;
- A revised list of greenhouse gases (GHG) to be reported on by Parties in the second commitment period; and
- Amendments to several articles of the Kyoto Protocol which specifically referenced issues pertaining to the first commitment period and which needed to be updated for the second commitment period.

During the second commitment period, Parties committed to reduce GHG emissions by at least 18 percent below 1990 levels in the eight-year period from 2013 to 2020; however, the composition of Parties in the second commitment period is different from the first.

The EU and its Member States have committed to this second phase of the Kyoto Protocol and established to reduce their collective emissions to 20% below their levels in 1990 or other chosen base years; this is also reflected in the Doha Amendment. The target will be fulfilled jointly with Iceland.
In line with the Council's conclusions of 9 March 2012 and the offer of the Union and its Member States to take on an 80% target under the second commitment period, the emission levels of the Member States are equal to the sum of the annual emission allocations (AEA) for the period 2013-2020 determined pursuant to Decision No 406/2009/EC of the European Parliament and of the Council. That amount, based on global warming potential values from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, was determined under Annex II to Commission Decision 2013/162/EU and adjusted by Commission Implementing Decisions 2013/634/EU and 2017/1471/EU. The emission level for Iceland was determined in the Agreement with Iceland.
Member States are allowed certain flexibility in meeting their AEAs: overachievement in a given year can be carried over to subsequent years, up to 2020, and an emission allocation of up to 5% during 2013-2019 may be carried forward from the following year (Article 3.2 of the Decision). Moreover, during 2013-2019 Member States may transfer part of their AEA for a given year to other Member States under certain conditions (Articles 3.4 and 3.5) and international credits can be used under certain quantitative and qualitative conditions (Article 5). In complying with the commitments of the Effort Sharing Decision, Italy used the flexibility of carrying over the surplus of AEAs for the years 2013, 2014 and 2015. In the period 2013-2017 Italy made no use of project credits and performed no transfers of AEAs to other Member States, therefore no specific information is reported according to Annex XIV and XV of Implementing Regulation 2014/749/EU.
The European Council adopted on 13 July 2015 the legislation necessary for the European Union to formally ratify the second commitment period of the Kyoto Protocol.
The Council adopted two decisions:

- Council Decision on the ratification of the Doha amendment to the Kyoto Protocol establishing the second commitment period, and
- Council Decision on the agreement between the EU, its Member States and Iceland, necessary for the joint fulfilment of the second commitment period of the Kyoto Protocol.

In parallel with the ratification by the EU, the Member States and Iceland will be finalising their national ratification processes. The EU, its Member States and Iceland are expected to simultaneously deposit their respective instruments of acceptance with the UN in the coming months.

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; IPCC, 2014; EMEP/CORINAIR, 2007; EMEP/EEA, 2016).
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/CP/2013/10/Add.3, Decision 24/CP.19. An analysis of the 2016 Italian GHG emission inventory, and a revision of the entire time series from 1990, communicated in the framework of the annual submission under the Climate Change Convention and the Kyoto Protocol, is provided in the document. It is also the annual submission to the European Commission in the framework of the Greenhouse Gas Monitoring Mechanism.

Concerning the reporting and accounting requirements, under the KP CP2 each Party is required to submit a report, the initial report, to facilitate the calculation of its assigned amount and to demonstrate its capacity to account for its emissions and assigned amount (UNFCC Decision 2/CMP.8). The ratification decision allows a joint initial report of the EU, its Member States and Iceland, to be prepared by the European Commission, and individual initial reports of each Member States and Iceland.
In its Initial Report, Italy specified its national assigned amount as well as the commitment period reserve. The election of cropland and grazing land management activities under Article 3, paragraph 4, of the Kyoto Protocol for the commitment period 2013-2020 is indicated in the same document.

Emission estimates comprise the six direct greenhouse gases under the Kyoto Protocol (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride) plus nitrogen trifluoride (NF_3) 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/sia-ispra/serie-storiche-emissioni.
Information on accounts, legal entities, Art.6 projects, holdings and transactions is publicly available at: http://www.info-ets.isprambiente.it/index.php?p=publicinfo.
The 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/10566.php .

The present document is the official submission, for the year 2018, under the UNFCCC and the Kyoto Protocol.
Nevertheless, it has to be noted that CRF reporter still contains some inconsistencies which may be present in the reporting tables due to software functionality.

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. This decision is updated by Decision 24/CP19, which calling the system national inventory arrangements does not change the basic requests of functionality and operability.
In addition, the Decision of the European Parliament and of the Council concerning a mechanism for monitoring Community greenhouse gas emissions (EC, 2004) 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 lands subject to activities under Article 3.3 and 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 Service 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, following the COP/MOP decisions and in accordance with the IPCC guidelines, greenhouse gases emissions by sources and removals by sinks in the land subject to art. 3.3 and art. 3.4 activities and to account for the net removals in order to allow the Italian Registry to issue the relevant amount of RMUs. Following the Ministerial Decree of 22.01.2013 by the Ministry of Environment, Land and Sea (MATTM), in agreement with the Ministry of Agriculture, Food and Forest Policies, the Institute for Services on Agricultural and Agro-food Market (ISMEA[1]) has been designated for the technical coordination of the section related to cropland and grazing land management of the National Registry of Carbon Sinks.
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.

Moreover, in the context of the Kyoto Protocol committments and its amendment ('Doha amendment') for the second Commitment Period (2013-2020), Italy adopted, in 2016, the Law N. 79/2016, "Ratification of the Doha amendment to the Kyoto Protocol", which establishes, according to article 12 of 525/2013/EU (the Monitoring Mechanism Regulation), the National system for policies, measures and emissions projections. ISPRA is also responsible of this system and, in cooperation with IMELS, collects all the information and data from the competent Ministries. Article 1 of the Decree implementing law N. 79 (9th December 2016), reports the list of information and data that are to be sent by the competent ministries to IMELS and ISPRA and also the timing for providing such information. With the establishment of this system, there has been a strenghthening of roles and obligations for statistical data flow, some of which are useful for the inventory scope.

The Italian National System, currently in place, is fully described in the document 'National Greenhouse Gas Inventory System in Italy' (ISPRA, 2016). 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/sia-ispra/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.
ISPRA is responsible for the general administration of the inventory and all aspects related to its preparation preparation, reporting and quality management. Activities include the collection and processing of data from

[1] ISMEA is a public body, providing support to public and private sector. According to DPR 31 March 2001, n. 200, ISMEA is part of the National Statistical System – SISTAN and of the National Agricultural Information System – SIAN.

different data sources, the selection of appropriate emissions factors and estimation methods consistent with the IPCC Guidelines, 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 information and data publication, primary to ISPRA for carrying out estimates. These institutions are part of the National Statistical System (Sistan), which periodically provides official statistics at national level; moreover, the National Statistical System ensures the homogeneity of the methods used for official statistics 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 approved the three-year plan for 2017-2019, updated for 2018 and 2019 (GU Serie Generale n.66, 20/03/2018). 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, 2016). 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. Several activities have been implemented and carried out; in particular IUTI (inventory of land use, see Annex 10) has been completed, resulting in land use classification, for all national territory, for the years 1990, 2000 and 2008. For 2012, land use and land use changes data were assessed through the survey on a IUTI's subgrid. Verification and validation activities have been undertaken and the resulting time series have been discussed with the institutions involved in the data providing; details are provided in paragraph 6.1.
Italy has elected cropland management (CM) and grazing land management (GM) as additional activities under Article 3.4. Following Decision 2/CMP.7, the forest management (FM) has to be compulsorily accounted for as an activity under Article 3.4.
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.

1.2.3 National Registry System

In March 2006 Italy started operating a national registry under Article 19 of Directive 2003/87/EC of the European Commission establishing the European Emission Trading Scheme (EU ETS). This registry was conceived for the administration of emissions allowances allocated to operators participating to the EU ETS and it has been developed according to the UN Data Exchange Standards document. As a consequence, in October 2008, after an initialization process and a go-live phase with the UNFCCC, the registry established under Directive 2003/87/CE also became part of the Kyoto system of registries, ensuring the precise tracking of holdings, issuances, transfers, cancellations and retirements of allowances and Kyoto units.

The consolidated platform which implements the national registries in a consolidated manner (including the registry of the EU) is called the Union registry 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 is fulfilled by each Party through a publically available web page hosted by the Union registry;
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 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 Union registry, the 28 national registries concerned were re-certified in June 2012 and switched over to their new national registry on 20 June 2012. Croatia was migrated and consolidated as of 1 March 2013. During the go-live process, all relevant transaction and holdings data were migrated to the Union registry platform and the individual connections to and from the ITL were re-established for each Party.

A complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of the EU and all consolidating national registries. This description includes:

- Readiness questionnaire
- Application logging
- Change management procedure
- Disaster recovery
- Manual Intervention
- Operational Plan
- Roles and responsibilities
- Security Plan
- Time Validation Plan
- Version change Management

The documents above are annexed to the National Inventory Report submission for year 2013.

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.

With regards to the administration of the Registry, the Italian Government adopted Legislative Decree N. 30 of 13 March 2013 (eventually modified by Legislative Decree N. 111 of 12 July 2015) which enforces European Directive 2009/29/EC amending Directive 2003/87/EC. According to this Decree ISPRA is responsible for the administration of the national section of the Union Registry and the Kyoto National Registry; the Institute performs this task under the supervision of the national Competent Authority.
The Decree 30/2013 also establishes that the economic resources for the technical and administrative support of the Registry will be supplied to ISPRA by account holders paying a fee. The amount of such a fee has been regulated by Ministerial Decree of 25th July 2016.

ISPRA set up an operational unit for the administration of the National Registry. In the reporting period, six persons have been working for this unit in order to maintain the Registry:

- chief of the unit (also responsible for security issues);
- employees in charge of Registry functions and operations, resolution of problems, implementation in the Registry of deliberations of Competent Authority, documents and procedures arrangement, helpdesk and support to users, reporting;
- employees dedicated to documentation archiving and some administrative tasks.

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 10, while information on changes in the National Registry is reported in Chapter 12.
SEF tables including all data referring to units holdings and transactions during the year 2017 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 studies 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 supported by national experiences and circumstances.

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

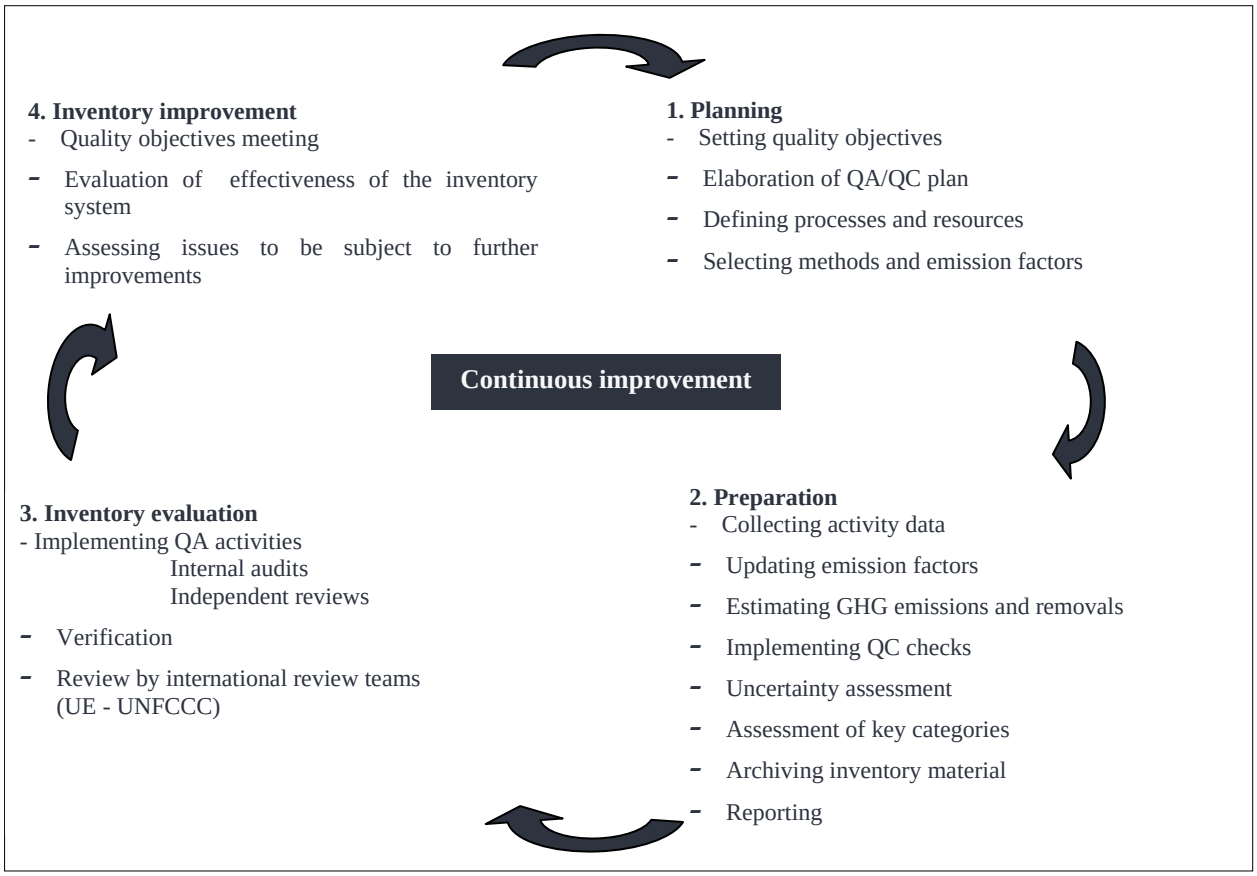

Figure 1.1 National Greenhouse Gas Inventory: annual inventory process

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 available on website at the address http://www.sinanet.isprambiente.it/it/sia-ispra/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 and EMEP/EEA Guidebooks (IPCC, 1997; IPCC, 2006; IPCC, 2000; IPCC, 2003; EMEP/CORINAIR, 2007; EMEP/EEA, 2016); 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.

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 2016, is included in Annex 9.

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

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 CATEGORIES	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6		Unspecified mix of		NF_3	
	Method applied	Emission factor	Method applied	Emission factor	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	T1,T2,T3	CS,D	T1,T2,T3	CR,CS,D,M	T1,T2,T3	CR,D,M										
A. Fuel combustion	T1,T2,T3	CS,D	T1,T2,T3	CR,D,M	T1,T2,T3	CR,D,M										
1. Energy industries	T3	CS	T3	CR,D	T3	CR,D										
2. Manufacturing industries a	T2	CS	T2	CR,D	T2	CR,D										
3. Transport	T1,T2,T3	CS,D	T1,T2,T3	CR,M	T1,T2,T3	CR,M										
4. Other sectors	T2	CS	T2	CR	T2	CR										
5. Other	T2	CS	T2	CR	T2	CR										
B. Fugitive emissions from fuels	T1,T2	CS,D	T1,T2	CR,CS,D	T1	D										
1. Solid fuels			T1,T2	CR,D												
2. Oil and natural gas	T1,T2	CS,D	T1,T2	CR,CS,D	T1	D										
C. CO_2 transport and storage																
2. Industrial processes	CR,CS,T1,T2	CR,CS,D,M,PS	D,T1	CR,CS,D	CS,T2	CS,D,PS	CS,T2	CS,D,PS	CS,T2	CS,PS	CS,T2	CS,PS			T2	CS
A. Mineral industry	T2	CS,PS														
B. Chemical industry	T2	CR,PS	D,T1	CR,CS,D	T2	D,PS	CS	PS	CS	PS						
C. Metal industry	T2	CR,CS,PS	D	CS,D			T2	PS								
D. Non-energy products from fuels and solvent use	CR,CS,T1,T2	CR,CS,D,M,PS														
E. Electronic industry							T2	CS	T2	CS	T2	CS			T2	CS
F. Product uses as ODS substitutes							T2	CS,D								
G. Other product manufacture and use					CS	CS					CS,T2	CS,PS				
H. Other																
3. Agriculture	T1	D	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[3]					CS,T1	CS,D										
E. Prescribed burning of savannas																
F. Field burning of agricultural residues			T1	CS,D	T1	CS,D										
G. Liming	T1	D														
H. Urea application	T1	D														
I. Other carbon-containing fertilizers																
J. Other																
4. Land use, land-use change and fores	T1,T2,T3	CS,D	T1,T2	CS,D	T1,T2	CS,D										
A. Forest land	T1,T2,T3	CS,D	T2	CS,D	T2	CS,D										
B. Cropland	T1,T2	CS,D	T1	D	T1	D										
C. Grassland	T1,T2,T3	CS,D	T1	CS	T1	CS										
D. Wetlands																
E. Settlements	T1	D			T1	D										
F. Other land																
G. Harvested wood products	T2	CS														
H. Other																
5. Waste	D	CS	D,T1,T2	CR,CS,D	D,T1	CR,CS,D										
A. Solid waste disposal			T2	CS												
B. Biological treatment of solid waste			D	CS,D	D	D										
C. Incineration and open burning of waste	D	CS	D,T1	CR,CS,D	D,T1	CR,CS,D										
D. Waste water treatment and discharge			T1	D	T1	CR,D										
E. Other																
6. Other ***(as specified in summary 1.A)***																

Use the following notation keys to specify the method applied:
D (IPCC default) **T1a, T1b, T1c** (IPCC Tier 1a, Tier 1b and Tier 1c, respectively) **CR** (CORINAIR) **M** (model)
RA (Reference Approach) **T2** (IPCC Tier 2) **CS** (Country Specific)
T1 (IPCC Tier 1) **T3** (IPCC Tier 3) **OTH** (Other)
If using more than one method within one source category, list all the relevant methods. Explanations regarding country-specific methods, other methods or any modifications to the default IPCC methods, as well as

Use the following notation keys to specify the emission factor used:
D (IPCC default) **CS** (Country Specific) **OTH** (Other)
CR (CORINAIR) **PS** (Plant Specific) **M** (model)

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 commitee. 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, 2009).
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. In any case, 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. For solvents, the amount of solvent use is provided by environmental publications of sectoral industries and specific associations as well as international statistics.
ISPRA directly collects data from the industrial associations under the ETS and other European directives, Large Combustion Plant and 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 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.

As for data disclosure, the inventory team is obliged to ensure confidentiality of sensitive information by legislation when data are communicated under specific directives or confidentiality is requested by data providers. In the case of data collection under the ETS, P-RTR, large combustion plants and other directives, the database of the complete information is available only to a specific group of authorised persons which has the legal responsibility for the respect of confidentiality issues. In other cases, each expert is responsible for the data received, and confidentiality. In any case, all data are placed on a password protected access environment at ISPRA and available only to authorised experts of the inventory team.

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 and used 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).
Following 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, 28 sources were individuated implementing Approach 1, whereas 31 sources were carried out by Approach 2. Including the LULUCF in the analysis, 35 categories were selected by Approach 1 and 35 by Approach 2. The description of these categories is shown in Table 1.3 and Table1.4.

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

Key categories (excluding the LULUCF sector)	
Chemical industry - CO_2 Ammonia production	L1
Chemical industry - N_2O Adipic acid production	L
Chemical industry - N_2O Nitric acid production	L1
Chemical industry - PFCs Fluorochemical production	L2
Direct N_2O Emissions from Managed soils	L
Energy industries - CO_2 gaseous fuels	L
Energy industries - CO_2 liquid fuels	L
Energy industries - CO_2 solid fuels	L
Enteric Fermentation - CH_4	L
Fugitive - CH_4 Oil and natural gas - Natural gas	L
Fugitive - CO_2 Oil and natural gas – Oil	L1
Fugitive - CO_2 Oil and natural gas - Other - flaring in refineries	L2
Fugitive - CO_2 Oil and natural gas - venting and flaring	L2
Indirect N_2O Emissions from Managed soils	L
Indirect N_2O Emissions from Manure Management	L2
Manufacturing industries and construction - CO_2 gaseous fuels	L
Manufacturing industries and construction - CO_2 liquid fuels	L
Manufacturing industries and construction - CO_2 solid fuels	L
Manufacturing industries and construction - N_2O liquid fuels	L2
Manure Management - CH_4	L
Manure Management - N_2O	L
Metal industry - CO_2 Iron and steel production	L1
Metal industry - PFCs Aluminium production	L
Mineral industry - CO_2 Cement production	L

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

Key categories (excluding the LULUCF sector)	
Mineral industry - CO_2 Lime production	L1
Mineral industry - CO_2 Other processes uses of carbonates	L1
Non-Energy products from Fuels and Solvent Use - CO_2	L2
Other sectors - CH_4 commercial, residential, agriculture biomass	L2
Other sectors - CO_2 commercial, residential, agriculture gaseous fuels	L
Other sectors - CO_2 commercial, residential, agriculture liquid fuels	L
Other sectors - N_2O commercial, residential, agriculture liquid fuels	L2
Rice cultivations - CH_4	L1
Solid waste disposal - CH_4	L
Transport - CH_4 Road transportation	L2
Transport - CO_2 Road transportation	L
Transport - CO_2 Waterborne navigation	L1
Transport – N_2O Road transportation	L2
Wastewater treatment and discharge - CH_4	L
Wastewater treatment and discharge - N_2O	L2

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

Key categories (including the LULUCF sector)	
Chemical industry - CO_2 Ammonia production	L1
Chemical industry - N_2O Adipic acid production	L
Chemical industry - N_2O Nitric acid production	L1
Chemical industry - PFCs Fluorochemical production	L2
Cropland Remaining Cropland - CO_2	L
Direct N_2O Emissions from Managed soils	L
Energy industries - CO_2 gaseous fuels	L
Energy industries - CO_2 liquid fuels	L
Energy industries - CO_2 solid fuels	L
Enteric Fermentation - CH_4	L
Forest Land remaining Forest Land - CO_2	L
Fugitive - CH_4 Oil and natural gas - Natural gas	L
Fugitive - CO_2 Oil and natural gas – Oil	L1
Fugitive - CO_2 Oil and natural gas - venting and flaring	L2
Grassland Remaining Grassland - CH_4	L2
Grassland Remaining Grassland - CO_2	L
Indirect N_2O Emissions from Managed soils	L
Indirect N_2O Emissions from Manure Management	L2
Land Converted to Cropland - CO_2	L2
Land Converted to Forest Land - CO_2	L
Land Converted to Grassland - CO_2	L2
Land Converted to Settlements - CO_2	L
Land Converted to Settlements - N_2O	L2
Manufacturing industries and construction - CO_2 gaseous fuels	L
Manufacturing industries and construction - CO_2 liquid fuels	L
Manufacturing industries and construction - CO_2 solid fuels	L
Manufacturing industries and construction - N_2O liquid fuels	L2
Manure Management - CH_4	L
Manure Management - N_2O	L1
Metal industry - CO_2 Iron and steel production	L1
Metal industry - PFCs Aluminium production	L1
Mineral industry - CO_2 Cement production	L
Mineral industry - CO_2 Lime production	L1
Mineral industry - CO_2 Other processes uses of carbonates	L1
Non-Energy products from Fuels and Solvent Use - CO_2	L
Other sectors - CH_4 commercial, residential, agriculture biomass	L2
Other sectors - CO_2 commercial, residential, agriculture gaseous fuels	L
Other sectors - CO_2 commercial, residential, agriculture liquid fuels	L
Other sectors - N_2O commercial, residential, agriculture liquid fuels	L2
Rice cultivations - CH_4	L1
Solid waste disposal - CH_4	L
Transport - CO_2 Civil Aviation	L1
Transport - CO_2 Road transportation	L
Transport - CO_2 Waterborne navigation	L1
Wastewater treatment and discharge - CH_4	L
Wastewater treatment and discharge - N_2O	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

Applying the analysis to the 2016 inventory, without the LULUCF sector, 44 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 2016

Key categories (excluding the LULUCF sector)	
Biological treatment of Solid waste - N_2O	L2,T2
Chemical industry - CO_2 Ammonia production	T1
Chemical industry - HFCs Fluorochemical production	T2
Chemical industry - N_2O Adipic acid production	T
Chemical industry - N_2O Nitric acid production	T
Chemical industry - PFCs Fluorochemical production	L,T
Direct N_2O Emissions from Managed soils	L, T2
Energy industries - CO_2 gaseous fuels	L,T
Energy industries - CO_2 liquid fuels	L,T
Energy industries - CO_2 solid fuels	L,T
Enteric Fermentation - CH_4	L,T
Fugitive - CH_4 Oil and natural gas - Natural gas	L,T
Fugitive - CO_2 Oil and natural gas - Oil	L1,T2
Indirect N_2O Emissions from Managed soils	L
Indirect N_2O Emissions from Manure Management	L2
Manufacturing industries and construction - CO_2 gaseous fuels	L,T1
Manufacturing industries and construction - CO_2 liquid fuels	L1,T
Manufacturing industries and construction - CO_2 solid fuels	L,T
Manufacturing industries and construction - N_2O liquid fuels	T2
Manure Management - CH_4	L
Metal industry - CO_2 Iron and steel production	T1
Metal industry - PFCs Aluminium production	T
Mineral industry - CO_2 Cement production	L,T
Mineral industry - CO_2 Lime production	L1
Mineral industry - CO_2 Other processes uses of carbonates	T1
Non-Energy products from Fuels and Solvent Use - CO_2	L2,T2
Other sectors - CH_4 commercial, residential, agriculture biomass	L,T
Other sectors - CO_2 commercial, residential, agriculture gaseous fuels	L,T
Other sectors - CO_2 commercial, residential, agriculture liquid fuels	L,T
Other sectors - CO_2 commercial, residential, agriculture other fossil fuels	L1,T
Other sectors - CO_2 commercial, residential, agriculture solid fuels	T1
Other sectors - N_2O commercial, residential, agriculture biomass	L2,T
Other sectors - N_2O commercial, residential, agriculture liquid fuels	L2
Product uses as substitutes for ozone depleting substances - HFCs Fire protection	L,T
Product uses as substitutes for ozone depleting substances - HFCs Foam blowing agents	L2,T2
Product uses as substitutes for ozone depleting substances - HFCs Refrigeration and Air conditioning	L,T
Rice cultivations - CH_4	L1
Solid waste disposal - CH_4	L,T
Transport - CH_4 Road transportation	T2
Transport - CO_2 Civil Aviation	L1,T1
Transport - CO_2 Road transportation	L,T
Transport - CO_2 Waterborne navigation	L1
Wastewater treatment and discharge - CH_4	L,T2
Wastewater treatment and discharge - N_2O	L2,T2

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

If considering emissions and removals from the LULUCF sector, 47 key categories were individuated as reported in Table 1.6.

Table 1.6 Key categories (including LULUCF) by the IPCC IPCC Approach 1 and Approach 2. Year 2016

Key categories (including the LULUCF sector)	
Biological treatment of Solid waste - N_2O	T2
Chemical industry- CO_2 Ammonia production	T1
Chemical industry- N_2O Adipic acid production	T
Chemical industry- N_2O Nitric acid production	T1
Chemical industry- PFCs Fluorochemical production	L,T
Cropland Remaining Cropland - CO_2	L,T2
Direct N_2O Emissions from Managed soils	L,T
Energy industries - CO_2 gaseous fuels	L,T
Energy industries - CO_2 liquid fuels	L,T
Energy industries - CO_2 solid fuels	L,T
Enteric Fermentation- CH_4	L,T
Forest Land remaining Forest Land - CO_2	L,T
Fugitive - CH_4 Oil and natural gas - Natural gas	L,T
Fugitive - CO_2 Oil and natural gas - Oil	L1
Grassland Remaining Grassland - CH_4	T2
Grassland Remaining Grassland - CO_2	L2,T
Harvest Wood Products - CO_2	T
Indirect N2O Emissions from Managed soils	L
Land Converted to Cropland - CO_2	L2
Land Converted to Forest Land - CO_2	L,T
Land Converted to Grassland - CO_2	L,T
Land Converted to Settlements - CO_2	L,T
Land Converted to Settlements - N_2O	L2
Manufacturing industries and construction - CO_2 gaseous fuels	L,T1
Manufacturing industries and construction - CO_2 liquid fuels	L1,T
Manufacturing industries and construction - CO_2 solid fuels	L1,T
Manure Management - CH_4	L
Metal industry - CO_2 Iron and steel production	T1
Metal industry - PFCs Aluminium production	T1
Mineral industry - CO_2 Cement production	L,T
Mineral industry - CO_2 Lime production	L1
Mineral industry - CO_2 Other processes uses of carbonates	T1
Other sectors - CH_4 commercial, residential, agriculture biomass	L,T
Other sectors - CO_2 commercial, residential, agriculture gaseous fuels	L,T
Other sectors - CO_2 commercial, residential, agriculture liquid fuels	L,T
Other sectors - CO_2 commercial, residential, agriculture other fossil fuels	L1,T1
Other sectors - N_2O commercial, residential, agriculture biomass	L2,T
Product uses as substitutes for ozone depleting substances - HFCs Fire Protection	L,T
Product uses as substitutes for ozone depleting substances - HFCs Foam blowing agents	T2
Product uses as substitutes for ozone depleting substances - HFCs Refrigeration and Air conditioning	L,T
Rice cultivations - CH_4	L1
Solid waste disposal - CH_4	L,T
Transport - CO_2 Civil Aviation	L1,T1
Transport - CO_2 Road transportation	L,T
Transport - CO_2 Waterborne navigation	L1
Wastewater treatment and discharge - CH_4	L
Wastewater treatment and discharge - N_2O	L2,T2

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

Key category analysis for KP-LULUCF was performed according to section 2.3.6 of the 2014 IPCC KP Supplement (IPCC, 2014). Results are also reported in Table 9.16 of chapter 9.
CO_2 emissions and removals from *Afforestation/Reforestation* and *Deforestation* activities (art. 3.3) and from *Forest management* (art. 3.4) have been assessed as key categories. CO_2 emissions and removals from *Cropland* and *Grazing land management* are identified as key categories. Their figures have been compared with Table 1.6, key categories for the latest reported year (2016) based on the level of emissions including LULUCF. The respective associated UNFCCC subcategories are *Land converting to forest land*, *Land converted to settlements*, and *Forest land remaining Forest land*, which are key categories at level and trend assessment, as well as *Cropland remaining cropland* and *Grassland remaining grassland*.

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 IPCC Guidelines 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, activities have been planned and are on going 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 (ISPRA, 2013) 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, 2018 [b]). These documents are publicly available at ISPRA website http://www.sinanet.isprambiente.it/it/sia-ispra/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 CO_2 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 registred in the ‘reference’ database.
General QC procedures also include data and documentation gathering. Specifically, the inventory analyst for a source category maintains a complete and separate project archive for that source category; the archive includes all the materials needed to develop the inventory for that year and is 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.gov.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.
ISPRA is also responsible for the provincial inventory at local scale; at now the provincial inventories at local scale for the years 1990, 1995, up to 2015 are available. 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 have 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/sia-ispra/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 context 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.
Moreover, from 2011, a report concerning the state of implementation of commitments to reduce greenhouse gases emissions, and describing emission trend and projections, is prepared by the Ministry of the

Environment in consultation with other relevant Ministers. The report is annexed to the economy and financial document (DEF) to be annually approved by the Government.

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 UNFCC 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 last in country review occurred in 2013 (UNFCC, 2013). In 2017, Italy was not subjected to a UNFCCC review and the last review report is related to the 2016 inventory; results of this last review are reported the document 'FCCC/ARR/2016/ITA' (UNFCCC, 2017). Details on the review processes and implementation of recommendations are described 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 was carried out in 2012 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. In 2016 another comprehensive review of Member States' inventories was carried out for the compliance years 2013 and 2014, and for the years 2005, 2008, 2009 and 2010. Also, in 2017, a detailed review of the Italian inventory was conducted. Following the main relevant recommendations, revision of the estimates were implemented.

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).
In 2007, 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 indentify 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'.
Also, in 2012, Italy was subjected to a broad review of its environmental performance by OECD which identified good practices and made recommendations to improve environmental policies and programmes; the issues reviewed included policy-making environment, towards green growth, multi-level environmental governance of water and climate change. Results of the analysis are reported in the relevant document (OECD, 2013) and available on website at the address http://www.oecd.org/env/country-reviews/reviewingenvironmentalperformance.htm.

A bilateral independent review between Italy and Spain was undertaken in 2012, with a focus on the revision of the GHG inventories of both the Parties. Two in-country visits were held in 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 reported in a technical report. 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), and use of plant specific information.

In addition, an official independent review of the entire Italian greenhouse gas inventory was undertaken by the Aether consultants in 2013. Main findings and recommendations are reported in a final document, and regard mostly the transparency in the NIR, the improvement of QA/QC documentation and some pending issues in the LULUCF sector. These suggestions have been considered to improve the future submissions.

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, 2018 [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 and WG5 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.

Additional consistency checks of data are carried out in the context of the European Regulation No 525/2013. EU Member States shall report in textual and tabular format on data inconsistencies.
For example, according to Art. 7(1)(m)(i) of the EU Regulation, data on air pollutants estimated under the UNECE Convention on Long-range Transboundary Air Pollution and those under the UNFCCC Convention should not exceed the difference of more than +/–5 % between the total emissions for a specific pollutant otherwise text and a tabular format should be compiled by the Member State. As shown in chapter 2, para 2.4, these differences for Italy are far under the threshold.
Other relevant articles of the EU Regulation for data consistency are Article 10, on emissions reported under the European ETS, Article 11 and Article 12 related to F-gases international energy data.
Specifically, Article 10 regards the consistency of reported GHG emissions under UNFCCC with data from the EU emissions trading system in tabular and textual form by category; the detailed table is included in Annex 13 of the NIR.
As for Article 11, on consistency of F-gas estimates with data reported under Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases, the verification process is still on progress due to the large amount of data and the difficulty to analyze the amount of F-gases actually used by the national operators. However, activities are already carried out on verification of average emission factors and activity data reported at sectoral level.
Article 12 of the EU Implementing Regulation obliges Memeber States to report textual information on the comparison between the reference approach calculated on the basis of the data included in the GHG

inventory and the reference approach calculated on the basis of the data reported pursuant to Article 4 of Regulation (EC) No 1099/2008 of the European Parliament and of the Council (1) and Annex B to that Regulation (Eurostat energy data). If these differences are higher than +/– 2 %, in the total national apparent fossil fuel consumption at aggregate level for all fossil fuel categories, a tabular format shall also be compiled. For Italy these differences are below the determined threshold; also these data are reported in Annex 13 for the year 2016.

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 2016' (ISPRA, 2018 [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 2016 total emission figures without LULUCF, an uncertainty of 2.7% in the combined global warming potential (GWP) total emissions is estimated, whereas for the trend between the base year and 2016 the analysis assesses an uncertainty by 2.1%.
Including the LULUCF sector into national figures, the uncertainty according to Approach 1 is equal to 4.8% for the year 2016, whereas the uncertainty for the trend is estimated to be 3.9%.
The small variation in the uncertainty levels, as compared the previous submission, is mainly due to the recalculation process and consequent different weights of the categories and relevant uncertainties.
The assessment of uncertainty has also been applied to the base year emission levels. The results show an uncertainty of 2.1% in the combined GWP total emissions, excluding emissions and removals from LULUCF, whereas it increases to 2.9% including the LULUCF sector.

Approach 2 was implemented in previous years' submissions 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, to specific categories of the inventory. Also in that case, the results show that, applying methods higher than the error propagation method does not make a significant difference in figures if information on uncertainty levels is not sufficiently detailed. Montecarlo was applied to CO_2 emissions from road transport and N_2O 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 CO_2 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 CO_2 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 N_2O 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 which 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 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. More details can be found at category level in the relevant sections.

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 N_2O emissions from agricultural soils and indirect N_2O 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.

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, N_2O emissions from oil and natural gas exploration and refining and storage activities are reported under category 1.B.2.d other, flaring in refineries. Further investigation will be carried out closely with industry about these figures.

Table 1.7 Source and sinks not estimated in the 2016 inventory

Sources and sinks not estimated (NE)[1]			
GHG	**Sector[2]**	**Source/sink category [2]**	**Explanation**
CO_2, CH_4, N_2O	1 Energy	1.D2 Multilateral Operations	Information and statistical data are not available
Unspecified mix of HFCs and PFCs	2 IPPU	2.E Electronics Industry/2.E.4 Heat Transfer Fluid/Unspecified mix of HFCs and PFCs	Consumption and emission data are being collected by the relevant industry resulting in emission estimates less than 0.05% of national totals that could be considered insignificant
Net CO_2 emisisons/ remavals	4 LULUCF	4.D Wetlands/4.D.1. Wetlands remaining wetlands	Up to now, no information to estimate emissions from wetlands is available
CH_4	3 Agriculture	3.D Agricultural Soils	CH_4 emissions from managed soils have not been estimated as no methodology is not available in the IPCC Guidelines.

Table 1.8 Source and sinks reported elsewhere in the 2016 inventory

Sources and sinks reported elsewhere ("IE")[3]				
GHG	**Source/sink category**	**Allocation as per IPCC Guidelines**	**Allocation used by the Party**	**Explanation**
N_2O	1.B Fugitive Emissions from Fuels/1.B.2 Oil and Natural Gas and Other Emissions from Energy Production/1.B.2.a Oil/1.B.2.a.4 Refining / Storage	1.B.2.A.4	1.B.2.D flaring in refineries	No information available to distinguish the emissions.
CO_2	1.AD Feedstocks, reductants and other non-energy use of fuels/Liquid Fuels/Gasoline	1.AD Liquid fuel/Gasoline/LPG/Other Oil/Refinery feedstock/Residual oil	1.AD Liquid fuel/Naphta	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.
CO_2	2.C Metal Industry/2.C.5 Lead Production	2.C.5. Lead Production	2.C.6 Zinc production	CO_2 emissions from the sole zinc and lead integrated plant in Italy have been estimated. The available data do not allow to distinguish between zinc and lead emissions.
CO_2, CH_4	2.C Metal Industry/2.C.1 Iron and Steel Production/2.C.1.d Sinter	2.C.1.d Sinter Production	1.A.2.a	There is no information to distinguish between emissions from energy and process, so emissions are allocated in 1.A.2
HFC-134a HFC-245fa	2.F Product Uses as Substitutes for ODS/2.F.2 Foam Blowing Agents/2.F.2.a Closed Cells/HFC-134a and HFC-245fa			Emissions are included in emissions from manufacturing
HFC-227ea	2.F Product Uses as Substitutes for ODS/2.F.3 Fire Protection/HFC-227ea	2.F.3 Fire Protection/HFC-227ea from disposal	2.F.3 Fire Protection/HFC-227ea from stocks	Emissions are included in emissions from stocks
CO_2	4.A Forest Land/4.A.1 Forest Land Remaining Forest Land/4(V) Biomass Burning/Wildfires			CO2 emissions due to wildfires in forest land remaining forest land are included in table 4.A.1, Carbon stock change in living biomass, Losses
N_2O	4.A Forest Land/4.A.1 Forest Land Remaining Forest Land/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers	4(I) Direct N2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers	3.D.1 Direct N2O emissions from managed soils	N inputs to managed soils are reported in the agriculture sector
CO_2	4.G Harvested Wood Products/Approach B/Approach B2/Total HWP from Domestic Harvest/HWP Produced and Exported/Solid Wood/Sawnwood and Wood panels	Solid Wood/Sawnwood and Wood panels in HWP Produced and exported	Solid Wood/Sawnwood and wood panels in HWP produced and consumed domestically	HWP produced and exported are included in the HWP produced and consumed domestically

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 1990-2016 are reported in Tables A8.1.1- A8.1.5 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 CO_2 equivalent, excluding emissions and removals from LULUCF, have decreased by 17.5% between 1990 and 2016, varying from 518 to 428 CO_2 equivalent million tons (Mt).
The most important greenhouse gas, CO_2, which accounts for 81.9% of total emissions in CO_2 equivalent, shows a decrease by 20.4% between 1990 and 2016. In the energy sector, in particular, CO_2 emissions in 2016 are 18.2% lower than in 1990.
CH_4 and N_2O emissions are equal to 10.0% and 4.2% of the total CO_2 equivalent greenhouse gas emissions, respectively. CH_4 emissions have decreased by 11.1% from 1990 to 2016, while N_2O has decreased by 32.1%.
As for other greenhouse gases, HFCs account for 3.4% of total emissions, PFCs and SF_6 are equal to 0.4% and 0.1% of total emissions, respectively; the weight of NF_3 is less than 0.01%. Among these gases, HFCs show a strong increase in emissions, and the meaningful increasing trend will make them even more important in next years.
Figure 2.1 illustrates the national trend of greenhouse gases for 1990-2016, expressed in CO_2 equivalent terms and by substance; total emissions do not include emissions and removals from land use, land use change and forestry.

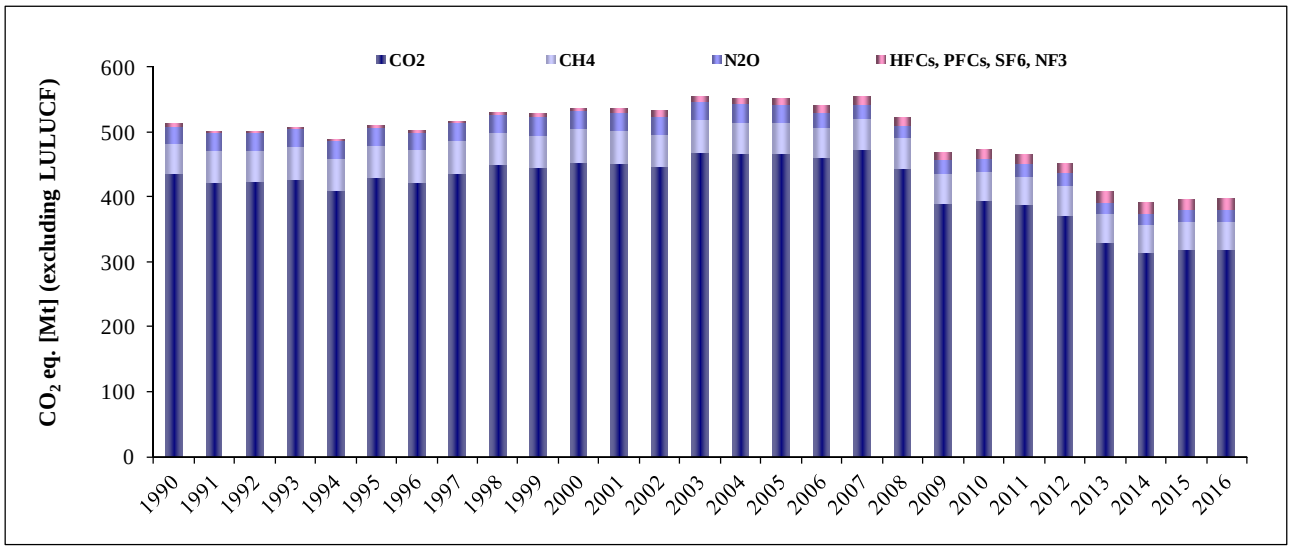

Figure 2.1 National greenhouse gas emissions from 1990 to 2016 (without LULUCF) (Mt CO_2 eq.)

The share of the different sectors, in terms of total emissions, remains nearly unvaried over the period 1990-2016. Specifically for the year 2016, the greatest part of the total greenhouse gas emissions is to be attributed to the energy sector, with a percentage of 81.1%, followed by industrial processes and agriculture, accounting for 7.5% and 7.1%, respectively, and waste contributing with 4.3% to total emissions.
Total greenhouse gas emissions and removals, including LULUCF sector, are shown in Figure 2.2 subdivided by sector.
Considering total GHG emissions with emissions and removals from LULUCF, the energy sector accounts, in 2016, for 75.8% of total emissions and removals, as absolute weight, followed by, industrial processes and agriculture (7.0% and 6.6%, respectively), LULUCF which contributes with 6.5%, and waste (4.0%).

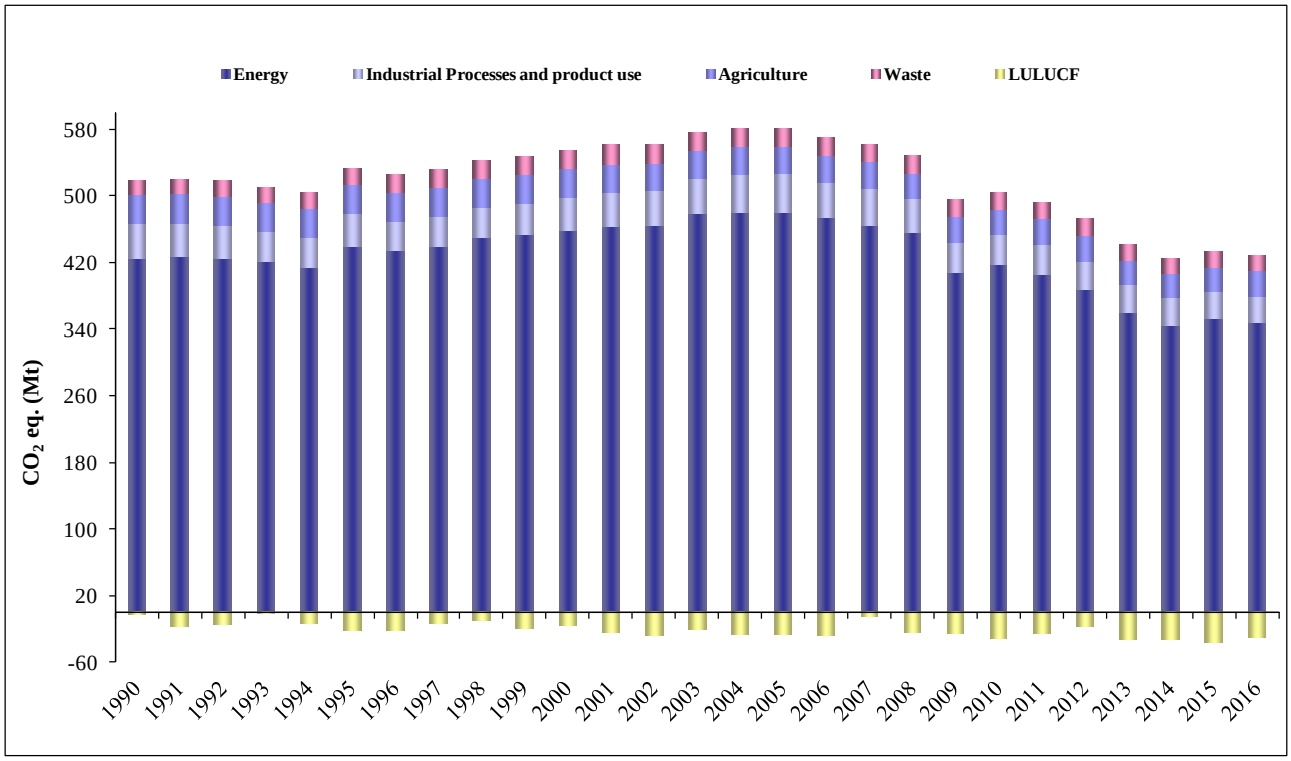

Figure 2.2 Greenhouse gas emissions and removals from 1990 to 2016 by sector (Mt CO_2 eq.)

2.2 Description and interpretation of emission trends by gas

2.2.1 Carbon dioxide emissions

CO_2 emissions, excluding CO_2 emissions and removals from LULUCF, have decreased by 20.4% from 1990 to 2016, ranging from 440 to 350 million tons.
The most relevant emissions derive from the energy industries (29.6%) and transportation (29.5%). Non-industrial combustion accounts for 22.2% and manufacturing and construction industries for 13.4%, while the remaining emissions derive from industrial processes (4.2%) and the other sectors (1.1%).
The trend of CO_2 emissions by sector is shown in Figure 2.3.

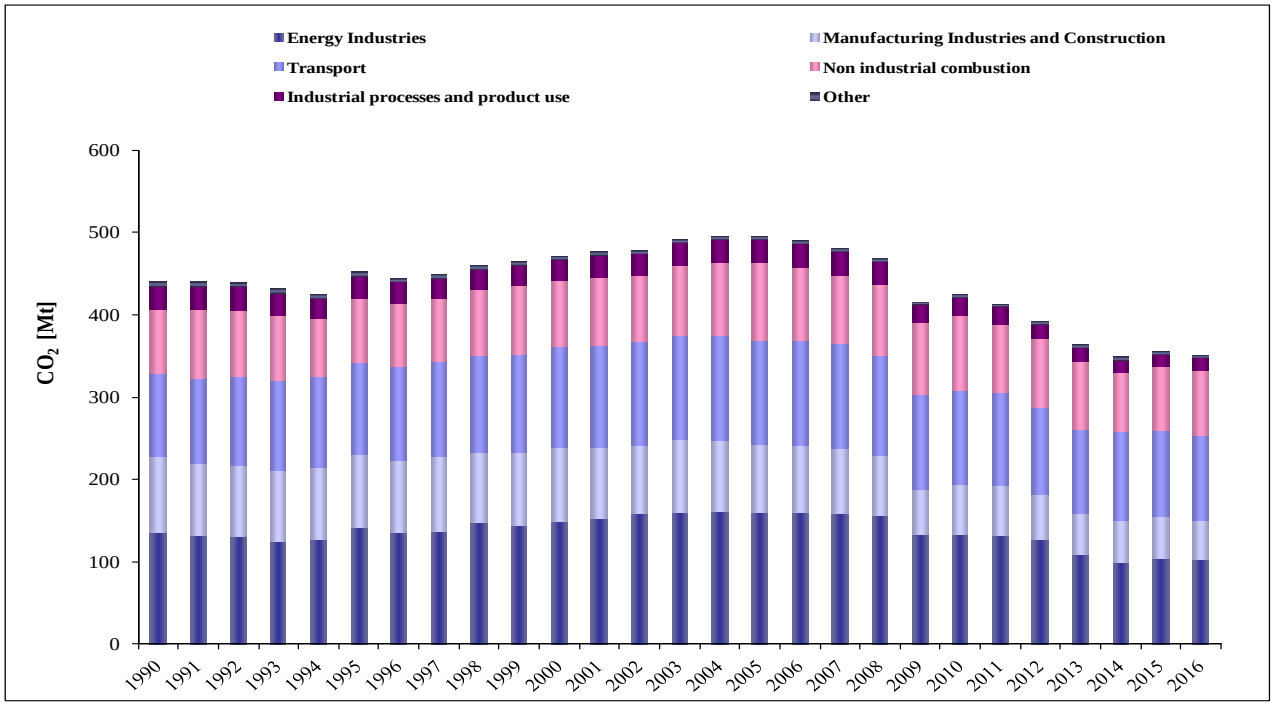

Figure 2.3 National CO_2 emissions by sector from 1990 to 2016 (Mt)

The main driver for the reduction of CO_2 emissions is the reduction in emissions observed in energy industries and manufacturing industries and construction; in the period 1990-2016, emissions from energy industries decreased by 23.9% while those from manufacturing industries and construction show a decrease of 48.8%. The transport sector shows an increase of emissions until 2007 and then a decrease both for the economical recession and the penetration of vehicles with low fuel consumption. Non industrial combustion emission trend is driven by the annual climatic variation while emissions from industrial processes decreased by 49.8% mainly for the decrease of cement production.

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

- Gross Domestic Product (GDP) at market prices as of 2010 (base year 1990=100);
- Total Energy Consumption;
- CO_2 emissions, excluding emissions and removals from land-use change and forests;
- CO_2 *intensity*, which represents CO_2 emissions per unit of total energy consumption.

CO_2 emissions in the 1990s essentially mirrored energy consumption. A decoupling between the curves is observed only in recent years, mainly as a result of the substitution of fuels with high carbon contents by methane gas in the production of electric energy and in industry; in the last years, the increase in the use of renewable sources has led to a notable reduction of CO_2 intensity.

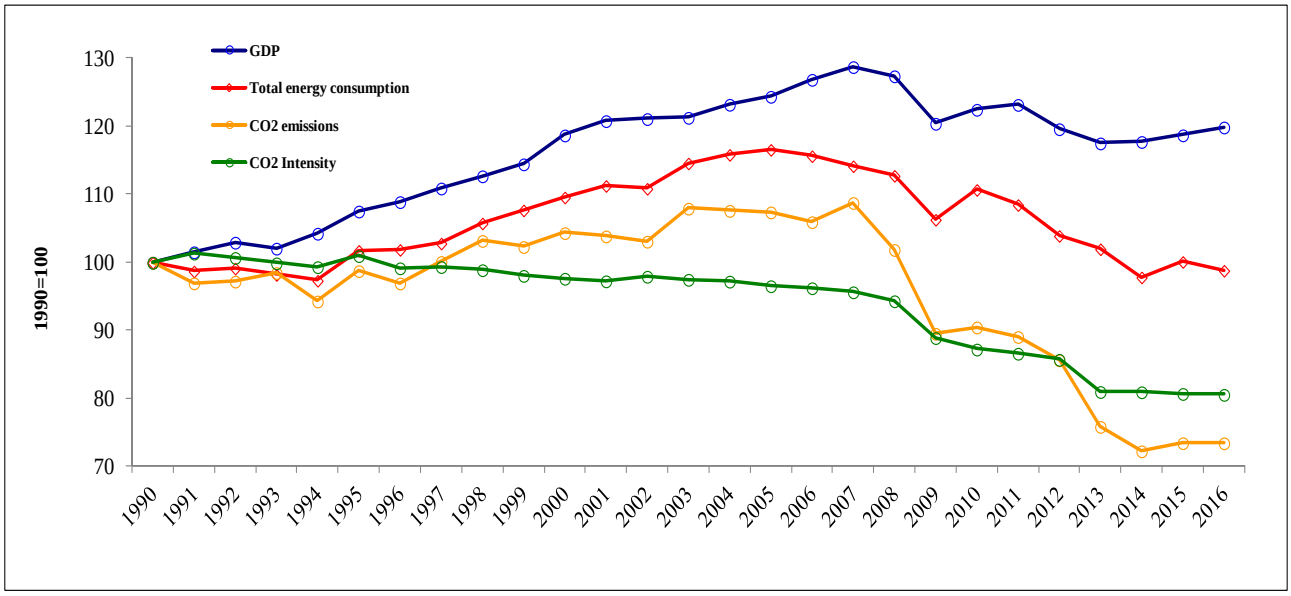

Figure 2.4 Energy-related and economic indicators and CO_2 emissions

2.2.2 Methane emissions

Methane emissions (excluding LULUCF) in 2016 represent 10.0% of total greenhouse gases, equal to 42.9 Mt in CO_2 equivalent, and show a decrease of 11.1% as compared to 1990 levels.

CH_4 emissions, in 2016, are mainly originated from the agriculture sector which accounts for 44.0% of total methane emissions, as well as from the waste (38.0%) and energy (17.9%) sectors.

Emissions in the agriculture sector regard mainly the enteric fermentation (74.4%) and manure management (16.5%) categories. The sector shows a decrease of emissions equal to 11.5% as compared to 1990, attributable widely to a reduction in livestock and the recovery of biogas for energy purposes.

Activities typically leading to emissions in the waste-management sector are the operation of dumping sites and the treatment of industrial waste-water. The waste sector shows an increase in CH_4 emission levels, equal to 5.2% compared to 1990; the largest sectoral shares of emissions are attributed to solid waste disposal on land (83.6%) and waste-water handling (15.3%), which show an increase equal to 11.6% and a decrease by 22.8%, respectively.

In the energy sector, the reduction of CH_4 emissions (-32.2%) is the result of two contrasting factors: on the one hand there has been a considerable reduction in emissions deriving from energy industries, 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 the increased use of methane and biomass in heating systems. Figure 2.5 shows the emission figures by sector.

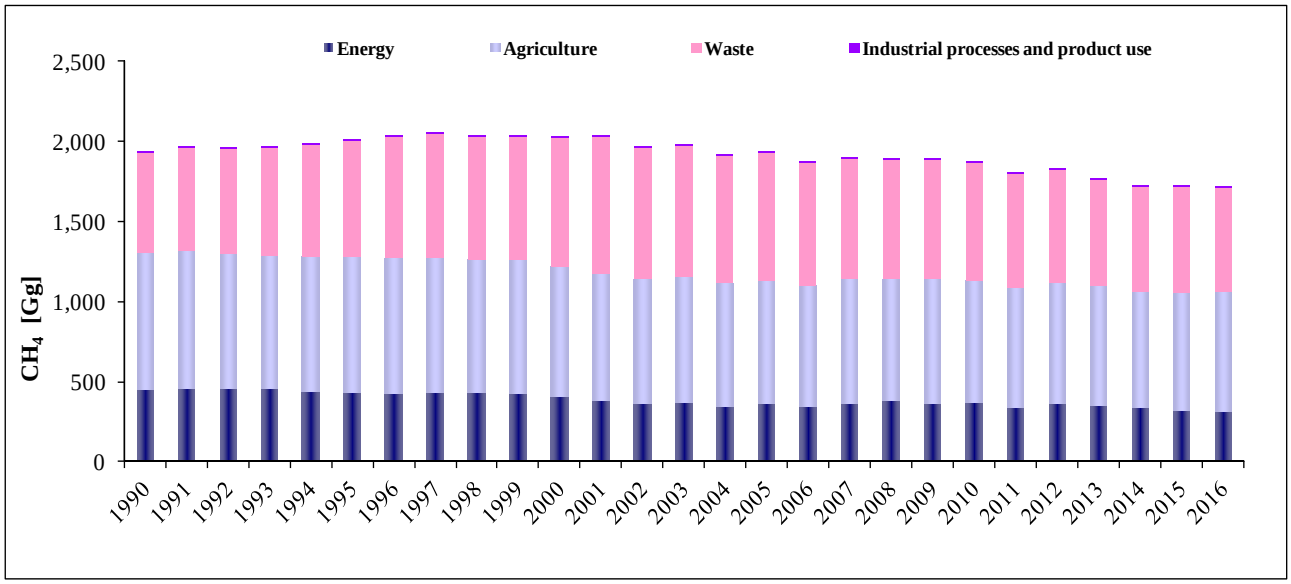

Figure 2.5 National CH_4 emissions by sector from 1990 to 2016 (Gg)

2.2.3 Nitrous oxide emissions

In 2016, nitrous oxide emissions (excluding LULUCF) represent 4.2% of total greenhouse gases, with a decrease of 32.1% between 1990 and 2016, from 26.4 to 18.0 Mt CO_2 equivalent.
The major source of N_2O emissions is the agricultural sector (61.2%), in particular the use of both chemical and organic fertilisers in agriculture, as well as the management of waste from the raising of animals. Emissions from the agriculture sector show a decrease of 17.4% during the period 1990-2016, due to a reduction in livestock number.
Emissions in the energy sector (25.0% of the total) show a decrease by 2.6% from 1990 to 2016; this trend can be traced primarily to the reduction of 47.4% in the manufacturing and construction industries (which account for 4.0% of the total N_2O emissions) due mainly to the reduction in the last years of cement production; the downward trend was counterbalanced by the increase of emissions by 38.2% in the civil sector, which accounts for 13.4% of the total N_2O emissions, as a result of the increased use of biomass in heating systems.
For the industrial sector, N_2O emissions show a decrease of 92.0% from 1990 to 2016. The decrease is almost totally due to the introduction of abatement systems in the nitric and adipic acid production plants which drastically reduced emissions from these processes. A further component which has contributed to the reduction is the decreasing use of N_2O for medical purposes.
Other emissions in the waste sector (10.6% of national N_2O emissions) primarily regard the processing of industrial and domestic waste-water treatment and the biological treatment of solid waste.

Figure 2.6 shows national emission figures by sector.

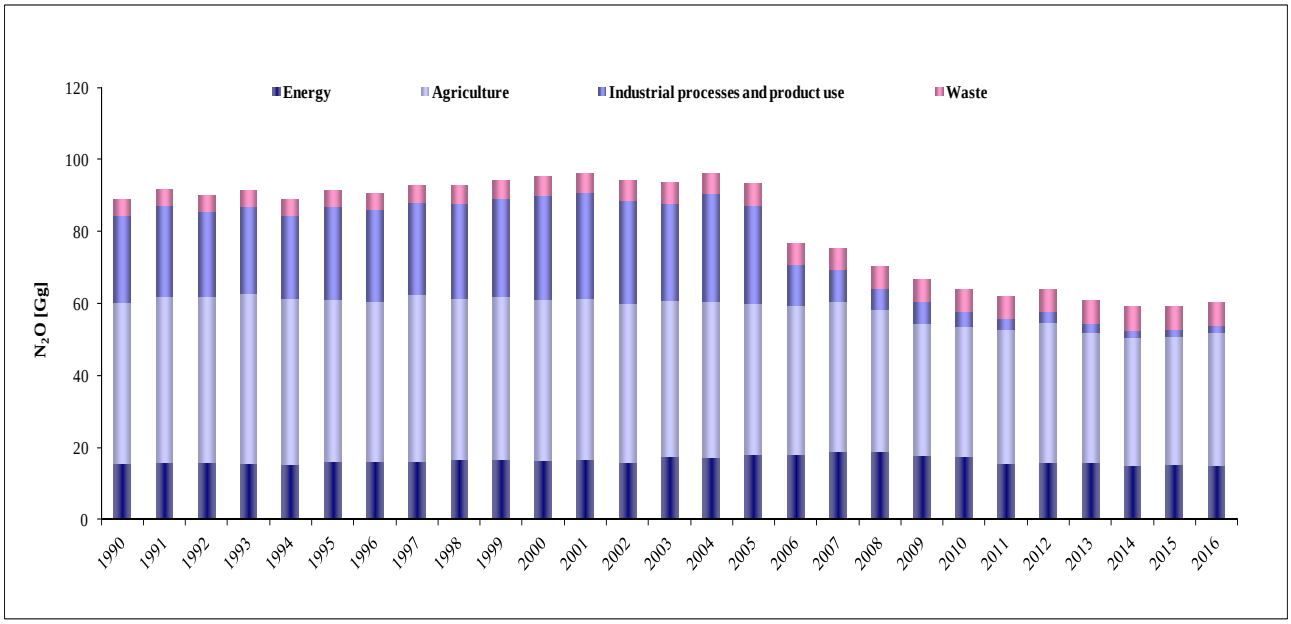

Figure 2.6 National N_2O emissions by sector from 1990 to 2016 (Gg)

2.2.4 Fluorinated gas emissions

Italy has set 1990 as the base year for emissions of fluorinated gases, HFCs, PFCs, SF_6 and 1995 for NF_3. Taken altogether, the emissions of fluorinated gases represent 3.9% of total greenhouse gases in CO_2 equivalent in 2016 and they show a significant increase between 1990 and 2016. This increase is the result of different features for the different gases.
HFCs, for instance, have increased considerably from 1990 to 2016, from 0.4 to 14.7 Mt in CO_2 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 44.0% from 1990 to 2016. The level of PFC emissions in 2016 is equal to 1.6 Mt in CO_2 equivalent, and it is due to by product emissions in fluorchemical production (91.7%), and the use of the gases in the production of semiconductors (8.3%).
Emissions of SF_6 are equal to 0.4 Mt in CO_2 equivalent in 2016, with a decrease of 7.9% as compared to 1990 levels. In 2016, 88% of SF_6 emissions derive from the gas contained in electrical equipments, 11.3% from the use of this substance in accelerators and 12.1% from the gas used in the semiconductors manufacture. NF_3 emissions account for 0.03 Mt in CO_2 equivalent in 2016 and derive from the semiconductors industry.

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.

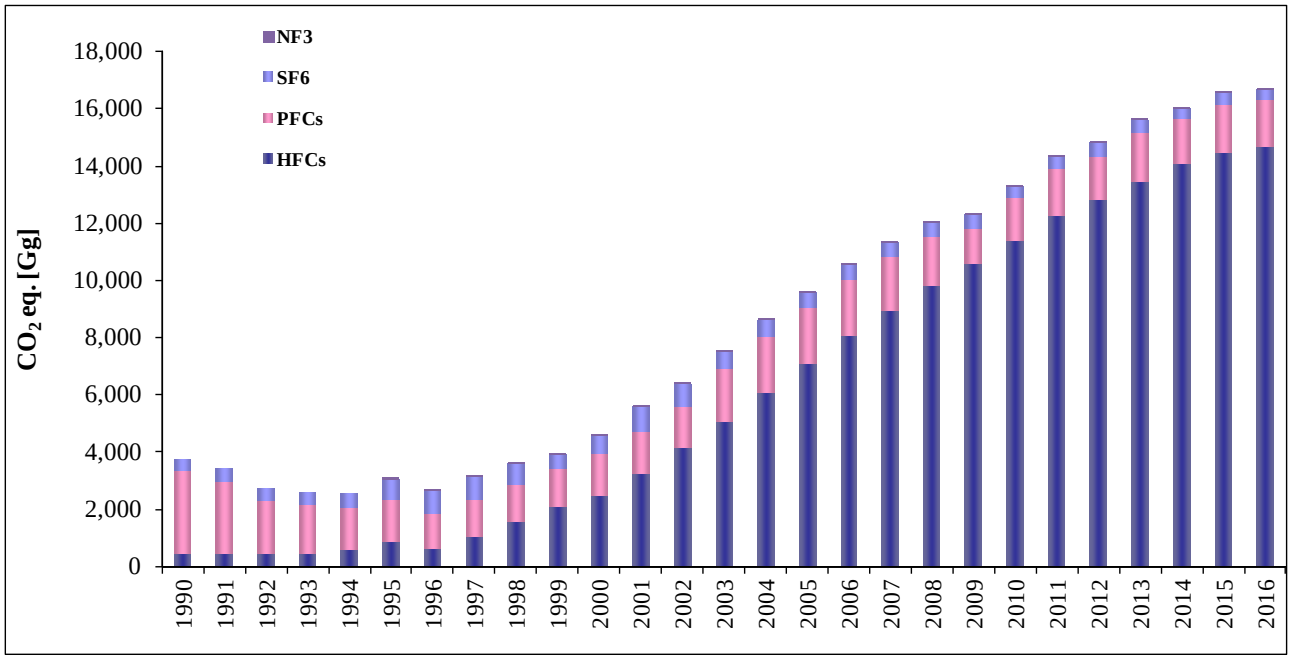

Figure 2.7 National emissions of fluorinated gases by sector from 1990 to 2016 (Gg CO_2 eq.)

2.3 Description and interpretation of emission trends by source

2.3.1 Energy

Emissions from the energy sector account for 81.1% of total national greenhouse gas emissions, excluding LULUCF, in 2016.

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

	1990	1995	2000	2005	2010	2015	2016
				Gg CO_2 eq.			
Total emissions	**425,499**	**439,343**	**459,130**	**480,163**	**417,157**	**352,536**	**347,080**
Fuel Combustion (Sectoral Approach)	412,622	427,216	448,312	470,783	408,316	344,986	339,860
Energy Industries	*137,158*	*141,694*	*149,461*	*161,298*	*134,012*	*105,800*	*104,358*
Manufacturing Industries and Construction	*93,235*	*91,346*	*92,195*	*83,914*	*62,581*	*50,920*	*47,945*
Transport	*102,100*	*113,621*	*123,262*	*128,047*	*115,159*	*105,988*	*104,505*
Other Sectors	*78,986*	*78,991*	*82,512*	*96,201*	*95,873*	*81,799*	*82,519*
Other	*1,143*	*1,566*	*881*	*1,323*	*692*	*478*	*533*
Fugitive Emissions from Fuels	12,877	12,127	10,818	9,381	8,841	7,551	7,221
Solid Fuels	*132*	*74*	*97*	*90*	*86*	*44*	*NO*
Oil and Natural Gas	*12,745*	*12,052*	*10,721*	*9,291*	*8,755*	*7,506*	*7,178*

Table 2.1 Total emissions from the energy sector by source (1990-2016) (Gg CO_2 eq.)

From 2005, GHG emissions from the energy sector are decreasing because 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. From 2008 to 2009 the decrease observed in GHG emissions is, indeed, equal to -10.4% followed by an increase (+2.1%) only from 2009 to 2010; since then, except for the increase of 2.2% between 2014 and 2015, the annual variations are always negative until 2016, when emissions the emissions decreased by 1.5% comparing to 2015.

Total greenhouse gas emissions, in CO_2 equivalent, show a decrease of about 18.4% from 1990 to 2016; in particular, an upward trend is noted from 1990 to 2005, with an increase by 12.8%, while between 2005 and 2016 emissions decreased by 27.7%.
The substance with the highest impact, in the energy sector, is CO_2, accounting for 96.5% of the sectoral total, in 2016, whose leves have decreased by 18.2% from 1990 to 2016.
CH_4 emissions trend, showing a decrease of 32.2% from 1990 to 2016, accounting for 2.2% of the total emission levels, is driven by the combined effect of technological improvements that limit volatile organic compounds (VOCs) from tail pipe and evaporative emissions (for cars) and the expansion of two-wheelers fleet.
N_2O shows a decrease of 2.6% with a share out of the total equal to 1.3%, mainly driven by the technology development in road transport and to the switch from gasoline to diesel fuel consumption.
In general, from 1990 to 2016 the decrease in emissions is driven by the reduction in the energy industries and manufacturing industries and construction, which account for 30.1% and 13.8% and reduced by 23.9% and 48.6%, respectively. Specifically, for the manufacturing industries and construction, the reason for the reduced emissions is the cut in production in some subsectors (e.g. chemical, construction and building materials, steel) due to the effects of the economic recession but also to an increase in efficiency, especially identified in the chemical sector. On the other hand, an increase in emissions still occurs in two relevant sectors, transport and other sectors, which increased by about 2.4% and 4.5% and account for 30.1% and 23.8%, respectively.
Road transport is the most relevant source in the transport sector, accounting in 2016 for 22.8% of total national CO_2 equivalent emissions. In 2016, GHG emissions from road transport were about 93.5% of the national emissions from transport. From 1990 to 2016, GHG emissions from the sector increased by 4.0%;

this trend has a twofold explanation: on one side, a strong increase starting from 1990 until 2007 (27.7%), due to the increase of vehicle fleet, total mileage and consequently fuel consumptions; on the other side, from 2007 onwards, a decrease in fuel consumption and emissions basically due to the economic crisis (emissions decrease of about -18.5%).
The increase in other sectors, which refer to emissions originated from energy use in the civil sector and from military mobile activities, is due, from 1990 to 2000, to the increase in numbers and size of building with heating, and to the trend in weather conditions, while from 2002, and especially in the last few years, to the increase in other greenhouse gas emissions than CO_2 for the growing use of woody biomass and biogas for heating.
Details on these figures are described in the specific chapter.

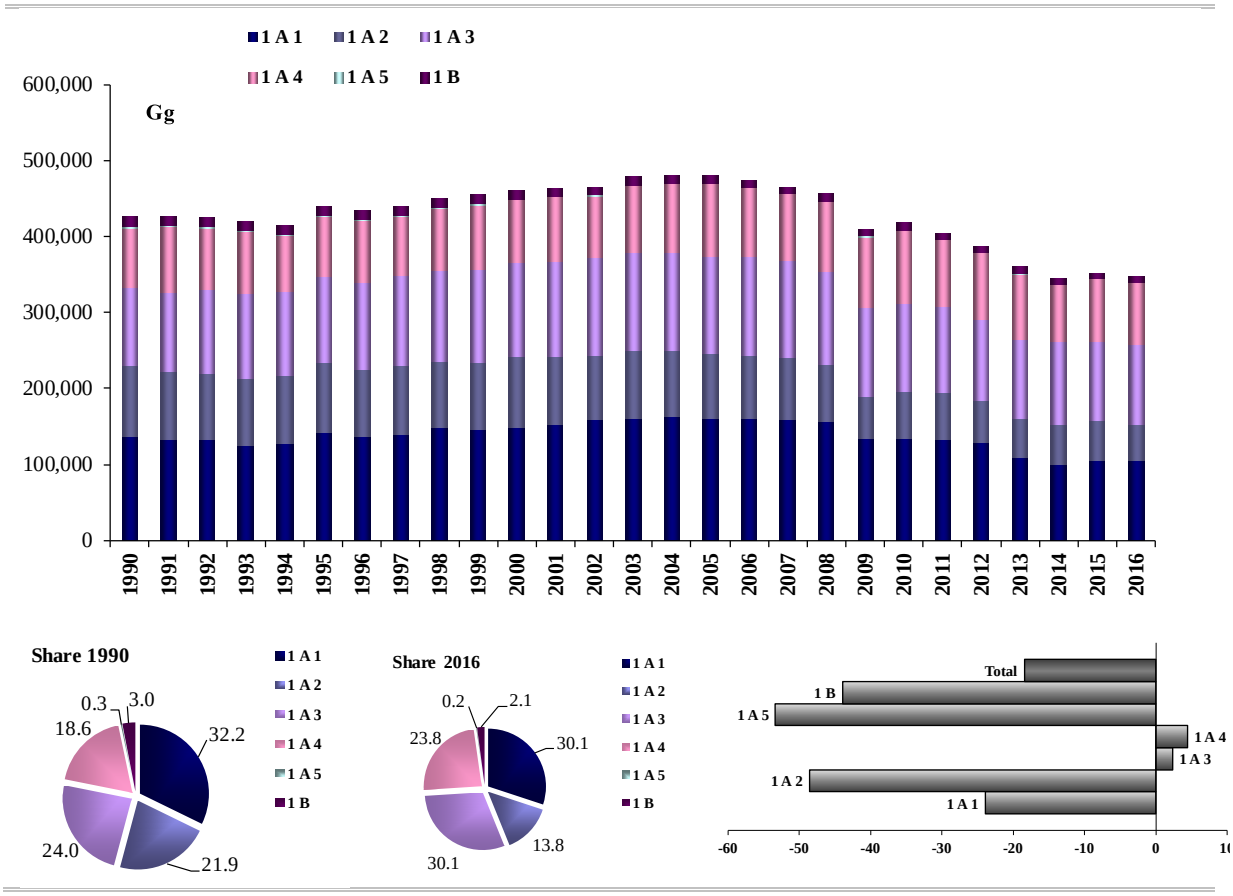

Figure 2.8 Trend of total emissions from the energy sector (1990-2016) (Gg CO_2 eq.)

2.3.2 Industrial processes and product use

Emissions from the industrial processes and product use sector account for 7.5% of total national greenhouse gas emissions, excluding LULUCF, in 2016.
Emission trends from industrial processes are reported in Table 2.2 and Figure 2.9.

Total emissions, in CO_2 equivalent, show a decrease of 20.7%, from 1990 to 2016. Taking into account emissions by substance, CO_2 and N_2O decreased by 49.8% and 92.0%, respectively; in terms of their weight out of the sectoral total emissions, CO_2 accounts for 46.0% and N_2O for 1.8%. CH_4 decreased by 63.1% but it accounts for only 0.1%.
The decrease in emissions is mostly to be attributed to a decrease in the mineral and chemical industries. Emissions from mineral production decreased by 48.8% , mostly for the reduction of cement production. The decrease of GHG emissions in the chemical industry (-70.8%) 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).

On the other hand, a considerable increase is observed in F-gas emissions (344.5%), whose share on total sectoral emissions is 52.1%. The main drivers of the increase are the consumptions of HFCs in refrigeration and air-conditioning devices, together with their use in pharmaceutical aerosols.

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

	1990	1995	2000	2005	2010	2015	2016
				Gg CO_2 eq.			
Total emissions	**40,473**	**38,215**	**39,161**	**46,710**	**36,357**	**32,282**	**32,098**
CO_2	29,385	27,338	25,904	28,772	21,783	15,000	14,761
CH_4	129	134	73	74	60	42	48
N_2O	7,199	7,701	8,599	8,251	1,224	613	574
F-gases	3,761	3,119	4,585	9,612	13,291	16,626	16,715
HFCS	*444*	*869*	*2,479*	*7,089*	*11,356*	*14,468*	*14,682*
PFCS	*2,907*	*1,492*	*1,488*	*1,940*	*1,520*	*1,688*	*1,629*
SF_6	*410*	*681*	*605*	*550*	*394*	*441*	*377*
NF_3	*NO*	*77*	*13*	*33*	*20*	*28*	*28*

Table 2.2 Total emissions from the industrial processes sector by gas (1990-2016) (Gg CO_2 eq.)

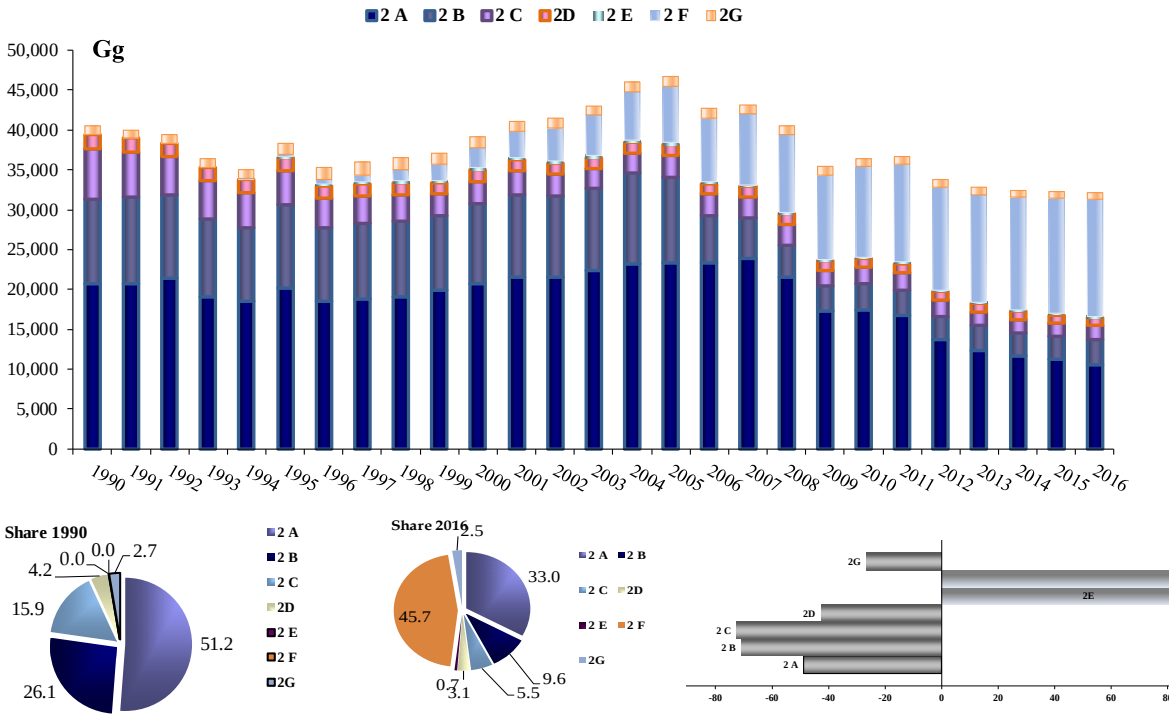

Figure 2.9 Trend of total emissions from the industrial processes sector (1990-2016) (Gg CO_2 eq.)

2.3.3 Agriculture

Emissions from the agriculture sector account for 7.1% of total national greenhouse gas emissions, in 2016, excluding LULUCF.

Emissions from the agriculture sector are reported in Table 2.3 and Figure 2.10.

	1990	1995	2000	2005	2010	2015	2016
				Gg CO_2 eq.			
Total emissions	**35,078**	**34,992**	**34,259**	**32,083**	**30,065**	**29,435**	**30,394**
Enteric Fermentation	15,497	15,319	15,048	13,709	13,530	13,696	14,039
Manure Management	6,824	6,439	6,373	6,055	5,988	5,179	5,228
Rice Cultivation	1,876	1,989	1,656	1,752	1,822	1,668	1,710
Agricultural Soils	10,396	10,713	10,636	10,026	8,352	8,434	8,857
Field Burning of Agricultural Residues	19	18	18	20	19	20	21
Liming	1	1	2	14	18	14	12
Urea application	465	512	525	507	335	425	527

Table 2.3 Total emissions from the agriculture sector by source (1990-2016) (Gg CO_2 eq.)

Emissions mostly refer to CH_4 and N_2O levels, which account for 62.1% and 36.1% of the total emissions of the sector, respectively. CO_2 accounts for the remaining 1.8% of total emissions. The decrease observed in total emissions (-13.4%) is mostly due to the decrease of CH_4 emissions from enteric fermentation (-9.4%) and to the decrease of N_2O (-14.8%) from agricultural soils, which categories account for 46.2% and 29.1% of the total sectoral emissions, respectively.

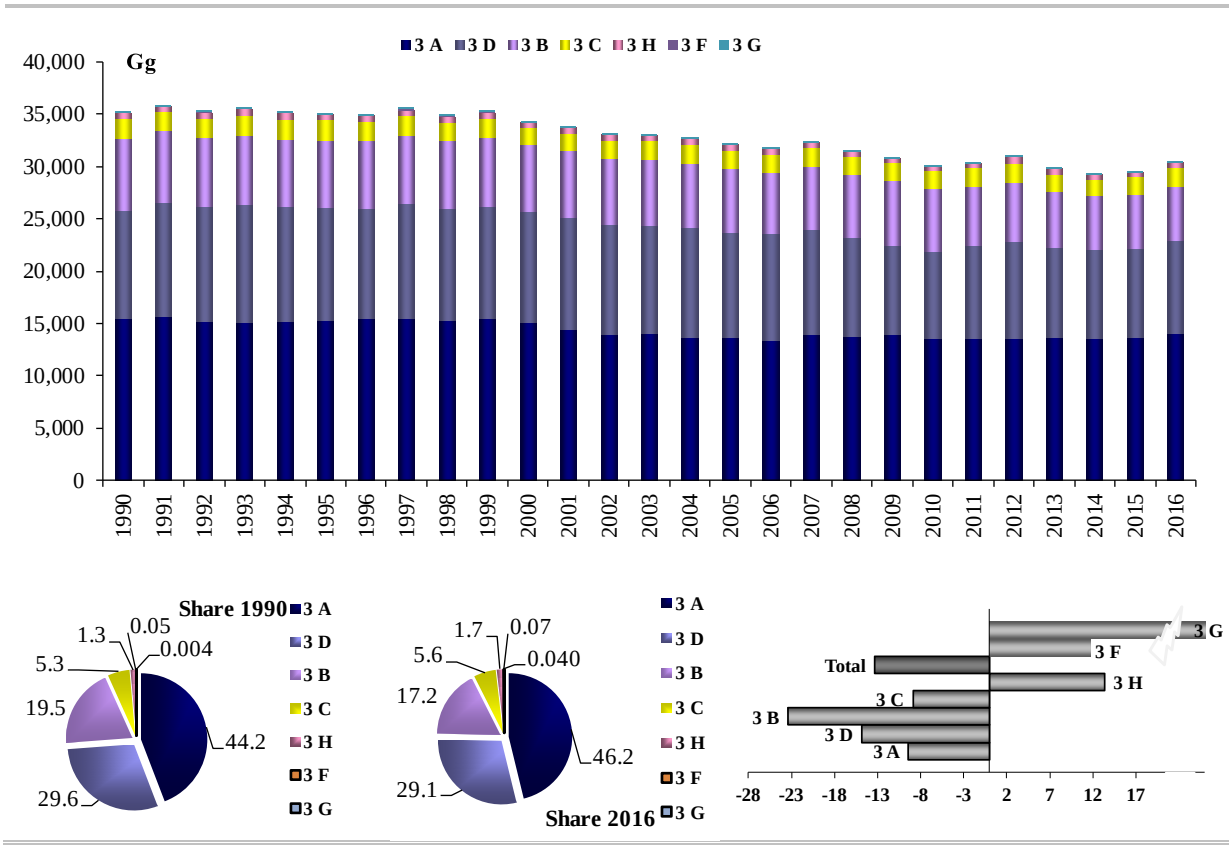

Figure 2.10 Trend of total emissions from the agriculture sector (1990-2016) (Gg CO_2 eq.)

Main drivers behind these downward trends are the reduction in the number of animals, especially cattle in the whole period as well as the use of nitrogen fertilizers, mainly due to the European Common Agricultural Policy (CAP) measures. In addition, there has been a significant increase in the recovery of the amount of biogas produced from animal manure and used in the energy sector for the production of electricity and combined electricity and heat production in the last years, thus contributing to the reduction of total emissions.

Detailed comments can be found in the specific chapter.

2.3.4 LULUCF

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

	1990	1995	2000	2005	2010	2015	2016
				Gg CO_2 eq.			
Total emissions	**-3,043**	**-21,574**	**-15,655**	**-27,509**	**-30,640**	**-35,326**	**-29,927**
Forest land	-16,840	-30,605	-24,904	-33,612	-35,591	-39,034	-35,802
Cropland	2,225	1,861	2,046	1,459	1,335	2,160	2,489
Grassland	4,936	-989	683	-2,643	-4,160	-6,656	-6,484
Wetlands	NE,NO	5	8	8	NE,NO	NO,NE	NO,NE
Settlements	7,145	8,941	6,982	7,804	7,897	7,936	9,692
Other land	NO	NO	NO	NO	NO	NO	NO
Harvested wood products	-520	-804	-476	-531	-128	267	172
Other (indirect N2O soils)	10	17	6	6	6	0	6

Table 2.4 Total emissions from the LULUCF sector by source/sink (1990-2016) (Gg CO_2 eq.)

Total removals, in CO_2 equivalent, in the LULUCF sector, show a high variability in the period, remarkably influenced by the annual fires occurrence and the relevant area burned by fires. CO_2 accounts for 96.4% of total emissions and removals of the sector. The key driver for the rise in removals is the increase of carbon stock changes from forest land (the area reported under forest land has increased by 23.3%).

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

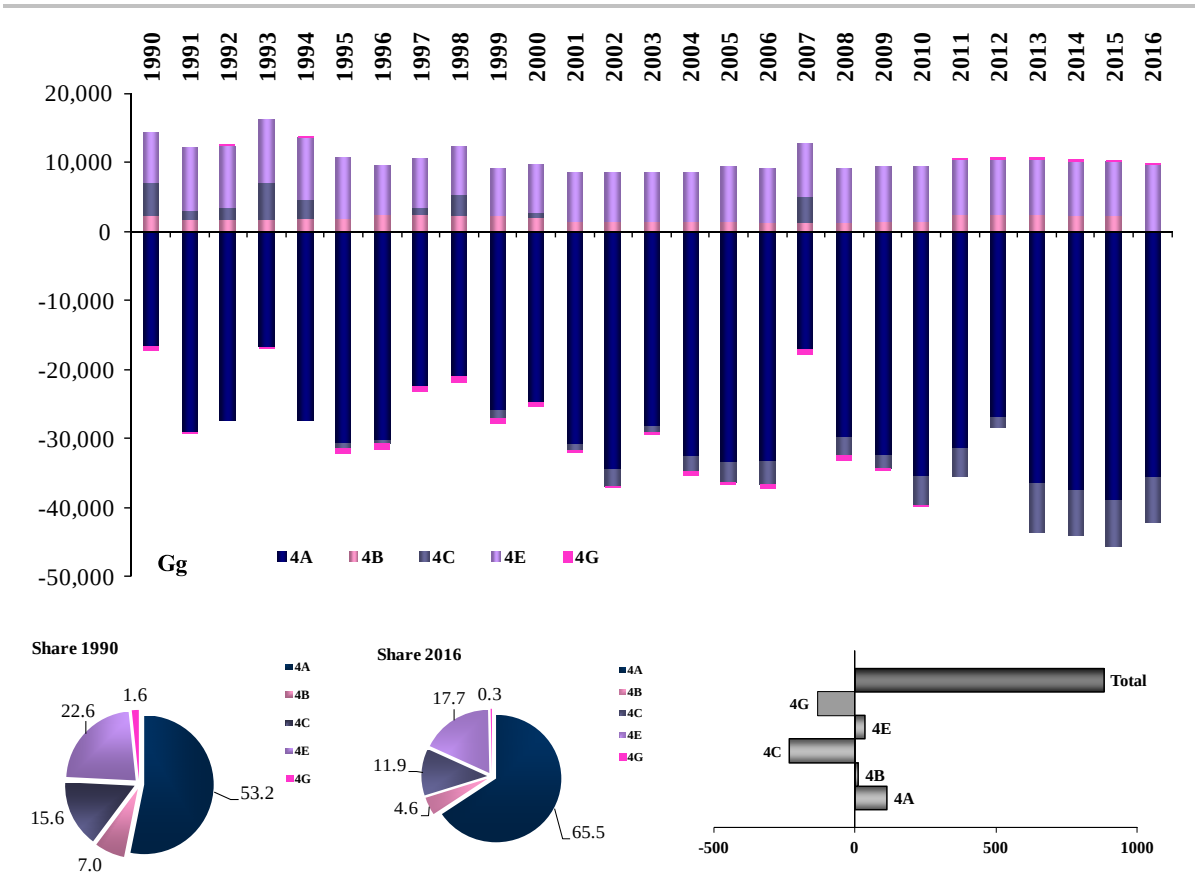

Figure 2.11 Trend of total emissions and removals from the LULUCF sector (1990-2016) (Gg CO_2 eq.)

2.3.5 Waste

Emissions from the waste sector account for 4.3% of total national greenhouse gas emissions, in 2016, excluding LULUCF.

Emissions from the waste sector are shown in Table 2.5 and Figure 2.12.

	1990	1995	2000	2005	2010	2015	2016
				Gg CO_2 eq.			
Total emissions	**17,313**	**20,013**	**21,914**	**21,895**	**20,410**	**18,625**	**18,290**
Solid waste disposal	12,206	15,123	17,200	17,002	15,558	13,979	13,621
Biological treatment of solid waste	25	58	249	489	619	642	653
Incineration and open burning of waste	594	547	286	313	243	173	176
Waste water treatment and discharge	4,488	4,285	4,180	4,091	3,990	3,832	3,839
Other	NA	NA	NA	NA	NA	NA	NA

Table 2.5 Total emissions from the waste sector by source (1990-2016) (Gg CO_2 eq.)

Total emissions, in CO_2 equivalent, increased by 5.6% from 1990 to 2016. The trend is mainly driven by the increase in emissions from solid waste disposal (11.6%), accounting for 74.5% of the total, counterbalanced by the decrease of emissions from waste water treatment (-14.5%), accounting for 21.0%.
Considering emissions by gas, the most important greenhouse gas is CH_4 which accounts for 89.1% of the total and shows an increase of 5.2% from 1990 to 2016. N_2O levels have increased by 43.9% while CO_2 decreased by 81.3%; these gases account for 10.4% and 0.5%, respectively.

Further details can be found in the specific chapter.

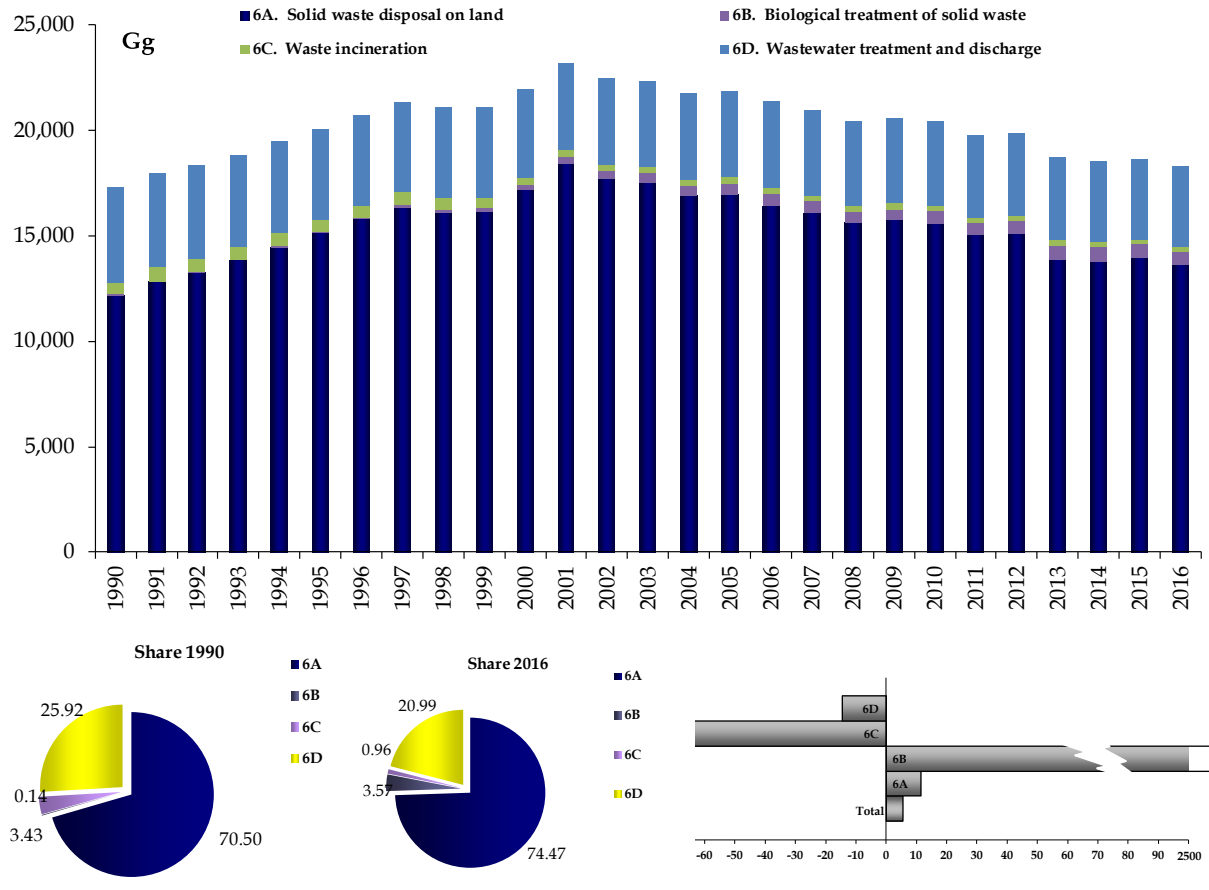

Figure 2.12 Trend of total emissions from the waste sector (1990-2016) (Gg CO_2 eq.)

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

Emission trends of NO_X, CO, NMVOC and SO_2 from 1990 to 2016 are presented in Table 2.6 and Figure 2.13.

	1990	1995	2000	2005	2010	2015	2016
				Gg			
NO_X	2,072	1,947	1,495	1,286	979	786	764
CO	7,209	7,256	4,854	3,448	3,076	2,377	2,309
NMVOC	1,996	2,028	1,590	1,338	1,117	918	904
SO_2	1,784	1,323	756	410	218	124	116

Table 2.6 Total emissions for indirect greenhouse gases and SO_2 (1990-2016) (Gg)

All gases show a significant reduction in 2016 as compared to 1990 levels. The highest reduction is observed for SO_2 (- 93.5%), CO levels have reduced by 68.0%, while NO_X and NMVOC show a decrease by 63.1% and 54.7%, respectively. A detailed description of the trend by gas and sector as well as the main reduction plans can be found in the Italian National Programme for the progressive reduction of the annual national emissions of SO_2, NO_X, NMVOC and NH_3, as requested by the 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.

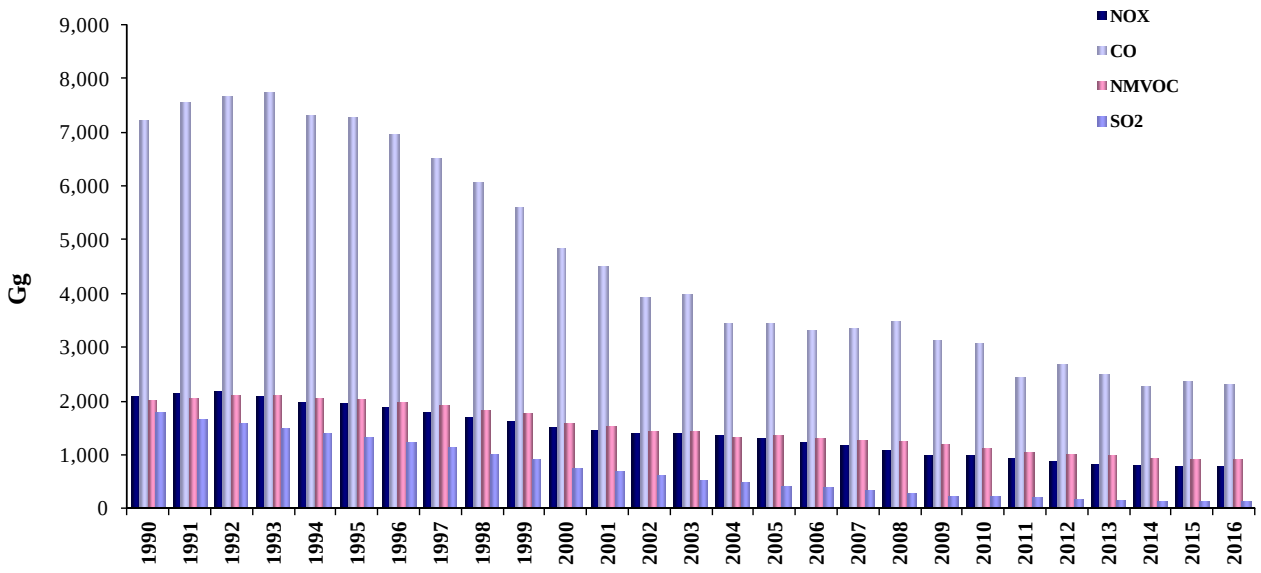

Figure 2.13 Trend of total emissions for indirect greenhouse gases and SO_2 (1990-2016) (Gg)

It should be noted that these figures differ from the national totals reported under the *United Nations Economic Commission for Europe* (UNECE) *Convention on Long Range Transboundary Air Pollution* (CLRTAP). If considering total emissions excluding the LULUCF sector, differences are to be attributed to the different accounting of emissions from the civil aviation sector and from fires. In the national totals under CLRTAP, in fact, emissions from aviation are calculated considering all LTO cycles, both domestic and international, excluding entirely the cruise phase. If national figures comprise LULUCF, on the other hand, differences are also to be attributed to fires; under the UNFCCC national total with LULUCF includes emissions from fires from forest, grassland and cropland whereas they are not considered in the national total for CLRTAP.

Emission trends of NO_X, CO, NMVOC and SO_2, exluding LULUCF, communicated under UNECE CLRTAP are presented in Table 2.7.
In the context of the European Regulation No 525/2013, Art. 7(1)(m)(i), EU Member States shall report on the consistency of data on air pollutants under the UNECE Convention on Long-range Transboundary Air Pollution and those under the UNFCCC Convention.
Differences in percentage terms between figures, without LULUCF, between the two Conventions are illustrated in Table 2.8.

	1990	1995	2000	2005	2010	2015	2016
				Gg			
NO_X	2,068	1,944	1,489	1,281	972	783	761
CO	7,210	7,257	4,855	3,448	3,075	2,378	2,310
NMVOC	1,996	2,028	1,590	1,339	1,117	918	904
SO_2	1,784	1,322	756	409	218	124	116

Table 2.7 Total emissions for indirect greenhouse gases and SO_2 (1990-2016) (Gg) under UNECE CLRTAP

	1990	1995	2000	2005	2010	2015	2016
NO_X	0.18%	0.18%	0.41%	0.39%	0.62%	0.43%	0.40%
CO	0.00%	-0.01%	-0.01%	0.00%	0.01%	-0.03%	-0.04%
NMVOC	0.00%	-0.01%	-0.01%	-0.02%	-0.01%	-0.02%	-0.02%
SO_2	0.01%	0.02%	0.05%	0.10%	0.19%	0.16%	0.16%

Table 2.8 Percentage differences between total emissions for indirect greenhouse gases and SO_2 under the UNFCCC and UNECE CLRTAP Conventions (1990-2016).

2.5 Indirect CO_2 and nitrous oxide emissions

Indirect emissions are originated from the atmospheric oxidation of CH_4, CO and NMVOCs. Italy has chosen to report indirect CO_2 emissions from the oxidation of NMVOCs including them in the relevant categories of solvent use. Details on how they are converted into indirect CO_2, can be found in the sections on non-energy-related products from fuels and solvents in Chapter 4.5.2.
Indirect emissions of N_2O take place as a result of two different nitrogen loss pathways. These pathways are the volatilization/emission of nitrogen as NH_3 and NO_X and the subsequent deposition of these forms of nitrogen as ammonium (NH_4 +) and oxidised nitrogen (NO_X) on soils and waters, and the leaching and runoff of nitrogen from synthetic and organic nitrogen fertilizer inputs, crop residues, mineralization of nitrogen through land use change or management practices, and urine and dung deposition from grazing animals, into groundwater, riparian areas and wetlands, rivers. All NH_3 or NO_X anthropogenic emissions are potential sources of N_2O emissions.
Indirect N_2O emissions are estimated according to Equation 7.1 of the 2006 IPCC Guidelines (IPCC, 2006) on the basis of NO_X and NH_3 national emissions disaggreagated at sectoral level (ISPRA, 2017 [a]) and reported as memo item in the relevant sectors, except for the agriculture sector where emissions are already included in the national totals.
This method assumes that N_2O emissions from atmospheric deposition are reported by the country that produced the original NO_X and NH_3 emissions. In reality, the ultimate formation of N_2O may occur in another country due to atmospheric transport of emissions. Also, the method does not account for the probable lag time between NO_X and NH_3 emissions and subsequent production of N_2O in soils and surface waters. This time lag is expected to be small related to an annual reporting cycle.

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 (CO_2), NO_X as nitrogen dioxide, nitrous oxide (N_2O), methane (CH_4), non methane volatile organic compounds (NMVOC), carbon monoxide (CO), and sulphur dioxide (SO_2). 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:

Total Emission = Emission Factor x Activity Statistic

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

Emission = Σ Point Source Emissions

However, it is necessary to carry out an estimate of the fuel consumption associated with these point sources, so that 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.
Fugitive emissions are also estimated and reported under 1B category and the relevant information are provided in paragraph 3.9.
From the 2015 submission, the UNFCCC Reporting Guidelines require estimating a new source category, emissions from the CO_2 storage and distribution category, but in Italy this activity and the relevant emissions do not occur yet.

According to the IPCC 2006 Guidelines (IPCC, 2006), 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.g 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.

These 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 5.C (Waste incineration).
In fact, energy recovered by these plants is mainly used for district heating of commercial buildings. In particular, for 2016, more than 98% of the total amount of waste incinerated is treated in plants with energy recovery system. To estimate CO_2 emissions, considering the total amount of waste incinerated in plants with energy recovery, carbon content is calculated, as described in paragraph 7.4.2, 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 7.24-7.28. Waste amount is then converted in energy content applying a conversion factor equal to 9.2 GJ/t of waste. In 2016, the resulting average emission factor is equal to 116.5 kg CO_2/GJ.
Emissions from landfill gas recovered are used for heating and power in commercial facilities and reported under 1.A.4.a in biomass. In 2016, the resulting average emission factor is equal to 51.9 kg CO_2/GJ. 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 2016, the resulting average emission factor is equal to 54.5 kg CO_2/GJ.
We allocate these emissions to the 1.A.4 category because the energy produced in these plants, incinerators or landfills, as well as energy produced by biogas collection from manure and agriculture residue, is prevalently auto-consumed for heating and electricity of the buildings or animal recoveries, and only a few amount of energy produced goes to the net. 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 2016, the energy sector accounts for 95.6% of CO_2 emissions, 17.9% of CH_4 and 25.0% of N_2O. In terms of CO_2 equivalent, the energy sector shares 81.1% 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 1990-2016 (Mt CO_2 eq.)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Total Energy	425.5	439.3	459.1	480.2	417.2	404.7	387.0	360.0	345.1	352.5	347.1
CO_2	409.6	423.7	444.1	465.7	402.6	391.6	373.2	346.3	332.3	340.0	334.9
CH_4	11.3	10.9	10.0	9.1	9.4	8.5	9.1	8.9	8.3	8.0	7.7
N_2O	4.6	4.8	5.0	5.3	5.2	4.6	4.8	4.7	4.5	4.6	4.5

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. From 2008 to 2009 the decrease observed in GHG emissions is equal to -10.4% indeed, followed by a slight increase, equal to +2.1% from 2009 to 2010; since then annual variations are always negative till 2015 where emissions increased of 2.2% with respect to 2014 due to a reduction in energy production by hydroelectric which resulted in an increase of energy production from thermoelectric plants to satisfy the energy demand.
In 2016 emissions from the sector decrease of 1.5 % with respect the previous year as a consequence of a shift from coal to natural gas fuel consumption for energy production.

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). From 2010 to 2014 a drop in electricity generation from fossil fuels has been observed in Italy. The drop has been driven both by the economic recession and by the increase of renewable sources for energy production. The use of natural gas and coal is generally driven by the market; in 2011, from one side there was a minor availability (and higher prices) of natural gas imported by pipelines from Algeria and Libya, due to the "spring revolutions" occurring in these countries in that year, on the other side a new coal power plant, one of the biggest in Italy, was fully operative with a production of around 12500 GWh explaining the increasing trend of electricity production from solid fuels.
In "other fuels" a multitude of fuels are included, as biomass, waste, biogas from agriculture residues and waste and synthesis gases from heavy residual or chemical processes. The breakdown is available to the inventory expert allowing emission estimations but it is confidential and not published by the owner of the information, TERNA.

Table 3.2 Production of electricity by sources 1990-2015 (GWh)

Source	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
	GWh										
Hydroelectric	35,079	41,907	50,900	42,927	54,407	47,757	43,854	54,672	60,256	46,970	44,257
Thermoelectric	178,590	196,123	220,455	253,073	231,248	228,507	217,561	192,987	176,171	192,054	199,430
- solid fuels	32,042	24,122	26,272	43,606	39,734	44,726	49,141	45,104	43,455	43,201	35,608
- natural gas	39,082	46,442	97,607	149,259	152,737	144,539	129,058	108,876	93,637	110,860	126,148
- derivated gases	3,552	3,443	4,252	5,837	4,731	5,442	5,000	3,426	3,104	2,220	2,832
- oil products	102,718	120,783	85,878	35,846	9,908	8,474	7,023	5,418	4,764	5,620	4,127
- other fuels	1,196	1,333	6,446	18,525	24,138	25,326	27,340	30,163	31,211	30,151	30,715

Geothermic	3,222	3,436	4,705	5,325	5,376	5,654	5,592	5,659	5,916	6,185	6,289
Eolic and Photovoltaic	0	14	569	2,347	11,032	20,652	32,269	36,486	37,485	37,786	39,793
Total	**216,891**	**241,480**	**276,629**	**303,672**	**302,062**	**302,570**	**299,276**	**289,803**	**279,828**	**282,994**	**289,769**

Source: TERNA

More in general, the share of the total energy consumption by primary sources in the period 1990- 2016, reported in Table 3.3, shows an evident change from oil products and solid fuels to natural gas and renewable while the share of consumption of electricity is variable and driven by the market.

Table 3.3 Total energy consumptions by primary sources 1990-2015 (%)

Sources	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
						%					
renewable	0.7	0.9	1.1	2.0	4.3	4.7	5.1	7.5	7.4	7.6	7.5
solid fuels	9.6	7.9	6.9	8.6	8.0	9.0	9.4	8.2	8.3	7.7	7.0
natural gas	23.7	25.7	31.4	36.0	36.2	34.6	34.8	33.2	30.6	32.6	34.6
crude oil	56.2	54.9	49.5	43.1	38.5	37.5	35.3	33.7	34.5	34.6	34.4
primary electricity	9.8	10.5	11.1	10.3	13.1	14.1	15.3	17.4	19.3	17.6	16.5

Source: Ministry of Economic Development

Further analysis on the electricity generation time series and CO_2 emission factors are available at the following web address: http://www.sinanet.isprambiente.it/it/sia-ispra/serie-storiche-emissioni/fattori-di-emissione-per-la-produzione-ed-il-consumo-di-energia-elettrica-in-italia/view.

Recalculations

In 2015 submission, recalculations regarded the whole sector due to the application of the IPCC 2006 Guidelines which provide new default emission and oxidation factors for all the fuels In particular in the Guidelines (IPCC, 2006) oxidation factors are supposed to be equal to 1 for all the fuels. Time series have been reconstructed for all the fuels taking in account the default values proposed by the Guidelines and national circumstances. In Annex 6 more detailed information is provided especially with regard to time series of country specific CO_2 emission factors.

In 2018 submission some recalculations occurred as in the following.
The whole time series of road transport emissions has been recalculated because of the update of the version of the model used COPERT 5 v.5.1.
Fuel consumption time series of solid fuels have been updated taking in account the last submission of energy balance from the Ministry of Economic Development to the Joint Questionnaire OECD/IEA/EUROSTAT. Detailed information is reported in paragraph 3.5.3.
The energy conversion factor from toe to GJ has been changed from 41.8398 to 41.868 according to the international statistics. As a consequence CO_2 emission factors have been slightly revised from 2005 for carbon coke and coke oven coke, from 2008 for natural gas and from 2013 for coal and petcoke. Updated emission factors are provided in Annex 6.
Waste fuel consumption for commercial heating activity data has been updated from 2014 because of the update of activity data for some industrial waste plants. Detailed information is reported in paragraph 3.6.
Emissions from aviation have been recalculated from 1990 on the basis of information on activity data and emission factors provided by Eurocontrol. Additional information is provided in paragraph 3.5.1.
Other minor changes in activity data occurred for 2015.

Recalculations affected the whole time series 1990-2015 for all gases.
The following table shows the percentage differences between the 2018 and 2017 submissions for the total energy sector and by gas.
Recalculation resulted for the energy sector in an increase of GHG emissions in 1990 of 1.2% and decrease in 2015 of 0.5% mainly due to the update of solid fuel consumption activity data from EUROSTAT.

Table 3.4 Emission recalculations in the energy sector 1990-2015 (%)

Year	GHG	CO2	CH4	N2O
1990	1.17	1.23	-0.52	0.04
1991	1.22	1.28	-0.67	0.10
1992	0.92	0.97	-0.55	-0.13
1993	0.61	0.67	-0.56	-1.13
1994	0.90	1.02	-0.54	-5.11
1995	0.89	1.06	-0.58	-9.80
1996	0.67	0.93	-0.68	-15.29
1997	0.87	1.19	-0.60	-18.69
1998	0.59	0.96	-0.57	-22.06
1999	0.49	0.89	-0.53	-24.49
2000	0.89	1.02	-0.46	-7.63
2001	0.69	0.82	-0.43	-7.67
2002	0.59	0.70	-0.39	-7.34
2003	0.59	0.69	-0.32	-6.23
2004	0.51	0.60	-0.22	-6.03
2005	0.77	0.79	-0.11	0.40
2006	0.55	0.57	-0.01	0.24
2007	0.38	0.39	0.12	-0.09
2008	0.32	0.33	0.18	-0.10
2009	-0.05	-0.06	0.17	-0.02
2010	-0.11	-0.11	0.22	-0.16
2011	0.15	0.13	0.97	0.17
2012	0.44	0.44	0.57	0.29
2013	0.15	0.13	0.78	0.55
2014	0.44	0.42	0.91	0.71
2015	-0.48	-0.50	0.42	-0.36

Source: ISPRA elaborations

Key categories

Key category analysis, for the years 1990 and 2016, identified 23 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, key categories for 2016 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 2016

KEY CATEGORIES	without LULUCF	with LULUCF	Relevant paragraphs	Notes
1 Transport - CO_2 Road transportation	L,T	L,T	3.5.3	Tables 3.21-3.29
2 Other sectors - CO_2 commercial, residential, agriculture gaseous fuels	L,T	L,T	3.6	Tables 3.32-3.35
3 Energy industries - CO_2 solid fuels	L,T	L,T	3.3	Tables 3.6-3.9
4 Energy industries - CO_2 gaseous fuels	L,T	L,T	3.3	Tables 3.6-3.9
5 Manufacturing industries and construction - CO_2 gaseous fuels	L,T1	L,T1	3.4	Tables 3.10-3.13
6 Energy industries - CO_2 liquid fuels	L,T	L,T	3.3	Tables 3.6-3.9
7 Other sectors - CO_2 commercial, residential, agriculture liquid fuels	L,T	L,T	3.9	Tables 3.32-3.35

KEY CATEGORIES	without LULUCF	with LULUCF	Relevant paragraphs	Notes
8 Manufacturing industries and construction - CO_2 liquid fuels	L1,T	L1,T	3.4	Tables 3.10-3.13
9 Fugitive - CH_4 Oil and natural gas - Natural gas	L,T	L,T	3.9	Tables 3.40-3.46
10 Other sectors - CH_4 commercial, residential, agriculture biomass	L,T	L,T	3.6	Tables 3.32-3.35
11 Manufacturing industries and construction - CO_2 solid fuels	L,T	L1,T	3.4	Tables 3.10-3.13
12 Other sectors - CO_2 commercial, residential, agriculture other fossil fuels	L1,T	L1,T1	3.6	Tables 3.32-3.35
13 Other sectors - N_2O commercial, residential, agriculture biomass	L2,T	L2,T	3.6	Tables 3.32-3.35
14 Transport - CO_2 Waterborne navigation	L1	L1	3.5.4	Table 3.30
15 Transport - CO_2 Civil Aviation	L1,T1	L1,T1	3.5.1	Tables 3.15-3.19
16 Fugitive - CO_2 Oil and natural gas - Oil	L1,T2	L1	3.9	Tables 3.40-3.46
17 Other sectors - N_2O commercial, residential, agriculture liquid fuels	L2		3.6	Tables 3.32-3.35
18 Manufacturing industries and construction - N_2O liquid fuels	T2		3.4	Tables 3.10-3.13
19 Other sectors - CO_2 commercial, residential, agriculture solid fuels	T1		3.6	Tables 3.32-3.35
20 Transport - CH_4 Road transportation	T2		3.5.3	Tables 3.21-3.29

With reference to the box, fourteen key categories (n. 2-8, 10-13, 17-18, and 19) 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.
Ten out of fourteen key categories refer to CO_2 emissions, two categories refer to CH_4 and N_2O emissions from the use of biomass in the residential sector, the other two categories refer to N_2O emissions from liquid fuels in manufacturing and other sectors.
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 TERNA 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 the energy emissions trend, for CO_2, N_2O and CH_4, is mainly driven by the thermoelectric production, see Tables A2.1 and A2.4 for more details.
In the following table emissions in CO_2 equivalent for stationary combustion, key category at level assessment are summarized.
From 1990 to 2016, 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 CO_2 emissions from combustion of liquid fuels and an increase of emissions from gaseous fuels used in the different sectors.
The increase of CH_4 emissions from other sector reflects the increase of the use of biomass for residential heating.

Table 3.5 Stationary combustion, GHG emissions in 1990 and 2016

	1990	2016
Energy industries - CO_2 liquid fuels	81,085	18,188
Energy industries - CO_2 solid fuels	38,646	37,299
Other sectors - CO_2 commercial, residential, agriculture liquid fuels	38,274	14,965
Other sectors - CO_2 commercial, residential, agriculture gaseous fuels	36,401	57,924
Manufacturing industries and construction - CO_2 liquid fuels	34,677	7,994
Manufacturing industries and construction - CO_2 gaseous fuels	32,110	29,750
Manufacturing industries and construction - CO_2 solid fuels	24,926	8,802

	1990	2016
Energy industries - CO_2 gaseous fuels	16,573	48,090
Other sectors - CH_4 commercial, residential, agriculture biomass	997	2,211
Other sectors - N_2O commercial, residential, agriculture liquid fuels	996	764
Manufacturing industries and construction - N_2O liquid fuels	941	361
Other sectors - CO_2 commercial, residential, agriculture solid fuels	899	0
Other sectors - N_2O commercial, residential, agriculture biomass	532	1,208
Other sectors - CO_2 commercial, residential, agriculture other fossil fuels	526	4,920

Source: ISPRA elaborations

Another group of key categories (n. 1, 14, 15, and 20) 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 the ninety years, in particular CO_2 from air transport and road transport, as can be seen in Table 3.19 and Table 3.28, respectively. In the last years CO_2 emissions from road transport started to decrease as a consequence of the economical crisis and the reduction of the average fuel consumption per kilometre of the new vehicles. The trend of N_2O and CH_4 emissions is linked to technological changes occurred in the period.
Finally, the last two key categories (n.9 and 16) 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 2016 taking into account LULUCF emissions and removals.
CO_2 fugitive emissions from flaring in refineries, CO_2 fugitive emissions from venting and flaring and N_2O emissions from road transportation are key categories only for 1990 at level assessment taking in account the uncertainty.

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, N_2O and CH_4 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, 2016 data are reported, while the full time series is available on website: http://dgerm.sviluppoeconomico.gov.it/dgerm/ben.asp. At the same web address data communicated by Italy to the Joint Questionnaire OECD/IEA/EUROSTAT are available in the format revisited by EUROSTAT. Some differences between data communicated to the international organizations and EUROSTAT publication have been observed and are under investigation; they should mainly due to the use of default instead of country specific energy conversion factors and different classification criteria of fuels.
Data submitted by the Ministry of Economic Development to the Joint Questionnaire IEA/OECD/EUROSTAT have been used, in particular for solid fuel consumptions, and fuel consumption in transport and other non industrial sectors. At the time it was not possible to reconstruct the entire time series

and data from national energy balance (BEN) have been also used for the all time series; moreover the complete use of the energy data provided by the MSE to the Joint Questionnaire is planned in substitution of the national energy balances.
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, 2006) but emissions of other GHGs and other pollutants are included. CORINAIR methodology (EMEP/EEA, 2016) 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” (MSE, several years)Primary fuels. According to the IPCC 2006 Guidelines (IPCC, 2006) in the energy sector are reported only emissions from the combustion of lubricants in two strokes engines while the other emissions are reported in the IPPU sector. From 2001 onwards, it has been necessary to use also these 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.
In this category, gaseous fuels refer to natural gas while solid fuels mainly to coal used to produce energy and derived gases used in the integrated iron and steel plants; liquid fuels include residual oil fuel consumption used for energy production in power plants and different fuels used in refineries. The CO_2 implied emission factor trend for the sector is driven by the liquid fuel consumption in the petroleum refining industry (93% of the total of liquid) where many fuels, with very different emission factors, are used, such as refinery gas, that have an average emission factor value equal to 58.2 t/TJ, and petroleum coke with an average emission factor equal to 96.3 t/TJ. In the last years, due also to the economical crisis, a reduction in the consumption of synthesis gas from heavy residual fuels (in 2016 the average emission factors t CO_2/TJ values are about 79.7 and 104.0 for heavy residual fuels and synthesis gas respectively) is observed, resulting in the interannual variations. Emission factors time series for these fuels are reported in Annex 6.

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. These producers account in 2016 for 93.6% 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.

Under biomass, wood and charcoal consumption and relevant emissions are reported untill 2007; CO_2 emission factor is shown in Table 3.12 while CH_4 and N_2O emission factors are equal to 30 g/GJ and 4 g/GJ respectively. From 2008 also bioliquid fuel is used and included under biomass (CH_4 and N_2O emission factors equal to 12 g/GJ and 2 g/GJ respectively), resulting in the decrease of the average emission factor.
Other fuels subcategory refer mainly to fuel consumptions of other liquid, solid and gaseous fuels such as industrial wastes (89.8 tCO_2/TJ), that are more than half of the total TJ of the subcategory, as plastics, rubber, and solvents, synthesis gas from heavy residual (104.0 tCO_2/TJ in 2016) and other liquid fuels (76.6 tCO_2/TJ in 2016); the average CO_2 emission factor has been calculated for the whole time series and it is equal to 93.8 t/TJ in 2016.
CO_2 implied emission factor trend of liquid fuels for this category is driven by the mix of high and low sulphur fuel oil consumptions that is changed in the years as a consequence of the adoption of air quality European Directives introducing air pollutants ceilings at the stacks, and the policies at national level which established stringent ceiling for new and old plants and a timing scheduled for their implementation. The CH_4 implied emission factor is the weighted average of gasoil and residual oil emission factors equal to 1.5 g/GJ and 3 g/GJ respectively. The general decreasing trend is due to the minor use of fuel oil for energy production, with a minimum in 2016, while the amount of gasoil, which is related to the start up of power plants and to the gasoil used in stationary engines, has a more stable trend.

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 2016 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, OECD, 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. These reports are prepared by independent qualified verifiers and concern the CO_2 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 CO_2 emissions, and also N_2O and CH_4 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 CO_2 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. These data are reported in the other energy industries, Tables 1.A.1.b and 1.A1.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 shows a decrease in fuel consumption and overall decrease in GHG emissions. However, a slower increase is observed in CH_4 emissions due to the increase in use of natural gas and biomass.

Table 3.6 Public electricity and heat production: Energy data (TJ) and GHG emissions, 1990-2016

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Fuel consumption (TJ)	1,417,987	1,466,844	1,666,089	1,794,195	1,436,165	1,430,348	1,386,070	1,205,257	1,097,942	1,205,336	1,206,040
GHG (Gg)	107,195	110,209	116,269	121,083	94,326	93,451	92,118	78,906	71,778	79,057	76,369
CO_2 (Gg)	106,797	109,815	115,901	120,660	93,973	93,051	91,696	78,472	71,349	78,641	75,980
CH_4 (Gg)	3.7	4.0	3.8	4.1	3.5	4.0	4.1	4.4	4.4	4.2	4.3
N_2O (Gg)	1.0	1.0	0.9	1.1	0.9	1.0	1.1	1.1	1.1	1.0	0.9

Source: ISPRA elaborations

In 2016, an slight increase in fuel consumptions and decrease of CO_2 emissions is observed as a consequence of the shift from coal to natural gas for energy production.
As the main data source refers to the all 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 (12 plants in 2016), 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. These power plants are generally owned by other companies but are located inside the refinery premises or just sideway. In 2016 the power plants included in this source category have generated 8.3% 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 (MSE, several years).
For the part of the energy and related emissions due to the power plants, the source is TERNA (see Annex 2 for further details). The quota of total energy consumption from electricity production included in 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 CO_2 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 2016 is reported, with energy and emission data.

Table 3.7 Refineries, CO_2 emission calculation, year 2016

	Consumption, TJ				CO_2 emissions, Gg			
REFINERIES	Petroleum coke	Ref. gas	Liquid fuels	Natural gas	Petroleum coke	Ref. gas	Liquid fuels	Natural gas
energy			110,150	73,133			8,915	4,219
furnaces	21,858	90,803	6,823		2,106	5,286	501	
TOTAL				302,768				21,026

Source: ISPRA elaborations

From 2005, the weighted average of CO_2 emission factor reported by operators in the context 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 fuels 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, explains the general growth of the IEF for liquid fuel reported in the CRF for this sector.

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

Liquid fuel consumptions in petroleum refining (TJ), 1990-2016

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Refinery gas	119,257	138,257	118,581	129,925	133,618	117,930	100,935	99,076	93,416	114,007	102,912
Naphta	527	869	4,447	2,451	1,221	1,093	784	479	1,772	146	0
Pet coke	29,140	28,672	40,622	49,902	42,825	45,427	40,680	29,869	30,911	29,478	21,858
Synthesis gas	0	0	36,425	65,021	78,628	63,053	66,277	75,332	71,573	61,763	63,282
Fuel oil	87,553	101,483	86,741	76,135	75,584	82,765	83,985	39,301	30,666	31,236	38,744
LPG	2,026	1,980	3,255	2,595	1,796	1,243	1,059	1,428	645	1,583	1,243
Gasoil	2,561	2,072	7,264	11,325	880	1,047	931	171	1,196	0	1,542
Gasoline	3,429	4,524	304	959	0	0	0	0	0	0	0
Total	244,492	277,857	297,639	338,312	334,552	312,558	294,652	245,656	230,179	238,212	229,581

3.3.2.3 Uncertainty and time-series consistency

The combined uncertainty in CO_2 emissions from refineries is estimated to be about 4.2% in annual emissions; a higher uncertainty, equal to 50.1%, is calculated for CH_4 and N_2O emissions because of the uncertainty levels attributed to the related emission factors.
Montecarlo analysis has been carried out to estimate uncertainty of CO_2 emissions from stationary combustion of solid, liquid and gaseous fuels emissions, resulting in 5.1%, 3.3% and 5.8%, respectively. Normal distributions were 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, 2010-2016 are reported.

Table 3.8 Refineries, GHG emission time series

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
CO_2 emissions, Mt	17.2	19.6	22.3	26.4	28.0	26.9	25.7	22.1	21.0	20.9	21.0
CH_4 emissions, Gg	0.46	0.53	0.59	0.67	0.72	0.69	0.68	0.56	0.52	0.51	0.52
N_2O emissions, Gg	0.49	0.56	0.60	0.68	0.68	0.64	0.61	0.51	0.48	0.50	0.48
Refinery, total, Mt CO_2 eq	17.4	19.7	22.5	26.6	28.2	27.1	25.9	22.3	21.2	21.1	21.2

Source: ISPRA elaborations

An upward trend in emission levels is observed from 1990 to 2010 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 2010 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.

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 2018 submission, recalculation occurred because of the updating of the energy conversion factor according to the international statistics.

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 2016 the power plants included in this source category have generated about 2% of all electricity produced with combustion processes in Italy.
With regard to the manufacture of other solid fuels, in Italy, charcoal was produced in the traditional way until the sixties while now it is prevalently produced in modern furnaces (e.g with the VMR system) where exhaust gases are collected and recycled to produce the energy for the furnace itself. This system ensures

good management of the exhausts and the temperature, so that any waste of energy is prevented and emissions are kept to a minimum.
So CH_4 emissions from the production of charcoal are not accounted for also considering that the emission factor available in the Revised 1996 IPCC Guidelines, in Table 1-14 vol.3 (IPCC, 1997), refers to production processes in developing countries not applicable to our country anymore. Moreover in the IPCC Good Practice Guidance as well as in the IPCC 2006 Guidelines no guidance is supplied for charcoal production.

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.

CH_4 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 CO_2 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 CH_4 and N_2O emissions on account of the uncertainty levels attributed to the related emission factors.
Montecarlo analysis has been carried out to estimate uncertainty of CO_2 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, 2010-2016 are reported.

Table 3.9 Manufacture of solid fuels, GHG emission time series

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
CO_2 emissions, Mt	12.4	11.6	10.6	13.5	11.4	12.1	10.3	7.6	7.3	5.6	6.8
CH_4 emissions, Gg	4.9	3.8	2.3	1.2	0.6	0.7	0.6	0.5	0.5	0.5	0.5
N_2O emissions, Gg	0.12	0.10	0.08	0.11	0.08	0.09	0.09	0.06	0.06	0.04	0.05

Total, Mt CO_2 eq	12.6	11.7	10.7	13.6	11.5	12.1	10.3	7.6	7.3	5.6	6.8

Source: ISPRA elaborations

The trend of CO_2 and N_2O 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. In 2012 a further drop occurred for the economic crisis and for environmental constrains of the main iron and steel integrated plants that should reduce its productions. In 2015 a drop is still observed (around 1.7 Mt CO_2) consistently with the production activities reduction of the main iron and steel integrated plants.
The trend of CH_4 emissions is driven by the coke production trend, decreased from 6.4 Mt in 1990 to 2.0 Mt in 2016 and by the renewal of the production plants. In particular the strong reduction of CH_4 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, as well as in 2013, 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 CO_2 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 CO_2 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 CO_2 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 2018 submission, recalculations occurred for this category for all the time series due to the update of solid fuel consumptions according to energy data provided to the Joint Questionnaire OECD/IEA/EUROSTAT. Moreover energy conversion factors have been updated according to the international statistics.

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 SO_2 emissions are estimated.
In 2016, energy use in industry account for 13.4% of total national CO_2 emissions, 0.6% of CH_4, 4.0% of N_2O. In term of CO_2 equivalent, the manufacturing industry shares 11.2% of total national greenhouse gas emissions.

Four key categories have been identified for this sector in 2016, for level and trend assessment, using both the IPCC Approach 1 and Approach 2:

Manufacturing industries and construction - CO_2 gaseous fuels (L, T);
Manufacturing industries and construction - CO_2 solid fuels (L, T);
Manufacturing industries and construction - CO_2 liquid fuels (L1, T);
Manufacturing industries and construction - N_2O liquid fuels (T2).

All these categories are key categories for 1990, with and without LULUCF and, except N_2O from liquid fuels, are also key category including the LULUCF estimates in the 2016 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, 2000, 2005 and 2010-2016. Industrial emissions show oscillations, related to economic cycles.

Table 3.10 Manufacturing industry, GHG emission time series

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
CO_2 emissions, Gg	91,713	90,001	90,762	82,313	61,372	60,264	54,555	50,544	51,544	49,876	46,955
CH_4 emissions, Gg	6.78	6.95	5.68	6.23	5.48	8.96	8.78	11.34	12.11	11.06	11.11
N_2O emissions, **G**g	4.54	3.93	4.33	4.85	3.60	3.35	2.87	2.70	2.68	2.58	2.39
Industry, total, Gg CO_2 eq	93,235	91,346	92,195	83,914	62,581	61,488	55,629	51,633	52,645	50,920	47,945

Source: ISPRA elaborations

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

Table 3.11 Trend in greenhouse gas emissions from the manufacturing industry sector, 1990-2016

GAS/SUBSOURCE	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
CO_2 (Gg)											
1.A.2.a Iron and Steel	24,389	23,603	21,990	18,482	15,348	16,001	15,397	11,602	11,535	9,424	10,609
1.A.2.b Non-Ferrous Metals	728	902	1,251	1,176	1,169	1,143	1,079	1,119	1,068	1,105	1,018
1.A.2.c Chemicals	19,424	17,355	12,280	10,946	8,237	7,605	7,503	8,004	7,895	7,927	8,493
1.A.2.d Pulp, Paper and Print	3,079	4,163	4,236	4,594	4,605	4,450	4,315	4,264	4,146	4,662	4,039
1.A.2.e Food	3,859	5,070	6,266	6,494	4,433	4,303	3,533	3,533	3,476	3,564	3,473
1.A.2.f Non-metallic minerals	20,980	18,637	24,559	23,559	17,055	18,247	14,605	13,423	14,075	13,174	11,458
1.A.2.g Other	19,255	20,271	20,180	17,061	10,525	8,515	8,123	8,600	9,349	10,019	7,865
CH_4 (Mg)											
1.A.2.a Iron and Steel	3,795	4,226	3,093	3,304	2,880	3,254	3,315	2,612	2,663	2,062	2,280
1.A.2.b Non-Ferrous Metals	13	16	26	24	22	21	20	22	21	23	18
1.A.2.c Chemicals	801	678	318	330	199	180	181	168	169	175	190
1.A.2.d Pulp, Paper and Print	77	94	91	104	85	81	78	83	79	90	74
1.A.2.e Food	105	128	175	395	820	4,048	4,035	7,379	8,128	7,644	7,569
1.A.2.f Non-metallic	1,412	1,276	1,463	1,624	1,197	1,161	967	879	844	842	811

GAS/SUBSOURCE	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
minerals											
1.A.2.g Other	577	537	516	453	276	212	183	200	209	228	169
N_2O (Mg)											
1.A.2.a Iron and Steel	410	414	366	387	305	327	316	245	246	186	211
1.A.2.b Non-Ferrous Metals	13	16	25	23	22	21	20	21	20	21	18
1.A.2.c Chemicals	349	286	159	150	111	98	101	94	110	97	98
1.A.2.d Pulp, Paper and Print	64	82	81	89	82	79	77	77	75	84	71
1.A.2.e Food	52	53	76	89	57	120	101	166	181	176	168
1.A.2.f Non-metallic minerals	2,644	2,285	2,630	2,986	2,183	2,102	1,715	1,533	1,451	1,427	1,352
1.A.2.g Other	1,006	795	997	1,124	835	607	537	565	596	584	471

Source: ISPRA elaborations

A general trend of reduction in emissions is observed from 1990 to 2016; some sub sectors reduced sharply (iron and steel, non metallic minerals), other sub sectors (non ferrous metals, pulp and paper) increased their emissions. In 2009 an overall reduction of emissions for all the sectors occurred due to the effects of the economic recession. In 2010 production levels restored for iron and steel, but a further significant drop is noted in 2013 due to environmental constraints of the main integrated iron and steel plant in Italy, located in Taranto, which had to reduce its steel production level. Non metallic minerals emission trend is driven by the cement industry which strongly reduced its production levels in 2009 and further in 2012, in relation to the economic recession and the crisis of building construction sector; a further decrease of this sector is observed in 2016. The increase of CH_4 and N_2O emissions in the last years for food sector is driven by the increase of biomass used as a fuel in this sector.

3.4.2 Source category description

The category 1.A.2 comprises seven 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 Non-metallic minerals, 1.A.2.g 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. From 2015 only one integrated plant remain in operation. The maximum production was around 11 Mt/y in 1995 and in 2005-2008, with lower values in other years and the lowest of 5 Mt in 2015.

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.

With the aim to avoid double counting process-related emissions from the iron and steel subcategory are reported in the industrial processes sector. CH_4 emissions are estimated for each emitting activities according to the classification of activities described in the EMEP/EEA guidebook and consequently allocated at the combustion or industrial processes sector in consideration of the relevant methodological issues. More in detail CH_4 process emissions for pig iron and steel production are already allocated to the industrial processes sector as well as fugitive CH_4 emissions from coke production are reported under fugitive emissions while CH_4 emissions from the combustion of fuels are allocated to the energy sector.

This subsector is one of the most important of 1.A.2 category and accounts, in 2016, for 22.3% of total 1.A.2 GHG emissions, and 2.5% of total national emissions.

Non-Ferrous Metals
In Italy, the production of primary aluminium stopped in 2013 (and was 232 Gg in 1990) while secondary aluminium accounts for 350 Gg in 1990 and 722 Gg in 2016. These productions however use electricity as the primary energy source so the emissions due to the direct use of fossil fuels are limited.
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. Magnesium production is not occurring. 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
CO_2, CH_4 and N_2O 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 2012, with limited yearly variations, and a reduction in the last years.
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 2016 the production has been greatly reduced, with less than half of the 1990 production still occurring in 2016.
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 CO_2 emissions due to electricity generation has reduced from 1990 to 2016.

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 2016. Most of the pulp was imported in 1990, while in 2016 half of the pulp used is produced locally from recycled paper. The paper production is expanding and activity data (total paper produced) were 6.3 Mt in 1990 and 8.9 Mt in 2016. 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 CO_2 emissions due to electricity generation has strongly reduced from 1990 to 2016.

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 fuel consumption was estimated to be 62 PJ in 1990 and 109 PJ in 2016, about half of energy from biomass. Value added at constant prices has increased of 0.6% per years from 1990 to 2003 and almost constant from 2004.
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 CO_2 emissions due to electricity generation has reduced from 1990 to 2016.

Non-metallic minerals
This sector, which refers to construction materials, is 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 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 subsector is the most important of 1.A.2 category and accounts, in 2016, for 24.2% of total 1.A.2 GHG emissions, and 2.7% of total national emissions.

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.
The remaining "other industries" include furniture and other various "made in Italy" products that produce not negligible amounts of 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, reported in category 1.A.1.a, the percentage of the category 1.A.2.g CO_2 emissions due to electricity generation has reduced in the last years.
Indirect emissions of the whole 1.A.2 sector are reported under this category but we plan to report them in the relevant subsectors for the next submission.

3.4.3 Methodological issues

Energy consumption for this sector is reported in the BEN (see Annex 5). The data comprise specification of consumption for 13 sub-sectors and more than 25 fuels. These 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; CO_2 emission factors used for 2016 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 1.00 for solid, liquid and gaseous fuels, as suggested by the IPCC 2006 guidelines (IPCC, 2006).
For some fuels as natural gas, coal and residual oil, country specific emission factors are available for the whole time series; so their time series takes into account different oxidation factors according to the improving of combustion efficiency occurred in the nineties, but considering the value equal to 1.00 from 2005.
For petroleum coke, synthesis gas from heavy residual, refinery gases, iron and steel derived gases, coking coal, anthracite, coke oven coke from 2005, and for residual gases from chemical processes, from 2007, CO_2 emission factors have been calculated based on the data reported by operators under the EU ETS scheme. See Annex 6 for further details.
For the other fuels where national information was not available default emission factors provided by the IPCC 2006 Guidelines have been used (IPCC, 2006).

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	73.300	3.101	3.067
Jet gasoline	70.000	3.101	2.931
Jet kerosene	71.500	3.153	2.994
Petroleum Coke in industry*	93.459	3.121	3.913
Petroleum Coke in refineries*	96.332	3.416	4.033
Gasoil	74.100	3.186	3.102
Orimulsion	77.000	2.118	3.224
Fuel oil*	76.604	3.143	3.207
Heavy residual in refineries*	79.700	3.104	3.337
Synthesis gas from heavy residual*	103.993	0.929	4.354
Residual gases from chemical processes*	48.814	2.367	2.044
Gaseous fuels			
Natural gas*	57.693	1.978 (sm^3)	2.415
Solid fuels			
Steam coal*	95.124	2.351	3.983
"sub-bituminous" coal	96.100	1.816	4.024
Lignite	101.000	1.202	4.229
Coking coal*	94.240	2.969	3.946
Anthracite*	101.637	2.924	4.255
Coke oven coke*	109.495	3.217	4.584
Biomass			
Solid Biomass*	(94.600)	(0.962)	(3.961)
Derived Gases			
Refinery Gas*	58.211	2.652 (sm^3)	2.437
Coke Oven Gas*	43.700	0.758 (sm^3)	1.830
Oxygen converter Gas*	203.868	1.309 (sm^3)	8.536
Blast furnace*	247.893	0.952 (sm^3)	10.379
Other fuels (fossil)			
Municipal solid waste*	116.457	1.071	4.486
Industrial solid waste*	78.592	2.019	3.291
*country specific emission factors			

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, the 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 the BEN than ETS, at fuel sector level, a verification procedure is carried out.

Since 2007 data, ISPRA verifies actual data from both sources and communicates potential discrepancies to MSE. Thus a verification procedure is started that can eventually 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.

Biomass fuel consumption in the sector is driven by the use of wood in the non-metallic sub category and biogas from agriculture residues in the food sub category. The trend of the implied emission factors are driven in the last years by the exponential increase of the biogas fuel consumption, observed mainly in the food processing industry, and the strong decrease of wood consumption in industry, as supplied by the national energy balance (MSE, several years [a]).

Other fuels include industrial waste fuel consumption reported in the non-metallic mineral sub category. The use of industrial waste in manufacturing industries is linked to the use in the last 10 years in cement production plants and refers to the consumption of RDF (Refuse-derived Fuel), plastics, tyres, waste oils and solvents. The average emission factor time series is reported in Table A6.12 of Annex 6 and it have been derived from data reported to the ETS by the plants using that fuel.

Iron and steel
For this sector, all main installations are included in EU ETS, but only from 2013 all sources of emissions are included. In the previous years only part of the processes of integrated steel making was 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.
So the EU ETS data have been of limited use for this subsector and the procedure set up starting from the total carbon input to the steel making process, is 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 national energy balance 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 CO_2 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 2016 is equal to 72.2 t/TJ and the trend is quite stable with figures around 70 t/TJ. CH_4 implied emission factor is equal to 23.3 kg/TJ in 2016 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, 2016). Apart from combustion emissions, the heating of plant feedstock and product can lead to substantial CH_4 emissions which are to be accounted for in the combustion process.

Non-Ferrous Metals
These plants are mostly excluded from EU ETS; primary aluminium producing plants should have been included from 2013, but the only Italian plant closed in the same year. These 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. According to the national Energy Balance no more solid fuels are used from 2016 in this subsector.

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, which report also under the E-PRTR, are included from 2013. In this case, the 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 TERNA 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. The relevant CO_2 emission factor is reported in Table 3.12 above.
Fuel consumptions of derived chemical and petrochemical fuels, which could be considered as petrol derived fuels, were reported in the past in the “other fossil fuels” category for chemicals industries. With the aim to improve the comparison between reference and sectoral approaches, these fuels have been reported under the liquid fuel category. The average CO_2 emission factor at sectoral level for liquid fuels is driven by the weight of synthesis gases from chemical processes fuel consumptions which have an average CO_2 emission factor close to that of refinery gas. The relevant CO_2 emission factor is 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.
From 2010 submission CH_4 and N_2O 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 in 2009 the use of biomass sharply reduced with a further reduction in the following years to return in the last three years at the same level of 2009. 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. From 2013 only biogas is included and, in 2016, CO_2 emission factor is equal to 56.1 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.
Liquid fuel refers to fuel oil and LPG fuel consumption driving the variability of the average emission factors.
For the years up to 2002, solid fuel consumption was mainly related to the consumption of coke and small amount of lignite. From 2012 the fuel consumption and relevant emission factors refers only to anthracite.
Biomass includes fuel consumption of steam wood and biogas from food industrial residual. The CH_4 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 CH_4 equal to 153 kg/TJ, while in the other manufacturing industries biomass refers to wood and similar with an emission factor for CH_4 equal to 30 kg/TJ.
CH_4 emissions from biogas fuel combustion take in account the technology used to produce energy and heat from biogas combustion, usually stationary engines, which is not fully efficient and results in higher emissions of VOC, CO and PM. The emission factor is reported in the Corinair Guideboook (EMEP/CORINAIR, 2007) as the maximum for stationary engines. We plan to collect the relevant information at plant level to update this emission factor taking into account the improvement in technology in the last years with respect to the nineties.
Biogas from food industrial residual has an emission factor for N_2O, equal to 3 kg/TJ, while wood and similar have an emission factor equal to 4 kg/TJ.

Non-metallic minerals
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, the data for construction material are reported separately and they can be cross cheeked 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. CH_4 emission factor is equal to 27.5 kg/TJ and refers to the use of these non conventional fuels for the cement production (EMEP/EEA, 2009).

Other
This sector comprises emissions from many different industrial subsectors, mainly not subject to EU ETS.

3.4.4 Uncertainty and time-series consistency

The combined uncertainty in CO_2 emissions for this category is estimated to be about 4% in annual emissions; a higher uncertainty is calculated for CH_4 and N_2O 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-g.

Montecarlo analysis has been carried out to estimate uncertainty of CO_2 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.

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, 1990-2016 (TJ)

	1990	1995	2000	2005	2010	2013	2014	2015	2016
1.A.2 Manufacturing Industries and Construction	**1,324,054**	**1,355,830**	**1,387,698**	**1,298,130**	**966,962**	**851,347**	**869,396**	**832,472**	**798,825**
a. Iron and Steel	330,622	318,930	313,948	289,947	235,477	181,677	178,871	138,043	159,915
b. Non-Ferrous Metals	11,868	15,023	20,476	19,952	19,469	18,978	18,155	18,456	17,531
c. Chemicals	292,180	270,420	203,174	179,946	141,043	136,396	134,301	132,935	140,777
d. Pulp, Paper and Print	50,554	70,361	74,208	79,687	79,067	74,200	72,183	80,546	70,041
e. Food Processing, Beverages and Tobacco	62,176	85,194	103,622	107,941	78,465	109,330	113,278	110,603	109,201
f. Non-metallic minerals	276,790	268,626	341,476	342,031	244,519	190,684	198,233	191,602	175,356
g. Other	299,863	327,278	330,795	278,628	168,922	140,083	154,373	160,287	126,005

Source: ISPRA elaborations

Emission levels observed from 1990 to 2005 are nearly constant with some oscillations, linked to the economic cycles. After year 2005 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 energy efficiency. For the iron and steel sector, a drop is observed in the last years coherent with the reduction of the production activities in the main national iron and steel integrated plants.

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-g) 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

Recalculations occurred for this category since 1990 because of the update of solid fuels consumptions according to energy data submitted to EUROSTAT resulting in an increase of energy and CO_2 emissions in the nineties especially for the iron and steel subcategory.
Energy conversion factor has been updated according to the international statistics resulting in the updating of CO_2 emission factors from 2005 carbon coke and coke oven coke, from 2008 for natural gas and from 2013 for coal and petcoke. Different petcoke emission factors for refineries and other industry have been determined on the basis of ETS to improve the CO_2 emission estimates at sub sectoral level. Updated emission factors are provided in Annex 6.
The recalculation of the 1.A.2 subsector resulted in a increase of 8.5% in 1990 and decrease of 3.2% in 2015 for CO_2.

3.4.7 Source-specific planned improvements

A revision of fuel consumption time series at sub-sectoral level is planned for the next submission on the basis of energy data communicated by the Ministry of Economic Development to the Joint Questionnaire OECD/IEA/EUROSTAT after a verification and comparison with data up to now used and available in the National Energy Balance reports (MSE, several years).

3.5 Transport

This sector shows an increase in emissions over time, reflecting the trend observed in fuel consumption for road transportation which account for more than 90% of GHG sectoral emissions. The mobility demand and, particularly, the road transportation share have increased in the period from 1990 to 2016, although since 2008 emissions from the sector begin to decrease.
Emissions show an increase of about 2.4 % from 1990 to 2016, and this results from an increase of about 26.7% from 1990 to 2007 and from a decrease of about -19.2% from 2007 to 2016; despite of an inversion of the trend between 2013 and 2014, a further reduction is observed in last two years.
In 2012 a drop is observed in CO_2 emissions due to a sharp reduction of gasoline and diesel fuel consumption for road transport, explained mainly by the economic crisis, contributing to the reduction of movements of passengers and goods, and in a minor way by the penetration in the market of low consumption vehicles.

The time series of CO_2, CH_4 and N_2O emissions, in Mt CO_2 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 N_2O emissions is related to the evolution of the technologies in the road transport sector and the distribution between the different fuels 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 9.6 million vehicles in 2016) that use gasoline and it increased of about 44.9% since 1990 (this fleet not completely complies with strict VOC emissions controls).

Table 3.14 GHG emissions for the transport sector (Mt CO_2 eq.)

	1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
CO_2 Mt CO_2 eq	100.24	111.42	121.30	126.45	113.87	112.85	105.30	102.65	107.45	104.84	103.38
CH_4 Mt CO_2 eq	0.91	1.03	0.78	0.50	0.31	0.29	0.26	0.25	0.24	0.23	0.22
N_2O Mt CO_2 eq	0.95	1.18	1.19	1.10	0.98	0.95	0.91	0.89	0.93	0.92	0.91
Total, Mt CO_2 eq.	**102.10**	**113.62**	**123.26**	**128.05**	**115.16**	**114.09**	**106.47**	**103.78**	**108.62**	**105.99**	**104.51**

Source: ISPRA elaborations

CO_2 from road vehicles is key category both in 1990 and 2016, in level and trend (Tier 1 and Tier 2) with and without LULUCF.
CO_2 from waterborne navigation is key category both in 1990 and 2016, in level (Tier 1) with and without LULUCF.
CO_2 from civil aviation is key category: in 2016, in level and trend (Tier 1), with and without LULUCF; in 1990, in level (Tier1) with LULUCF.
CH_4 deriving from road transportation is key category in 2016 in trend (Tier2), without LULUCF and in 1990 in level (Tier 2) without LULUCF.
N_2O deriving from road transportation is key category in 1990 in level (Tier 2) without LULUCF.

3.5.1 Aviation

3.5.1.1 Source category description

The IPCC methodology 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 CO_2 emissions. CH_4 and N_2O emissions also occur and are estimated in this category but their contribution is insignificant.

In 2016 total GHG emissions from this source category were about 2.1% of the national total emissions from transport, and about 0.5% of the GHG national total (in terms of CO_2 only, the share is almost the same).
From 1990 to 2015, GHG emissions from the sector increased by 27.4% due to the expansion of the aviation transport mode; nevertheless since 2010 a reduction is observed in GHG emissions, equal to -25.3%. Therefore, emission fluctuations over time are mostly dictated by the growth rates in the number of flights.
CO_2 deriving from civil aviation is key category in 2015, in level (Tier 1), with and without LULUCF, in 1990 in level (Tier1) with LULUCF, and in trend (Tier1) with and without LULUCF.

3.5.1.2 Methodological issues

According to the IPCC Guidelines and Good Practice Guidance (IPCC, 1997; IPCC, 2000; IPCC, 2006) and the Guidebook (EMEP/CORINAIR, 2007; EMEP/EEA, 2016), 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]). 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 and include fuel used for engines and airframe testing;
- 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), the Italian civil aviation in the national aviation statistics yearbooks (ENAC/MIT, several years), which report total national and international commercial air traffic, scheduled and not scheduled flights including charter and airtaxi, EUROCONTROL flights data time series 2002 – 2016 (EUROCONTROL, several years).

An overall assessment and comparison with EUROCONTROL emission estimates was carried out which lead to an update of the methodology used by Italy for this category. Data on the number of flights, fuel consumption and emission factors were provided by EUROCONTROL in the framework of a specific project funded by the European Commission, and quality checked by the European Environmental Agency and its relevant Topic Centre (ETC/ACM), aimed at improving the reporting and the quality of emission estimates from the aviation sector of each EU Member State under both the UNFCCC and LRTAP conventions. The Advanced Emissions Model (AEM) was applied by Eurocontrol to derive these figures, according to a Tier 3 methodology (EMEP/EEA, 2016).

EUROCONTROL fuel and emissions time series cover the period 2005-2016, while the number of flights are available since 2002. In this year submission, EUROCONTROL data, related to Italy, on the number of flights have been used to update the national inventory from 2002, while fuel and emissions data have been used since 2005.

For the time series from 1990 to 1999, figures for emission and consumption factors are derived by the EMEP/CORINAIR guidebook (EMEP/CORINAIR, 2007), both for LTO cycles and cruise phases, taking into account national specificities. These specificities derived 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 for the same year (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. These national average emissions and consumption factors were therefore used to estimate emissions for LTO cycles and cruise both for domestic and international flights from 1990 to 1999.
Specifically, for the year referred to in the survey, the 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 about whether the flight is international or domestic and the related distance travelled has also been considered.
A Tier 3 method has been applied for 1999. In fact, figures on the number of flights, destination, aircraft fleet and engines have been provided by the local airport authorities, national airlines and 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 from 1990 to 1999 considering the official statistics of the aviation sector (ENAC/MIT, several years) and applying the average consumption and emission factors.
From 2005, fuel consumption and emission factors were derived from the database made available to EU Member States by EUROCONTROL, as previously described. These data were used for updating fuel consumption factors, and emission factors of all pollutants. For the period between 1999 and 2005, where relevant,, a linear interpolation has been applied to calculate these parameters.
Estimates were carried out applying the consumption and emission factors to the national official aviation statistics (ENAC/MIT, several years) and EUROCONTROL data on movements from 2002 (EUROCONTROL, 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 2016 are shown in Table 3.15 where domestic flights are those entirely within Italy.
Since 2002, emission time series have been updated on the basis of EUROCONTROL flights data, considering departures from and arrivals to all airports in Italy, regarding flights flying under instrument flight rules (IFR), including civil helicopters flights and excluding flights flagged as military, when the above flights they can be identified while, from 1990 to 2001, data from ENAC have been used (ENAC/MIT, several years).

Table 3.15 Aircraft Movement Data (LTO cycles)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Domestic flights	186,446	199,585	319,963	350,092	368,545	391,655	373,866	356,716	354,515	354,016	327,121
International flights	139,733	184,233	303,747	381,192	402,893	440,549	420,521	391,103	406,981	417,076	410,300

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

Emission factors are reported in Table 3.16 and Table 3.17.
CO_2 and SO_2, emission factors (in kg/TJ) depend on the fuel quality and they have been assumed according to the information available in literature that the quality of jet fuel does not change in the period. CO_2 emission factors are those in the 2006 IPCC Guidelines (IPCC, 2006), while SO_2 emission factor is equal to 1 kg/t of fuel.
For N_2O, because of emission factors are not available at engine/airplane level in the relevant EMEP and IPCC Guidelines which are based on the ICAO database, and the 2006 IPCC Guidelines default value has been used, equal to 2 kg/TJ (IPCC, 2006).
For the other gases, including CH_4, emission factors depend from the technologies and vary in the time series according to the surveys as already described in this paragraph.

Table 3.16 CO_2 and SO_2 emission factors for Aviation (kg/t) 1990-2016

	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-CO_2 emission factors for Aviation (2016)

	Units	CH_4	N_2O	NO_X	CO	NMVOC	Fuel
Domestic LTO	kg/LTO	0.128	0.052	7.575	6.021	0.935	598.098
International LTO	kg/LTO	0.164	0.067	10.958	7.350	1.084	767.191
Domestic Cruise	kg/t fuel	-	0.087	15.242	4.536	0.635	-
International Cruise	kg/t fuel	-	0.081	15.663	2.216	0.318	-
Aircraft Military ([a])	kg/t fuel	0.400	0.200	15.800	126.000	3.600	-

Source: ([a]) EMEP/CORINAIR, 2007; EMEP/EEA 2016; Eurocontrol, several years

Total fuel consumptions, both domestic and international, are reported by LTO and cruise in Table 3.18.

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

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
						Gg					
Domestic LTO	111	120	208	233	227	209	192	171	179	168	166
International LTO	130	175	258	268	295	286	284	281	309	327	343
Domestic cruise	357	384	654	664	702	687	620	562	555	524	524
International cruise	1246	1688	2297	2459	2536	2675	2585	2571	2591	2748	2966

Source: ISPRA elaborations

Emissions from military aircrafts are also estimated and reported under category 1.A.5.b 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).
CO_2 and SO_2 emission factors depend on fuel properties; as regards CO_2, aaccording to the adoption of the 2006 IPCC Guidelines, emission factors have been calculated assuming that 100% of the fuel carbon is oxidized to CO_2.
Therefore, emissions are calculated by multiplying military fuel consumption data for the EMEP/CORINAIR default emission factors shown in Table 3.17.

3.5.1.3 Uncertainty and time-series consistency

The combined uncertainty in CO_2 emissions from aviation is estimated to be about 4% in annual emissions; a higher uncertainty is calculated for CH_4 and N_2O 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 2016 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 years.

Table 3.19 GHG emissions from domestic aviation

		1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
CO_2	*Gg*	1,493.12	1,588.54	2,717.21	2,833.19	2,951.96	2,813.65	2,557.57	2,289.42	2,290.33	2,160.32	2,155.21
CH_4	*Mg*	26.89	27.65	47.86	52.77	52.69	46.31	43.04	37.05	38.73	36.47	36.07
N_2O	*Mg*	41.78	44.44	76.02	79.26	82.59	78.71	71.55	64.04	64.07	60.43	60.29

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.
Different QA/QC and verification activities are carried out for this category.
As regards past years, the results of the national studies and methodologies, applied at national and airport level, were 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, included participants from ENAC, Ministry of Environment, Land and Sea, Ministry of Transport, national airlines and local airport authorities. The results reflected differences between airports, aircrafts used and times in mode spent for each operation.
Currently, verification and comparison activities regard activity data and emission factors. In particular, number of flights have been compared considering different sources: ENAC, ASSAEROPORTI, ISTAT, EUROCONTROL and verification activities have been performed on the basis of the updated EUROCONTROL data on fuel consumption and emission factors resulting in an update and improving of the national inventory.
Furthermore, there is an ongoing collaboration and data exchange with regional environmental agencies on this issue.

3.5.1.5 Source-specific recalculations

Recalculations were performed in this submission, on the basis of the complete integration in the Italian inventory of EUROCONTROL data time series, and in particular CH_4, NMVOC and CO emissions not considered before, resulting in variations consumption and emission factors, respect to previous submission. Moreover we correct an error occurred in the previous submission in the distribution between domestic and international number of flights for the calculation of fuel consumption and CO_2 time series, resulting in a general update of CO_2 emissions from this category.

3.5.1.6 Source-specific planned improvements

Improvements for next submissions are planned on the basis of the outcome of the ongoing quality assurance and quality control activities, in particular with regard to the results of investigation about data and information deriving from different sources, in particular further assessment of EUROCONTROL data, and comparison with ISTAT information.

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 gasoil consumption for railways reported in BEN (MSE, several years [a]), and on the methodology Tier1, and emission factors from the EMEP/EEA Emission Inventory Guidebook 2016 (EMEP/EEA, 2016).
In the previous submission recalculations affected this category for the whole time series due to the adoption of the National Energy Balance figures officially provided to the OECD/IEA/EUROSTAT Joint Questionnaire and to the adoption of the updated factors of the 2016 version of the EMEP/EEA Emission Inventory Guidebook (EMEP/EEA, 2016), for NO_X, NMVOC and PM, as well as the consideration of the European Directive 2004/26/EC (EC, 2004) which introduced emission limits for the new rail traction engines for the same pollutants.
As regards the use of lubricants in diesel locomotives in railways, according to the review process and to the 2006 IPCC Guidelines, emission estimates from lubricants have been reported under IPPU instead of under the energy sector, except for lubricants related to the use in two stroke engines in road transport.
Fuel consumption data are collected by the Ministry of Economic Development, responsible of the energy balance, from the companies with diesel railways. The activity is present only in those areas without electrified railways, which are limited in the national territory. The trend reflects the decrease of the use of these railways. Because of low values, emissions from railways do not represent a key category.
Carbon dioxide and sulphur dioxide emissions are calculated on fuel based emission factors using fuel consumption data from BEN. The CO_2 emission factors for diesel fuel derive from ad hoc studies about the properties of transportation fuels sold in Italy, performed by Ispra since the nineties, and whose results are representative and applicable with reference to three different time phases: 1990 – 1999; 2000 – 2011; 2012 – 2016 (Innovhub, several years).
Values for SO_2 vary annually according to the variation of the sulphur-content of fuels produced, imported and commercialized, and it is yearly monitored according to legislative constraints; moreover it is officially communicated to the European Commission in the framework of European Directives on fuel quality (ISPRA, several years). Emissions of CO, NMVOC, NO_x, N_2O and methane are based on the EMEP/EEA methodology (EMEP/EEA, 2016) taking into account the implementation of the relevant European Directives to reduce atmospheric pollutants.
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 in 2015 (kg/t)

	CO_2	CH_4	N_2O	NO_x *kg/t*	CO	NMVOC	SO_2
Diesel trains	3,151	0.18	1.24	44.4	10.7	4.16	0.015

Source: EMEP/EEA,2016; IPCC, 2016

GHG emissions from railways accounted in 2016 for about 0.05% of the total transport sector emissions.
No specific improvements are planned for the next submission.

3.5.3 Road Transport

3.5.3.1 Source category description

This section addresses the estimation of emissions related to category 1.A.3.b Road transportation.
In 2016, total GHG emissions from this category were about 93.5% of the total national emissions from transport, 28.2% of the energy sector and about 22.8% of the GHG national total.

From 1990 to 2016, GHG emissions from the sector increased by 4.0%; this trend has a twofold explanation: on one side a strong increase starting from 1990 until 2007 (27.7%), due to the increase of vehicle fleet, total mileage and consequently fuel consumptions and on the other side, in the last years, from 2007 onwards, a decrease in fuel consumption and emissions basically due to the economic crisis (emissions decrease of about -18.5%).

CO_2 emissions from road transport are key category, both in 1990 and in 2016, with approach 1 and approach 2, with and without LULUCF, at level and trend assessment. CH_4 emissions are key category in 1990 at level assessment with approach 2 without LULUCF and in trend with approach 2 without LULUCF. N_2O emissions have been identified as key category in 1990 at level assessment with approach 2 without LULUCF.

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 CO_2 emissions from biomass fuel consumption are included and reported: as regards biodiesel, under diesel fuel category; as regards bioethanol, under gasoline fuel category. Biomass fuel refers prevalently to the use of biodiesel which is mixed with diesel fuel and to the use of bioethanol by the passenger cars subsector E85 with reference to a blend consisting of 85% bioethanol and 15% gasoline by volume.

CO_2 emissions are calculated on the basis of the amount of carbon in the fuel. In the model used to calculate emissions, the fuel consumption input, which is balanced with the fuel consumption estimated by the model, includes both fossil and bio fuels; then CO_2 emissions related to biomass are subtracted to the total with the aim to be reported under biomass.
CH_4 and N_2O emissions depend on the technology of vehicles and could not be calculated without more detailed information regarding the type and technology of vehicles and the associated fuel 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 2016 (EMEP/EEA, 2016), a national methodology has been developed and applied to estimate emissions.

The model COPERT 5 (updated version 5.1, December 2017) has been used and applied for the whole time series in 2018 submission. COPERT 5 introduces upgrades both from software and methodological point of view respect to the previous model COPERT 4 used (http://emisia.com/products/copert/copert-5).
New methodological features have been introduced.
As regards fuel, updates concern: fuel energy instead of fuel mass calculations; distinction between primary and end (blends) fuels, automated energy balance.
Regarding vehicle types, updated vehicle category naming, new vehicle types and emission control technology level, have been introduced.
As regards emission factors, one function type and the possibility to distinguish between peak/off-peak urban, have been implemented.

As regards CO_2 emissions from catalytic converters using urea (reported under category 2.D.3), Italian road transport emissions estimation about CO_2 from urea based catalysts is implemented in the model used (Copert 5 v.5.1).
In particular, for diesel passenger cars and light duty trucks Euro VI, the consumption of urea is assumed to be equal to 2% of fuel consumption, the selective catalytic reduction (SCR) ratio being equal to 10%; for diesel heavy duty trucks and buses, the consumption of urea is assumed to be equal to 6% of fuel consumption at Euro V level (SCR ratio = 76.2%) and equal to 3.5% at Euro VI level (SCR ratio = 100%).
With regard to the purity (the mass fraction of urea in the urea-based additive), the default value of thirty two and half percent has been used (IPCC, 2006).

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 or sulphur content of the fuels consumed. In 2018 consumption data have been updated for the whole time series according to data officially communicated to the Joint Questionnaire OECD/IEA/EUROSTAT.
Consumption data for the fuel consumed by road transport in Italy are taken from the BEN (MSE, several years [a]), in physical units (taking into account the use in road transportation, in machinery as regards gasoline, in commercial and public service, and subtracting the quantities for military use in diesel oil and off-road uses in petrol).

Emissions of CO_2, expressed as kg carbon per tonne of fuel, are based on the H/C and O/C ratios of the fuel. The increase in fuel consumption due to air conditioning use implies that extra CO_2 emissions in g/km are calculated as a function of temperature and relative humidity; nevertheless because of CO_2 emissions depend on total statistical fuel consumption, there is not impact on the CO_2 officially reported but instead on other pollutants.
Emissions of SO_2 are based on the sulphur content of the fuel, on the assumption that all the sulphur in the fuel is transformed completely into SO_2. 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, 2016).

Fuel consumption data derive basically from the National Energy Balance (MSE, several years [a]); supplementary information is taken from the Oil Bulletin (MSE, several years [b]) and from the statistics published by the Association of Oil Companies (UP, several years). As regards biofuels, the consumption has increased in view of the targets to be respected by Italy and set in the framework of the European directive 20-20-20. The trend of biodiesel is explained by the fact that this biofuel has been tested since 1994 to 1996 before entering in production since 1998. The consumption of bioethanol, related to E85 passenger cars category, is introduced since 2008, according to data resulting in the BEN.

Values of the fuel-based emission factors for CO_2 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 1, as suggested by the 2006 IPCC guidelines (IPCC, 2006). 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 CO_2 emission factors.

The final report on the physic-chemical characterization of fossil fuels used in Italy, carried out by the Fuel Experimental Station, that is an Italian Institute operating in the framework of the Department of Industry, has been used since 2015 submission, with the aim to improve fuel quality specifications. Fuel information has also been updated for the whole time series on the basis of the annual reports published by ISPRA about the fuel quality in Italy. Fuel information has been updated also as regards country specific fuel consumption factors for gasoline and diesel passenger cars on the basis of the results published by EEA in the report "Monitoring CO_2 emissions from new passenger cars and vans in 2016" (EEA, 2017).
A specific survey was also conducted to characterize the national fuel used in 2000-2001.

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 into account the IPCC default values and the specific energy content of the national fuels. For further details see the relevant paragraph in Annex 6.

Values for SO_2 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 (ISPRA, several years); 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 CO2 /TJ	Mg CO2/Mg
Mtbe	73,072	-
Gasoline, 1990-'99, interpolated emission factor	71,034	3,121
Gasoline, test data, 2000-2011[b,c]	71,864	3,141
Gasoline, test data, 2012-2016[c]	73,338	3,140
Gas oil, 1990-'99, IPCC OECD[a]	73,274	3,127
Gas oil, engines, test data, 2000-2011[b,c]	73,892	3,169
Gas oil, engines, test data, 2012-2016[c]	73,648	3,151
LPG, 1990-'99, IPCCa Europe	64,350	3,000
LPG, test data, 2000-2016[b,c]	65,592	3,024
Natural gas (dry) 1990	55,292	-
Natural gas (dry) 2016	57,693	-

a Revised 1996 IPCC Guidelines for National GHG Inventories, Reference Manual, ch1, tables 1-36 to 1-42
b APAT, 2003 [b]
c Emission factor in kg carbon/tonne, based on Fuel Experimental Station (Innovhub, several years)

Emissions of CO_2 and SO_2 can be broken down by vehicle type based on estimated fuel consumption factors and traffic data in a manner similar to the traffic-based emissions described below for other pollutants. The current inventory used fuel consumption factors expressed as grams of fuel per kilometre for each vehicle type and average speed calculated from the emission functions and speed-coefficients provided by the model COPERT 5 (EMISIA SA, 2017). Mileage and fuel consumptions calculated from COPERT functions are shown in Table 3.22 for each vehicle, fuel and road type in Italy in 2016.

Table 3.22 Average fuel consumption and mileage for main vehicle category and road type, year 2016

		Fuel Consumption (TJ)				Mileage (kveh_km)			
		Urban	Rural	Highway	*TOTAL*	Urban	Rural	Highway	*TOTAL*
Passenger Cars	Petrol	114.754	94.636	61.545	*270.935*	31.130.023	48.578.068	28.147.357	*107.855.448*
Passenger Cars	Diesel	96.514	240.539	151.678	*488.731*	30.523.838	115.181.492	65.938.804	*211.644.135*
Passenger Cars	Petrol Hybrid	794	682	481	*1.956*	329.449	494.174	274.541	*1.098.164*
Passenger Cars	LPG Bifuel	28.169	21.668	23.897	*73.734*	7.954.282	10.605.710	7.954.282	*26.514.274*
Passenger Cars	CNG Bifuel	15.226	10.311	8.917	*34.455*	3.313.815	4.418.420	3.313.815	*11.046.049*
		-	-	-	-	-	-	-	-
Light Commercial Vehicles	Petrol	3.090	2.915	1.040	*7.046*	450.387	990.851	360.309	*1.801.547*
Light Commercial Vehicles	Diesel	52.731	67.191	37.894	*157.816*	11.679.821	25.695.606	9.343.857	*46.719.285*
		-	-	-	-	-	-	-	-
Heavy Duty Trucks	Petrol	3	6	2	*10*	297	890	297	*1.484*
Heavy Duty Trucks	Diesel	41.163	87.554	131.321	*260.039*	3.261.872	10.822.774	15.913.867	*29.998.513*
		-	-	-	-	-	-	-	-
Buses	Diesel	12.018	10.041	16.040	*38.100*	803.401	1.059.855	2.015.838	*3.879.094*
Buses	CNG	2.753	210	-	*2.963*	142.479	15.831	-	*158.310*
		-	-	-	-	-	-	-	-
Mopeds	Petrol	4.296	1.841	-	*6.137*	6.380.696	2.734.584	-	*9.115.279*
Motorcycles	Petrol	16.867	9.046	1.759	*27.671*	12.825.725	7.481.673	1.068.810	*21.376.209*

Source: ISPRA elaborations
Notes: Biodiesel included in diesel; bioethanol included in gasoline.

3.5.3.2.1.a The fuel balance process

An automatic fuel balancing procedure is implemented in Copert 5 to ensure that the breakdown of fuel consumption by each vehicle type calculated on the basis of the fuel consumption factors once added up matches the BEN figures for total fuel consumption in Italy (adjusted for off-road consumption).
In Copert 5 the automatic energy balance process has been introduced, and it has been applied for this 2018 submission. This simulation is started up having the target to equalize calculated and statistical consumptions, separately for fuel, at national level, with the aim to obtain final estimates the most accurate as possible. Once all data and input parameters have been inserted and all options have been set reflecting the peculiar situation of the Country, emissions and consumptions are calculated by the model in the detail of the vehicle category legislation standard; then the aggregated consumption values so calculated are compared with the input statistical national aggregated values (deriving basically from the National Energy Balance, as described above), with the aim to minimize the deviation.

3.5.3.2.2 Traffic-based emissions

Emissions of NMVOC, NO_X, CO, CH_4 and N_2O are calculated from emission factors expressed in grams per kilometre and road traffic statistics estimated by ISPRA on the basis of data released from: Ministry of Transport (MIT, several years), the Automobile Club of Italy (ACI, several years), the National Association of Cycle-Motorcycle Accessories (ANCMA, several years), the National Institute of Statistics (ISTAT), the National Association of concessionaries of motorways and tunnels (AISCAT).
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 5 (EMISIA SA, 2017). 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.
N_2O emission factors derive from the application of Copert 5 v.5.1 model (EMISIA SA, 2017).
Tier 3 is implemented, according to which N_2O is connected to the aftertreatment devices, such as catalytic converters and diesel particle filters. N_2O emissions are significant for catalyst vehicles, in particular when the catalyst is under partially oxidizing conditions, when the catalyst has not reached its light-off temperature yet or when the catalyst is aged. So N_2O emissions depend on the vehicle age or cumulative mileage. Moreover, aftertreatment ageing depends upon the fuel sulphur level. Hence, different emission factors are explained by the variation in fuel sulphur content and in the driving conditions (EMEP/EEA, 2016).
Only for diesel and LPG passengers cars and for diesel light duty vehicles, the Copert model reports an emission factor equal to 0 for conventional vehicles, while for heavy duty and buses diesel vehicles, as well as for gasoline passenger cars, light and heavy duty vehicles, mopeds and motorcycles, emission factors are available in the model.
Because of those zero values, noticeable variations may appear between IEF referred to consecutive years where the fleet consists just of conventional vehicles and Euro 1 vehicles; such differences are then explained by the different share of Euro 1 vehicles out of the total.
As regards newer vehicles, N_2O emissions may derive as a byproduct from SCR systems, this issue needs to be monitored to reveal how much this is could be a problem in real world conditions (EMEP/EEA, 2016).

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 vehicles on the road powered by different fuels and in terms of the fraction of vehicles on the road relating 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 5 methodology: in brief, the emissions from motor vehicles fall into three different types calculated as hot exhaust emissions, cold-start emissions, and evaporative emissions for NMVOC; 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 (EMISIA, 2017). 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;
- Hybrid Gasoline passenger cars;
- Gasoline Light Goods Vehicles (Gross Vehicle Weight (GVW) <= 3.5 tonnes);
- Diesel Light Goods Vehicles (Gross Vehicle Weight (GVW) <= 3.5 tonnes);
- Rigid-axle Heavy Goods Vehicles (GVW > 3.5 tonnes);
- Articulated Heavy Goods Vehicles (GVW > 3.5 tonnes);
- Diesel Buses and coaches;
- CNG Buses;
- Mopeds and motorcycles.

Basic data derive from different sources.
Detailed data on the national fleet composition are found in the yearly report from ACI (ACI, several years), used from 1990 to 2006, except for mopeds for which estimates have been elaborated on the basis of National Association of Cycle-Motorcycle Accessories data on mopeds fleet composition and mileages (ANCMA, several years). ANCMA data have been used up to 2011; since 2012 MIT mopeds fleet data have been used, because starting from 2012, mopeds are estimated to be all registered.

Starting from the 2013 submission, specific fleet composition data were provided by the MIT for all vehicle categories from 2007 onwards. The Ministry of Transport in the national transport yearbook (MIT, several years) reports mileages time series. Furthermore since 2015 MIT supplies information relating the distribution of old gasoline cars over the detailed vehicles categories (PRE ECE; ECE 15/00-01; ECE 15/02; ECE 15/03; ECE 15/04; information obtained from the registration year; data used for the updating of the time series since 2007).
Since 2014, MIT supplies updated information relating the reallocation of not defined vehicles categories (data used for the updating of the time series since 2007).
MIT data have been used relating to: the passenger cars (“Hybrid Gasoline” passenger cars category are introduced from 2007 onwards, the mini petrol (Gasoline < 0.8 l) passenger cars subsector is introduced since 2012 and diesel small (Diesel<1.4 l) subsector since 2007 onwards, in addition to the gasoline, diesel, LPG, CNG traditional ones); the diesel and gasoline light commercial vehicles; the breakdown of the heavy duty trucks, buses and coaches fleet according to the different weight classes and fuels (for HDT almost exclusively diesel, a negligible share consists of gasoline HDT vehicles; diesel for coaches; diesel and CNG for buses); the 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 since 2005).

Fleet values for urban buses have been updated according to the updating of the data on urban public buses, published on CNIT (Ministry of Transport, several years).

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, 3.25 and 3.26 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 technological evolution: circulating fleet calculated as stock data multiplied by effective mileage (%)

	1990	1995	2000	2005	2010	2015	2016
PRE ECE, pre-1973	0.05	0.03	0.01	0.01	0.002	0.002	0.002
ECE 15/00-01, 1973-1978	0.11	0.04	0.01	0.004	0.003	0.003	0.003
ECE 15/02-03, 1978-1984	0.32	0.15	0.03	0.01	0.01	0.007	0.01
ECE 15/04, 1985-1992	0.53	0.56	0.28	0.10	0.04	0.03	0.03
PC Euro 1 - 91/441/EEC, from 1/1/93	0.001	0.23	0.27	0.17	0.05	0.02	0.02
PC Euro 2 - 94/12/EEC, from 1/1/97	-	-	0.39	0.32	0.22	0.12	0.10
PC Euro 3 - 98/69/EC Stage2000, from 1/1/2001	-	-	-	0.31	0.19	0.13	0.12
PC Euro 4 - 98/69/EC Stage2005, from 1/1/2006	-	-	-	0.09	0.44	0.43	0.40
PC Euro 5 - EC 715/2007, from 1/1/2011	-	-	-	-	0.04	0.21	0.20
PC Euro 6 - EC 715/2007, from 9/1/2015	-	-	-	-	-	0.06	0.12
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00
a. Gasoline cars technological evolution							
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**
Conventional, pre-1993	1.00	0.92	0.34	0.06	0.01	0.00	0.004
PC Euro 1 - 91/441/EEC, from 1/1/93	-	0.08	0.10	0.03	0.01	0.00	0.002
PC Euro 2 - 94/12/EEC, from 1/1/97	-	-	0.56	0.22	0.05	0.02	0.02
PC Euro 3 - 98/69/EC Stage2000, from 1/1/2001	-	-	-	0.56	0.31	0.18	0.16
PC Euro 4 - 98/69/EC Stage2005, from 1/1/2006	-	-	-	0.12	0.55	0.42	0.39
PC Euro 5 - EC 715/2007, from 1/1/2011	-	-	-	-	0.07	0.34	0.31
PC Euro 6 - EC 715/2007, from 9/1/2015	-	-	-	-	0.0001	0.04	0.12
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00
b. Diesel cars technological evolution							
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**
Conventional, pre-1993	1.00	0.90	0.71	0.47	0.04	0.01	0.01
PC Euro 1 - 91/441/EEC, from 1/1/93	-	0.10	0.20	0.26	0.03	0.01	0.01
PC Euro 2 - 94/12/EEC, from 1/1/97	-	-	0.09	0.19	0.08	0.03	0.03
PC Euro 3 - 98/69/EC Stage2000, from 1/1/2001	-	-	-	0.06	0.08	0.05	0.04
PC Euro 4 - 98/69/EC Stage2005, from 1/1/2006	-	-	-	0.01	0.75	0.45	0.42
PC Euro 5 - EC 715/2007, from 1/1/2011	-	-	-	-	0.03	0.36	0.34
PC Euro 6 - EC 715/2007, from 9/1/2015	-	-	-	-	-	0.08	0.15
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00
c. Lpg cars technological evolution							
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**
PC Euro 4 - 98/69/EC Stage2005, from 1/1/2006	1.00	1.00	1.00	1.00	0.90	0.57	0.55
PC Euro 5 - EC 715/2007, from 1/1/2011	-	-	-	-	0.10	0.34	0.31
PC Euro 6 - EC 715/2007, from 9/1/2015	-	-	-	-	-	0.10	0.14
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00
d. CNG cars technological evolution							
		2007	**2008**	**2009**	**2010**	**2015**	**2016**
PC Euro 4 - 98/69/EC Stage2005, from 1/1/2006		1.00	1.00	0.79	0.70	0.36	0.07
PC Euro 5 - EC 715/2007, from 1/1/2011		-	-	0.21	0.30	0.50	0.42

PC Euro 6 - EC 715/2007, from 9/1/2015	-	-	-	-	0.13	0.51
Total	1.00	1.00	1.00	1.00	1.00	1.00
e. Hybrid Gasoline cars technological evolution (from 2007 onwards)						

Source: ISPRA elaborations on ACI and MIT data

Table 3.24 Light Duty Vehicles technological evolution: circulating fleet calculated as stock data multiplied by effective mileage (%)

	1990	1995	2000	2005	2010	2015	2016
Conventional, pre 10/1/94	1.00	0.93	0.63	0.35	0.08	0.05	0.05
LD Euro 1 - 93/59/EEC, from 10/1/94	-	0.07	0.22	0.17	0.11	0.05	0.05
LD Euro 2 - 96/69/EEC, from 10/1/98	-	-	0.15	0.15	0.30	0.20	0.19
LD Euro 3 - 98/69/EC Stage2000, from 1/1/2002	-	-	-	0.31	0.26	0.19	0.18
LD Euro 4 - 98/69/EC Stage2005, from 1/1/2007	-	-	-	0.01	0.25	0.31	0.31
LD Euro 5 - 2008 Standards 715/2007/EC, from 1/1/2012	-	-	-	-	0.004	0.19	0.17
LD Euro 6	-	-	-	-	-	0.01	0.04
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00
a. Gasoline Light Duty Vehicles technological evolution							
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**
Conventional, pre 10/1/94	1.00	0.93	0.60	0.28	0.08	0.02	0.02
LD Euro 1 - 93/59/EEC, from 10/1/94	-	0.07	0.21	0.13	0.07	0.04	0.04
LD Euro 2 - 96/69/EEC, from 10/1/98	-	-	0.19	0.18	0.23	0.14	0.13
LD Euro 3 - 98/69/EC Stage2000, from 1/1/2002	-	-	-	0.39	0.33	0.23	0.21
LD Euro 4 - 98/69/EC Stage2005, from 1/1/2007	-	-	-	0.01	0.28	0.35	0.33
LD Euro 5 - 2008 Standards 715/2007/EC, from 1/1/2012	-	-	-	-	0.01	0.21	0.24
LD Euro 6	-	-	-	-	0.0000003	0.005	0.045
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00
b. Diesel Light Duty Vehicles technological evolution							

Source: ISPRA elaborations on ACI and MIT data

Table 3.25 Heavy Duty Trucks and Buses technological evolution: circulating fleet calculated as stock data multiplied by effective mileage (%)

	1990	1995	2000	2005	2010	2015	2016
Conventional, pre 10/1/93	1.00	0.90	0.68	0.40	0.19	0.11	0.10
HD Euro I - 91/542/EEC Stage I, from 10/1/93	-	0.10	0.10	0.06	0.05	0.04	0.04
HD Euro II - 91/542/EEC Stage II, from 10/1/96	-	-	0.22	0.27	0.22	0.18	0.17
HD Euro III - 2000 Standards, 99/96/EC, from 10/1/2001	-	-	-	0.27	0.34	0.32	0.30
HD Euro IV - 2005 Standards, 99/96/EC, from 10/1/2006	-	-	-	-	0.06	0.06	0.06
HD Euro V - 2008 Standards, 99/96/EC, from 10/1/2009	-	-	-	-	0.14	0.24	0.24
HD Euro VI – EC 595/2009, from 12/31/2013	-	-	-	-	-	0.04	0.09
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00
a. Heavy Duty Trucks technological evolution							
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**
Conventional, pre 10/1/93	1.00	0.93	0.65	0.34	0.16	0.06	0.05
HD Euro I - 91/542/EEC Stage I, from 10/1/93	-	0.07	0.07	0.08	0.06	0.04	0.04
HD Euro II - 91/542/EEC Stage II, from 10/1/96	-	-	0.28	0.32	0.29	0.24	0.22
HD Euro III - 2000 Standards, 99/96/EC, from 10/1/2001	-	-	-	0.26	0.30	0.30	0.29
HD Euro IV - 2005 Standards, 99/96/EC, from 10/1/2006	-	-	-	-	0.10	0.10	0.10
HD Euro V - 2008 Standards, 99/96/EC, from 10/1/2009	-	-	-	-	0.09	0.22	0.22
HD Euro VI – EC 595/2009, from 12/31/2013	-	-	-	-	-	0.04	0.08
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00
b. Diesel Buses technological evolution							
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**
Urban CNG Buses Euro I - 91/542/EEC Stage I, from 10/1/93	1.00	1.00	0.11	0.01	0.003	0.003	0.003
Urban CNG Buses Euro II - 91/542/EEC Stage II, from	-	-	0.89	0.20	0.10	0.05	0.04

	1990	1995	2000	2005	2010	2015	2016
10/1/96							
Urban CNG Buses Euro III - 2000 Standards, 99/96/EC, from 10/1/2001	-	-	-	0.79	0.09	0.07	0.06
Urban CNG Buses Euro IV - 2005 Standards, 99/96/EC, from 10/1/2006; Euro V - 2008 Standards, 99/96/EC, from 10/1/2009; EEV (Enhanced environmentally friendly vehicle; ref. 2001/27/EC and 1999/96/EC line C, optional limit emission values)	-	-	-	-	0.81	0.85	0.85
Urban CNG Buses Euro VI – EC 595/2009, from 12/31/2013	-	-	-	-	-	0.03	0.05
Total	1.00	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

Table 3.26 Mopeds and motorcycles technological evolution: circulating fleet calculated as stock data multiplied by effective mileage (%)

	1990	1995	2000	2005	2010	2015	2016
Mopeds and motorcycles - Conventional	1.00	1.00	0.86	0.46	0.22	0.12	0.11
Mopeds and motorcycles - Euro 1	-	-	0.14	0.28	0.17	0.11	0.10
Mopeds and motorcycles - Euro 2	-	-	-	0.21	0.34	0.35	0.36
Mopeds and motorcycles - Euro 3	-	-	-	0.04	0.27	0.41	0.41
Mopeds and motorcycles - Euro 4	-	-	-	-	-	-	0.01
Mopeds and motorcycles - Euro 5	-	-	-	-	-	-	0.0000002
Total	1.00	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 3.27, 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 3.27 Evolution of fleet consistency and mileage

	1990	1995	2000	2005	2010	2015	2016
All passenger vehicles (including moto), total mileage (10^9 veh-km/y)	329	400	430	433	392	400	393
Car fleet (10^6)	27	30	33	35	38	39	39
Moto, total mileage (10^9 veh-km/y)	30	39	41	42	33	32	30
Moto fleet (10^6)	7	7	9	10	10	10	10
Goods transport, total mileage (10^9 veh-km/y)	68	75	94	109	104	79	79
Truck fleet (10^6), including LDV	2	3	3	4	5	5	5

Source: ISPRA elaborations
Notes: The passenger vehicles include passenger cars and buses; the moto fleet includes mopeds and motorcycles; in the goods transport light commercial vehicles and heavy duty trucks are included.

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, 2016).

3.5.3.3 Uncertainty and time-series consistency

The combined uncertainty in CO_2 emissions from road transport is estimated to be about 4% in annual emissions; a higher uncertainty is calculated for CH_4 and N_2O emissions because of the uncertainty levels attributed to the related emission factors.
Montecarlo analysis has been carried out by EMISIA[2] 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 3.28 summarizes the time series of GHG emissions in CO_2 equivalent from road transport, highlighting the evolution of this source, characterized by an upward trend in CO_2 emission levels from 1990 to 2007, which is explained by the increasing of the fleet, total mileages, and fuel consumptions and by a decreasing trend from 2007 onwards, due, on one side, to the economical crisis, and on another side, to the propagation of the number of vehicles with low fuel consumption per kilometre. In 2016, with respect to 2007, a reduction in total mileages, fuel consumptions (gasoline and diesel) and consequently CO_2 emissions has been noted.
CH_4 and N_2O emission trends are consequence of the penetration of new technologies according to the main emission regulations. Specifically CH_4 and more in general VOC emissions have reduced along the time 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 N_2O emissions and implied emission factors are prevalently driven by the fleet composition and the penetration rate of the new vehicles/technologies. Moreover, in the COPERT model, N_2O 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 0.04 and 0.007 respectively in 1999 and 2000 and 0.0055 and 0.0025 respectively in 2004 and 2005 and changed from 0.0226 in 2004 to 0.0035 in 2005 for diesel oil.

Table 3.28 GHG emissions from road transport (Gg CO_2 equivalent)

		1990	1995	2000	2005	2010	2015	2016
CO_2	**Gg**	92.256,65	103.425,20	111.389,98	116.957,52	104.374,56	98.147,92	96.683,16
CH_4	**Gg CO_2 eq**	869,69	987,72	734,98	462,23	276,65	214,71	199,04
N_2O	**Gg CO_2 eq**	824,02	1.045,91	1.060,28	989,56	876,46	853,44	846,87
Total	**Gg CO_2 eq**	**93.950,36**	**105.458,83**	**113.185,25**	**118.409,30**	**105.527,67**	**99.216,07**	**97.729,07**

Source: ISPRA elaborations

[2] EMISIA: www.emisia.com

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://groupware.sinanet.isprambiente.it/expert_panel/library. In addition, road transport emission factors are shared and publicly available on the website http://www.sinanet.isprambiente.it/it/sia-ispra/fetransp.
Besides, time series resulting from the recalculation due to the application of COPERT have been discussed over time 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 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

The annual update of the emissions time series from road transport implies a periodic review process.
In 2018 submission the historical series has been generally revised according to the application of COPERT 5 model.
The automatic fuel balancing process has been applied, new functionality introduced by COPERT 5, with the aim to minimize the deviation between statistical and calculated fuel consumption values.
The final report on the physic-chemical characterization of fossil fuels used in Italy, carried out by the Fuel Experimental Station, has been used since 2015 submission, with the aim to improve fuel quality specifications. Fuel information has also been updated for the entire time series on the basis of the annual reports published by ISPRA about the fuel quality in Italy. On the basis of such report, RVP Country specific values have been inserted in the model for the entire time series.
Since 2015 fuel information has been updated also as regards country specific fuel consumption factors for passenger cars on the basis of the results published by EEA in the report "Monitoring CO_2 emissions from passenger cars and vans in 2016" (EEA, several years).

The application of COPERT 5 implies recalculations due to the introduced updates from the methodological point of view respect to the previous model COPERT 4 used. Updates are related to the fuel, concerning: fuel energy instead of fuel mass calculations; distinction between primary and end - blends - fuels, automated energy balance; updates regard vehicle types, updated vehicle category naming, new vehicle types and emission control technology level; as regards emission factors, one function type and the possibility to distinguish between peak/off-peak urban, have been implemented. The updated classification of the fleet has been considered, including also the CNG passenger cars in the detail of the engine capacity classes, previously estimated separately.

According to the 2006 IPCC Guidelines, emission estimates from lubricants have been reported under IPPU except lubricants used in two stroke engines in road transport; so CO_2 emissions from lubricants have been detailed and attributed just to the two stroke engines in road transport (1.A.3.b, Other liquid fuels), calculated by Copert model, while the remaining share has been considered in the IPPU sector.

Differences between 2018 and previous submission, for road transport GHG emissions, account for -0.5% in 1990 and -0.2% in 2015, reflecting basically the recalculations registered for the driver carbon dioxide values. As regards methane, discrepancies vary from -6.4% in 1990 to +7.5% in 2015; emissions of nitrous oxide show variations of -1.3% in 1990 and -2.2% in 2015. In Table 3.29 the recalculation time series is reported for all gases.

Table 3.29 Emission recalculations in road transport 1990-2015 (%)

Year	CO_2	CH4	N2O
1990	-0.4%	-6.4%	-1.3%
1991	-0.4%	-7.8%	-1.6%
1992	-0.5%	-6.1%	-2.0%
1993	-0.5%	-5.9%	-6.2%
1994	-0.5%	-5.8%	-20.8%
1995	-0.4%	-6.1%	-33.9%
1996	-0.4%	-7.1%	-45.0%
1997	-0.4%	-6.6%	-51.1%
1998	-0.4%	-6.5%	-56.8%
1999	-0.4%	-6.4%	-59.7%
2000	-0.3%	-6.0%	-27.9%
2001	-0.3%	-5.7%	-28.4%
2002	-0.2%	-5.1%	-26.1%
2003	-0.3%	-4.6%	-25.0%
2004	-0.2%	-3.2%	-24.6%
2005	-0.2%	-2.7%	0.0%
2006	-0.2%	-0.9%	0.1%
2007	-0.2%	2.0%	-0.6%
2008	-0.2%	3.1%	-0.9%
2009	-0.2%	5.0%	-0.8%
2010	-0.1%	6.1%	-1.6%
2011	-0.1%	6.7%	-1.7%
2012	-0.2%	6.3%	-2.0%
2013	-0.2%	6.8%	-2.0%
2014	-0.2%	7.1%	-1.9%
2015	-0.2%	7.5%	-2.2%

Source: ISPRA elaborations

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 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 CO_2 emissions derive from this category, whereas CH_4 and N_2O emissions are less important.

Emissions from navigation constituted 3.7% of the total GHG in the transport sector in 2016 and about 0.9% of the national total (considering CO_2 only, the share of emissions from navigation out of the total is almost the same). GHG emissions decreased by -30.3% from 1990 to 2016, because of the reduction in fuel consumed in harbour and navigation activities; the number of movements, showing an increase since 1990, reverses the trend in recent years.
CO_2 from waterborne navigation is key category both in 1990 and 2016, in level (Tier 1) with and without LULUCF.

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;IPCC 2006) and the EMEP/EEA Guidebook (EMEP/EEA, 2016). In particular, a national methodology has been developed following the EMEP/EEA 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/EEA, 2016). Inland, coastal and deep-sea fishing are estimated and reported under 1.A.4.c. International inland waterways do not occur in Italy.
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/EEA guidebook (EMEP/EEA, 2016), 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 (EMEP/CORINAIR, 2007).
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 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.

For maritime transportation only by Directive 1999/32/EC European Union started to examine environmental impact of navigation and in particular the sulphur content of fuels. This directive was amended by Directive 2005/33/EC that designated Baltic sea, English channel and north sea as sulphur emission control areas (SECA) limiting the content of sulphur in the fuel for these areas and introducing a limit of 0.1% of the sulphur content in the fuel used in EU harbours from 2010.
EU legislation combined with national normative resulted in the introduction of a limit of sulphur content in maritime gasoil equal to 0.2% (2% before) from 2002 and 0.1% from 2010 while for fuel oil some limits occur only from 2008 (maximum sulphur content of 1.5 % in harbour) and from 2010, 2% in domestic waters and 1% in harbour. For inland waterways, which include the navigation on the Po river and ferry-boats in the Venice lagoon, the same legislation is applied.
The composition of the fleet of gasoline fuelled recreational craft distinguished in two strokes and four strokes engine distribution is provided by the industrial category association (UCINA, several years); the trend of the average emission factors takes into account the switch from two strokes to four strokes engines of the national fleet due to the introduction in the market of new models. In 2000, the composition of the fleet was 90% two stroke engine equipped and 10% four stroke while in the last year four strokes engines are about 48% of the fleet. Gasoline fuel consumption for recreational crafts is not available on the National Energy balance for the last years so it is estimated on the basis of the fleet which has not significantly changed in the last years.
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 CO_2 emissions from maritime is estimated to be about 4% in annual emissions; a higher uncertainty is calculated for CH_4 and N_2O 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 3.30. 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 3.30 Marine fuel consumptions in domestic navigation and international bunkers (Gg) and GHG emissions from domestic navigation (Gg CO_2 eq.)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Gasoline for recreational craft (Gg)	182	210	213	199	169	149	99	99	99	99	99
Diesel oil for inland waterways (Gg)	20	23	20	25	18	22	25	30	28	27	27
Fuels used in domestic cruise navigation (Gg)	778	706	811	740	725	678	611	575	573	545	533
Fuel in harbours (dom+int ships) (Gg)	748	693	818	759	744	696	627	590	587	559	546
Fuel in international Bunkers (Gg)	1,403	1,287	1,306	2,147	2,175	2,245	1,959	1,540	1,389	1,742	2,127
Emissions from National Navigation (Gg)											
CO_2 (Gg)	5,470	5,163	5,903	5,459	5,249	4,895	4,322	4,106	4,085	3,907	3,824
CH_4 (Gg CO_2 eq.)	35	38	38	34	28	25	19	18	18	17	17
N_2O (Gg CO_2 eq.)	38	35	41	38	37	35	31	30	30	28	28
Total (Gg CO_2 eq.)	**5,543**	**5,236**	**5,983**	**5,531**	**5,315**	**4,955**	**4,373**	**4,154**	**4,132**	**3,953**	**3,869**

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

Recalculations, respect to the previous submission, regard emissions since 1990 due to the update of the energy conversion factor according to the international statistics

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 category includes all emissions from fuels delivered to the transportation by pipelines and storage of natural gas.
Mainly CO_2 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 CH_4 and N_2O emissions are estimated.
This category is not a key category.

3.5.5.2 Methodological issues

Emissions 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 [a]). Emission factors are those reported in the EMEP/EEA Guidebook for gas turbines (EMEP/CORINAIR, 2007), except for CO_2 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 taken into account to estimate air pollutants.

3.5.5.3 Uncertainty and time-series consistency

The combined uncertainty is estimated to be about 4% in annual emissions; a higher uncertainty is calculated for CH_4 and N_2O 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 9,664 TJ in 2015 with a peak of 19,098 TJ in 2010. GHG emissions follow the same trend of fuel consumption.

Table 3.31 Pipelines transport consumptions (Tj) and GHG emissions (Gg CO_2 eq.)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Consumption (TJ)	7,359	11,556	15,367	15,940	19,098	12,148	12,436	11,584	8,855	9,662	11,601
Emissions from Pipelines (Gg)											
CO_2 (Gg CO_2 eq.)	406.88	640.07	854.37	890.56	1,097.90	692.51	711.12	659.70	504.02	552.72	669.30
CH_4 (Gg CO_2 eq.)	0.46	0.72	0.96	1.00	1.19	0.76	0.78	0.72	0.55	0.60	0.73
N_2O (Gg CO_2 eq.)	6.58	10.33	13.74	14.25	17.07	10.86	11.12	10.36	7.92	8.64	10.37
Total (Gg CO_2 eq.)	**413.92**	**651.13**	**869.07**	**905.81**	**1,116.17**	**704.13**	**723.02**	**670.78**	**512.49**	**561.96**	**680.40**

Source: ISPRA elaborations

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 specific recalculations were performed concerning this source.

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/forestry/fisheries, and emissions from military mobile activities which are also included in category 1.A.5. All greenhouse gases as well as CO, NOx, NMVOC and SO_2 emissions are estimated.
In 2016, energy use in other sectors account for 22.4% of CO_2 emissions, 5.4% of CH_4, 13.5% of N_2O emissions. In term of CO_2 equivalent, other sectors share 19.4% of total national greenhouse gas emissions and 23.9% of total GHG emissions of the energy sector.

The trend of greenhouse gas emissions are summarised in Table 3.32. Emissions are reported in Gg for CO_2, and in Mg for CH_4 and N_2O. A general increase in emissions is observed from 1990 to 2000, due to the increase in activity data (numbers and size of building with heating); a sharp increase is observed in 2005 due to exceptionally cold weather conditions. CH_4 and N_2O emissions increase in the period is due to the growing use of woody biomass and biogas for heating. CH_4 and N_2O emissions of category 1.A.4.c are driven by the use of biomass, both wood and biogas, in the agriculture sector for heating of greenhouse and aquaculture plants; according to the national energy balance, wood biomass fuel started to be consumed in 2000 while biogas from agriculture residues sharply increased in the last years.

Table 3.32 Trend in greenhouse gas emissions from the other sectors, 1990-2016

GAS/SUBSOURCE	1990	1995	2000	2005	2010	2013	2014	2015	2016
CO_2 (Gg)									
1.A.4.a Commercial/ Institutional	12,195	14,591	17,652	24,169	28,407	23,802	21,119	22,415	22,803
1.A.4.b Residential	55,554	52,457	53,419	59,972	54,910	51,066	42,676	47,657	47,998
1.A.4.c Agriculture/ Forestry/ Fisheries	8,352	8,751	8,111	8,454	7,342	6,795	6,798	6,933	7,008
1.A.5 Other	1,071	1,496	837	1,233	652	585	573	459	515
CH_4 (Mg)									
1.A.4.a Commercial/ Institutional	621	908	2,019	3,111	4,023	4,541	4,708	4,499	4,661
1.A.4.b Residential	43,789	50,044	52,573	55,520	98,606	91,273	78,036	87,882	84,908
1.A.4.c Agriculture/ Forestry/ Fisheries	1,264	946	669	579	774	1,656	2,158	2,383	2,496
1.A.5 Other	173	223	126	160	65	55	66	54	64
N_2O (Mg)									
1.A.4.a Commercial/ Institutional	318	425	625	928	1,185	1,120	1,132	1,154	1,171
1.A.4.b Residential	3,014	3,173	3,304	3,522	5,261	4,872	4,150	4,659	4,527
1.A.4.c Agriculture/ Forestry/ Fisheries	2,515	2,757	2,610	2,684	2,373	2,259	2,282	2,327	2,383
1.A.5 Other	225	215	135	291	131	134	82	59	53

Source: ISPRA elaborations

Seven key categories have been identified for this sector for 2016, for level and trend assessment, using both the IPCC Approach 1 and Approach 2:

Other sectors - CO_2 commercial, residential, agriculture gaseous fuels (L, T);
Other sectors - CO_2 commercial, residential, agriculture liquid fuels (L, T);
Other sectors - CH_4 commercial, residential, agriculture biomass (L, T)
Other sectors - CO_2 commercial, residential, agriculture other fossil fuels (L1, T);
Other sectors - N_2O commercial, residential, agriculture biomass (L2, T)
Other sectors - N_2O commercial, residential, agriculture liquid fuels (L2)
Other sectors - CO_2 commercial, residential, agriculture solid fuels (T1).

All these categories, except N_2O emissions from liquid fuels and CO_2 emissions from solid fuels, are also key category including the LULUCF estimates in the key category assessment. Considering LULUCF, CO_2 emissions from other fossil fuels are key categories only using the Approach 1.

3.6.2 Source category description

This category includes 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. 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. Emissions from these plants are allocated in the commercial /institutional category because of the final use of heat and electricity production. In fact, until the early 2000s, electricity and heat produced by incinerators have been prevalently used to satisfy the energy demand from connected activities: heating of buildings, domestic hot water and electricity for offices. This is still true for industrial and hospital incinerators, meanwhile municipal solid waste incinerators have increased the amount of energy provided to the grid from the early 2000s until now. It would be possible to change the allocation of emissions but this could carry to an inconsistency in the time series.
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 Table 7.12 in the waste sector chapter the amount of waste and biogas fuel consumptions for 2016 are reported.
In 2016, this sector has a share of 5.4% of total GHG national emissions excluding LULUCF.

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 a small amount of biodiesel has been used in the residential sector and it has been reported under biomass category affecting the average emission factors.
In 2016, this sector has a share of 12.0% of total GHG national emissions.

Agriculture/ Forestry/ Fisheries
This subsector includes 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.
Up to 1999, biomass included only biogas recovered for energy purposes from the storage of animal manure and agriculture residuals, while from 2000, as reported in the National Energy Balance, a huge amount of wood has been consumed affecting implied emission factors.
In 2016, this sector has a share of 1.8% 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 2016, 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, 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, but this information is available in the Joint Questionnaire OECD/IEA/EUROSTAT prepared by the Ministry of Economical Development and officially sent to the international organizations. In this submission the updated fuel consumption time series according to the joint Questionnaire have been updated for the following fuels: steam coal, coke oven coke, residual oil, gasoil, kerosene, LPG, gas work gas.
For natural gas, which have not been yet updated with data reported to the international organizations, total consumption is 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. CH_4 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). No more solid fuels are used for heating purposes from 2013.
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 the respective CH_4 emission factors have been used: LPG 1 kg/TJ, fuel oil 3 kg/TJ and gasoil 7 kg/TJ.
Regarding natural gas, the country specific CH_4 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 and compared with the national ones.

Liquid and gaseous fuel CH_4 default emission factors(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, which refer to fossil waste, vary on an annual basis. For CO_2, the variation occurs from 1990, as a consequence of the mix of wastes used in incinerators, such as urban wastes, industrial, hospital, and oil wastes; for non-CO_2 gases, emission factors reported in EMEP/EEA (EMEP/EEA, 2013) applied at plant level have been considered, but specifically for CH_4 and N_2O this use does not result in changes of the implied emission factors because values are the same for the different kind of wastes, and emission factors are equal to 6.5 kg/TJ and 10.9 kg/TJ, respectively. In 2016 CO_2, average emission factors was equal to 116.5 kg/GJ,.

Regarding biomass fuel consumption in the following box CO_2, CH_4 and N_2O emission factors used in the national inventory for the different type of fuels are reported. CH_4 and N_2O emission factors derive from the EMEP/CORINAIR Guidebook (EMEP/CORINAIR, 2007), and the implied emission factors fluctuate as a function of the mix of fuels (wood, biogas, waste and biodiesel).

Regarding CO_2 from waste, fossil fraction emissions are distinguished by biomass to include them in the national totals. CO_2 emission factors are built on the basis of carbon content in each type of waste: municipal waste, industrial waste, oil, sludge and hospital. For biodiesel, the same CO_2 country specific emission factor as gasoil has been used (see Annex 6). Biogas emission factors are calculated starting from the stochiometric carbon value equal to 750 kg C/t and annual energy efficiencies provided by Terna (Terna, several years) for the respective use in commercial and agriculture sectors. Wood and steam wood average CO_2 emission factor is derived taking in account the typical national wood used and it is applied for the whole timeseries. Implied emission factors result from the mix of biomass fuels used for each category (1A4a, 1A4b, 1A4c).

Biomass CO_2, CH_4 and N_2O emission factor for 2016 (kg/TJ)

Fuel	CO_2	CH_4	N_2O
Wood	94600	320	14
Biogas landfills and sludge treatment	51917	153	3
Biogas agricolture residuos	54500	153	3
Waste	89833	7	11
Biodiesel	79600	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:

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

where

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

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

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

where

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

Population data have been revised based on a survey of machinery sales (Frustaci, 1999). Machinery lifetime is estimated on the European averages, see EMEP/CORINAIR (EMEP/CORINAIR, 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 1990-2015 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 CO_2 emissions in "Other sectors" is estimated to be about 4% in annual emissions; a higher uncertainty is calculated for CH_4 and N_2O emissions on account of the uncertainty levels attributed to the related emission factors.
Montecarlo analysis has been carried out to estimate uncertainty of CO_2 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 2016 are reported in Table 3.33.

Table 3.33 Trend in fuel consumption for the other sector, 1990-2016 (TJ)

	1990	1995	2000	2005	2010	2013	2014	2015	2016
					TJ				
1.A.4a.Commercial Institutional	213,360	258,970	316,681	427,772	492,010	421,312	375,441	393,921	394,931
1.A.4b. Residential	1,002,622	1,004,230	1,037,332	1,172,501	1,222,625	1,148,214	966,223	1,078,617	1,070,495
1.A.4c.AgricultureForestry Fisheries	114,638	121,163	111,480	116,837	103,166	101,882	104,203	107,097	108,628
1.A.5 Other	14,840	20,814	11,595	16,947	9,001	8,066	7,964	6,388	7,183

Source: ISPRA elaborations

In the following Table 3.34, total GHG emissions connected to the use of fossil fuels and waste derived fuels are reported for the whole time series. Total emissions from the sector are reported in Gg for CO_2, and in Mg for CH_4 and N_2O. An increase in emissions is observed from 1990 to 2000, due to the 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. CH_4 and N_2O emissions increase in the period due to the growing use of woody biomass for heating.

Table 3.34 Other sectors, GHG emission time series 1990-2015

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
CO_2 (Gg)	77,172	77,295	80,020	93,828	91,311	83,811	83,117	82,248	71,167	77,464	78,324
CH_4 (Mg)	45,847	52,120	55,387	59,370	103,468	69,343	96,700	97,524	84,968	94,819	92,129
N_2O (Mg)	6,072	6,569	6,674	7,425	8,950	7,250	8,317	8,384	7,646	8,198	8,134
GHG (Gg CO_2 eq)	80,128	80,556	83,393	97,525	96,565	87,706	88,012	87,185	75,570	82,278	83,052

Source: ISPRA elaborations

In Table 3.35, other sectors emissions are summarized according to main categories. From 1990 to 2016, an increase in the use of natural gas instead of fuel oil and gas oil in stationary combustion plants is observed; it results in a decrease of CO_2 emissions from combustion of liquid fuels and an increase of emissions from gaseous fuels. CH_4 and N_2O emissions increase in the period due to the increasing use of woody biomass for heating.

Table 3.35 Other sectors, GHG emissions in 1990 and 2016

		1990	2016
CO_2 other sectors liquid fuels	Gg	39,346	15,481
CO_2 other sectors solid fuels	Gg	899	0
CO_2 other sectors gaseous fuels	Gg	36,401	57,924
CO_2 other sectors other fuels	Gg	526	4,920
CH_4 other sectors	Mg	45,847	92,129
N_2O other sectors	Mg	6,072	8,134

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.4 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 sectors 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

Some recalculations have been done in this submission.
The energy conversion factor has been updated according to international statistics. As a consequence CO_2 emission factor for natural gas has been updated from 2008.
Waste fuel consumption for commercial heating activity data has been updated from 2014 because of the update of activity data for some industrial waste plants.
Natural gas fuel consumptions, for the whole time series, and biogas fuel consumptions, from 2005, have been updated on the basis of the last submission of energy balance provided by the Ministry of Economic Development to the Joint Questionnaire OECD/IEA/EUROSTAT.

As a consequence, time series for this category have been completely recalculated from 1990 affecting CO_2, CH_4 and N_2O emissions and resulting in minor recalculations equal to 0.07% for CO_2, 0.25% for CH_4 and 0.17% for N_2O in 2015.

3.6.7 Source-specific planned improvements

No further improvements are planned.

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 3.36 and 3.37 detailed data on petrochemical and other non-energy use for the year 2016 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

The quantities of fuels stored in products in the petrochemical plants are calculated on the basis of information contained in a detailed yearly report, the petrochemical bulletin, by Ministry of Economic development (MSE, several years [b]). The report elaborates results from a detailed questionnaire that all operators in Italy fill out monthly. The data are more detailed than those normally available by international statistics and refer to:

- input to plants;
- quantities of fuels returned to the market;
- fuels used internally for combustion;
- quantities stored in products.

National petrochemical balance includes information on petrochemical input entering the process and used for the production of petrochemical products, and petrochemical plants output, returns to the market, losses and internal consumption. Due to chemical reactions in the petrochemical transformation process, the output quantity of some fuels could be greater than the input quantity; in particular it occurs for light products as LPG, gasoline and refinery gas, and for fuel oil. Therefore for these fuels it is possible to have negative values of the balance. For this matter, with the aim to allow the reporting on CRF tables, these fuels have been added to naphta. The amount of fuels recovered from the petrochemical processes and returning on the market are considered as an output, because consumed for transportation or in the industrial sectors, and no carbon is stored.

In Table 3.36 and Table 3.37 the overall results and details by product are reported respectively.
In Table 3.36 the breakdown of total petrochemical process is reported; the percentages referring to the "net" input are calculated on the basis of the total input subtracting the quantity of fuels as gasoil, LPG, fuel oil and gasoline which return on the market because produced from the petrochemical processes.

In Table 3.37 the input to the petrochemical processes in petrochemical plants and the relevant losses, internal consumption and return to the market are reported, at fuel level, allowing the calculation of the quantity stored in products, subtracting the output (returns to the market, losses and internal consumption) from the input (petrochemical input). Carbon stored, for all the fuels, is therefore calculated from the amounts of fuels stored (in tonnes) multiplied by the relevant emission factors (tC/t) reported in Table 3.37.

An attempt was made to estimate the quantities stored in products according to the IPCC 1996 Guidelines, Reference Manual, ch1, tables 1-5 (IPCC, 1997), multiplying the IPCC percentage values in tables 1-5 of the Guidelines by the amount of fuels reported as "petrochemical input" in Table 3.37. The resulting estimate of about 5,268 Gg of products, for the year 2016, is 48% larger than the quantities reported, 3,482 Gg.

Non-energy products amount stored from refineries, and other manufacturers, are reported in the national energy balance (MSE, several years [a]) and the carbon stored is estimated with emission factors reported in Table 3.38. For lubricants the net carbon stored results from the difference between the amount of lubricants and the amount of recovered lubricant oils. The energy content has been calculated on the basis of the IPCC default values. Minor differences in the overall energy content of these products occur if the calculation is based on national parameters instead of IPCC default values.

In the CRF tables the fuel input amount is reported so that the fractions of carbon stored could be derived. As these fractions are derived from actual measurements they do not correspond to any default values and may vary over time.

Table 3.36 Other non-energy uses, year 2016

Breakdown of total petrochemical flow

	Petrochemical Input	Returns to refinery/market	Internal consumption / losses	Quantity stored in products
ALL ENERGY CARRIERS, Gg	7,915	3,386	1,047	3,482
% of total input		42.8%	13.2%	44.0%
% of net input			23.1%	76.9%

Source: ISPRA elaborations

Table 3.37 Petrochemical, detailed data from MSE, year 2016 (MSE, detailed petrochemical breakdown)

FUEL TYPE	Petroch. Input	Returns to refinery/ market	Internal consumption / losses	Quantity stored in products	% on total input	% on net input	Emission factor (IPCC)
	Gg	Gg	Gg	Gg			t C / t
LPG	298	404	8	-114			0.8146
Refinery gas	327	187	732	-592			0.7781
Virgin naphtha	4,214	0	0	4,214			0.8900
Gasoline	1,037	1,561	0	-524			0.8379
Kerosene	902	697	0	205			0.8606
Gas oil	377	273	4	100			0.8696
Fuel oil	301	146	82	74			0.8534
Petroleum coke	0	0	0	0			0.8666
Others (feedstock)	280	119	53	108			0.8462
Losses	0	0	0	0			0.8462
Natural gas	179	0	168	11			0.7511
total	7,915	3,386	1,047	3,482	44%	77%	

Source: ISPRA elaborations

Table 3.38 Other non-energy uses, year 2016, MSE several years [a]

NON ENERGY FROM REFINERIES	Quantity stored in products	Energy content IPCC '96	Total energy content	Emission factor
	Gg	TJ/Gg	PJ	Gg C / Gg
Bitumen + tar	2,557	40.19	102.8	0.8841
lubricants	1,198	40.19	48.2	0.8038
recovered lubricant oils	173	40.19	7.0	0.8038
paraffin	108	40.19	4.3	0.8368
others (benzene, others)	591	40.19	23.8	0.8368
Totals	4,627		186.0	

Source: ISPRA elaborations

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

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 provided 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

No recalculation occurred in the 2018 submission.

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 2016, GHG emissions from this source category account for 2.1% out of the total emissions in the energy sector. Trends in fugitive emissions are summarised in Table 3.46.

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

Key-category identification in the fugitive sector with the IPCC Approach 1 and Approach 2

Year		IPCC category	without LULUCF	with LULUCF
2016	CH_4	Oil and natural gas - Natural gas	L, T	L, T
	CO_2	Oil and natural gas - Oil	L1, T2	L1
1990	CH_4	Oil and natural gas - Natural gas	L	L
	CO_2	Oil and natural gas - Oil	L1	L1
	CO_2	Oil and natural gas - Venting and flaring	L2	L2
	CO_2	Oil and natural gas – Flaring in refineries	L2	-

Methane emissions are key categories for natural gas according to level and trend assessment with Approach 1 and Approach 2 with and without LULUCF; CO_2 emissions for oil are key category only for level with Approach 1 and for trend with Approach 2.
As concerns the level for the year 1990, CH_4 emissions are key categories for natural gas, either including or excluding LULUCF emissions and removals following both the Approaches. CO_2 emissions are key categories for oil only with Approach 1, while CO_2 emissions are key categories for venting and flaring only with Approach 2, as well CO_2 emissions from flaring in refineries but only exluding LULUCF emissions and removals.

Fugitive CH_4 and CO_2 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. CH_4 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. N_2O emissions from 1.B.1 are not occurring.

Fugitive CO_2 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.
CH_4 emissions reported in 1.B.2 refer mainly to the production of oil and natural gas and to the transmission in pipelines and distribution of natural gas, while N_2O 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 N_2O emissions in refining and storage are reported under flaring in refineries as shown in the following Table 3.39.

Table 3.39 Completeness of N_2O fugitive emissions

1.B. 2.a. Oil		
iv. Refining/storage	N_2O	Included in 1.B.2.d flaring in refineries

3.9.2 Methodological issues

Coal mining and handling
CH_4 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, 2006). Mining and post mining emissions have been calculated. As for CH_4 emissions from mining and post mining the average emission factors of the 2006 IPCC Guidelines (IPCC, 2006) have been selected, $18 m^3/t$ and $2.5 m^3/t$, respectively. As concerns CO_2 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 CH_4 and 6% of CO_2 by volume (Williams, 1993).
As for closed or abandoned mines there are no methods for estimating emissions from surface mines at present (IPCC, 2006). As for the only one underground mine closed from 1994 to 1999, there are no data for a country based approach to estimate fugitive emissions during the closure period. The emission estimations are carried out applying Tier 2 of the 2006 IPCC Guidelines for bituminous mines with 100% of gassy parameter.

Solid fuel transformation

CH_4 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) taking in account the information provided by the relevant operators in the framework og the EPRTR registry and the ETS, as addressed in paragraph 3.3.3 of this chapter.

With regard to the manufacture of other solid fuels, in Italy charcoal was produced in the traditional way until the sixties while now it is prevalently produced in modern furnaces (e.g with the VMR system) where exhaust gases are collected and recycled to produce the energy for the furnace itself. This system ensures good management of the exhausts and the temperature, so that any waste of energy is prevented and emissions are kept to a minimum. So CH_4 emissions from the production of charcoal are not accounted for also considering that the emission factor available in the Revised 1996 IPCC Guidelines, in Table 1-14 vol.3 (IPCC, 1997), refers to production processes in developing countries not applicable to our country anymore. Moreover in the IPCC Good Practice Guidance as well as in the IPCC 2006 Guidelines no guidance is supplied for charcoal production.

Oil transport and storage and refining

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 guidelines (IPCC, 2006).

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 3.40 provides the length of pipelines for oil and the amount of oil products transported since 1990.

Table 3.40 Length of pipelines for oil transport (km) and amount of transported oil products (Gg)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Length of pipelines (km)	4,140	4,235	4,346	4,328	4,291	4,290	4,290	4,303	4,308	4,022	4,012
Amount transported (Gg)	94,600	102,274	116,803	133,024	128,854	116,720	114,419	114,533	110,777	110,369	112,031

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 Guidelines (IPCC, 2006).

Fugitive CO_2 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 CO_2 emissions for flaring and for processes separately.

In Table 3.41, the time series of crude oil losses published in the BEN and crude oil processed in Italian refineries are shown.

Table 3.41 Refineries activities and losses

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Crude Oil losses (Mg)	1,004	937	757	576	664	658	626	693	630	664	670
Crude oil processing (Gg)	93,711	91,014	98,003	106,542	94,944	90,705	85,278	76,317	71,552	79,148	77,510

Source: MSE, UP

Oil and gas exploration

CO_2, CH_4, and N_2O 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) as no emission factors for number of wells were available in 2006 IPCC guidelines.

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.

Oil and gas production and processing

CH_4 emissions from the production of oil and natural gas as well for natural gas processing 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 guidelines (IPCC, 2006).

CH_4 emission factors for the whole time series have been calculated taking into account this information also for oil venting and flaring and for gas flaring.

For CO_2, the IPCC default emission factor has not been modified for each category, as no specific information is available.

N_2O emissions from flaring in oil and gas production have been estimated on the basis of activity production data and emission factors reported in the IPCC guidelines (IPCC, 2006).

As regards the decline of CH_4 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 3.42, the time series of national production of oil and gas are reported. Natural gas production should further reduce in the next years.

Table 3.42 National production of oil and natural gas

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Oil (Gg)	4,668	5,236	4,586	6,111	5,106	5,309	5,396	5,502	5,765	5,470	3,760
Natural gas (Mm^3)	17,296	20,383	16,766	11,962	8,265	8,339	8,511	7,705	7,286	6,877	6,021

Source: MSE

Natural gas transmission and distribution

CH_4 and CO_2 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. In other word the most relevant information is the amount of natural gas transmitted/distributed and the methane emissions reported by operators in their environmental reports or communicated to ISPRA.

The emissions communicated by main operators are estimated separately for transmission/distribution taking into account known lengths and materials of pipelines just to calibrate the model used to estimate fugitive emissions from minor 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).

CO_2 emissions have been calculated considering CO_2 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 3.43 shows average data for national pipelines natural gas.

Table 3.43 Average composition for pipelines natural gas and main parameters

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
HCV (kcal/m_3)	9,156	9,193	9,215	9,261	9,325	9,281	9,298	9,273	9,256	9,303	9,351
NCV (kcal/m_3)	8,255	8,290	8,320	8,354	8,412	8,370	8,387	8,364	8,348	8,391	8,444
Molecular weight	17.03	17.19	17.37	17.44	17.46	17.26	17.41	17.32	17.35	17.33	17.52
Density (kg/Sm_3)	0.72	0.73	0.74	0.74	0.74	0.73	0.74	0.73	0.73	0.73	0.74
CH_4 (molar %)	94.30	93.36	92.22	91.93	92.03	93.08	92.16	92.77	92.62	92.72	91.54
NMVOC (molar %)	3.45	4.09	4.84	5.35	5.74	5.00	5.48	5.04	5.04	5.26	6.17
CO_2 (molar %)	0.22	0.20	0.18	0.49	0.75	0.68	0.61	0.61	0.75	0.70	0.65
Other no carbon gas (molar %)	2.03	2.34	2.76	2.24	1.48	1.24	1.75	1.59	1.58	1.32	1.64
CH_4 (weight %)	88.83	87.14	85.16	84.53	84.52	86.52	84.89	85.94	85.64	85.80	83.79
NMVOC (weight %)	7.33	8.62	10.00	10.73	11.27	9.79	10.81	9.99	9.92	10.34	12.04
CO_2 (weight %)	0.57	0.51	0.47	1.23	1.89	1.73	1.54	1.54	1.91	1.78	1.62
Other no carbon gas (weight %)	3.27	3.74	4.37	3.51	2.30	1.95	2.76	2.53	2.52	2.10	2.56

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 3.44 provides the trend of natural gas distribution network length for each pipeline material and the average CH_4 emission factor.

Table 3.44 Length of low and medium pressure distribution network (km) and network emission factors for CH_4

Material	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Steel and cast iron (km)	102,061	131,271	141,848	154,886	198,706	197,369	199,899	200,647	202,137	203,116	204,062
Grey cast iron (km)	24,164	23,229	21,314	15,080	4,658	4,519	4,414	3,727	3,348	2,398	2,113
Polyethylene (km)	775	7,300	12,550	31,530	49,663	51,053	52,073	53,548	54,639	56,943	57,933
Total (km)	**127,000**	**161,800**	**175,712**	**201,496**	**253,027**	**252,940**	**256,386**	**257,922**	**260,124**	**262,457**	**264,108**
CH_4 Emission Factors (kg/km)	**1,958**	**1,417**	**1,227**	**1,000**	**715**	**707**	**676**	**660**	**626**	**541**	**525**

More details on the methodology used and on the basic information collected from operators are reported in a technical paper carried out by ISPRA in order to assess emissions from the whole natural gas distribution grid (Contaldi, 1999).
The study addressed natural gas leakages, pipelines material, and operating pressure with data of 1995. All main gas operators were involved. An estimation model was set up in order to approximate the known gas emissions from the main operators and total emissions for year 1995. Emission factors distinct by pressure (low, medium and high) and material (cast iron, grey cast iron, steel or polyethylene) was applied to achieve the goal. Emission factors from Battelle study for former West Germany was applied, cross checked with operator's data and modified where it is needed. The emission factors of minor operators (Other in the next table) are "worsened" to take account for lower quality standard.
The pipelines emission factors for transmission and distribution used for emission estimates are reported in the following box:

Emission factors for transmission and distribution in pipelines in 2016 by operator

Material	***Pressure***		
	High	***Medium***	***Low***
	m^3/km		
Steel	600 (SNAM) 700 (Other)	461 (Italgas) 610 (ENEL) 720 (Other)	461 (Italgas) 610 (ENEL) 589 (Other)
Cast iron	-	461 (Italgas) 610 (ENEL) 720 (Other)	461 (Italgas) 610 (ENEL) 589 (Other)
Grey cast iron	-	-	5694 (Italgas) 6205 (ENEL) 7136 (Other)
Polyethylene	-	-	540 (Italgas) 765 (Italgas/ENEL) 750 (Other)

SNAM is the main operator for national gas transmission and import-export. ITALGAS and ENEL are the main operators for gas distribution. They publish annually environmental reports with amount of natural gas conveyed and total leaks. Moreover SNAM provides to ISPRA chemical composition and energy content of national gas imported and produced. In 2016 SNAM accounts for about 93% of national pipelines length and about 99% of transported gas. ITALGAS and ENEL account for about 44% of distribution network length and about 41% of distributed gas. There are about 235 operators distributing natural gas. AEEG is the National Authority for Electricity and Gas. Starting from 2000 AEEG issues a yearly report with information on pipelines and network length, operating pressure, and network type concerning pipelines material. The estimation model calibrated on the main operators was used to estimate fugitive emissions from minor operators. Natural gas leaks by main operators and average composition of natural gas are used to estimate fugitive emissions. For minor operators lower quality standard and higher specific emission factors for network material, venting, and other accidental losses were considered.

In order to take account of different sources of emissions (LNG regasification plants, compression stations, pipeline import/transmission and distribution, venting, and other accidental losses) the total leaks communicated by main operators and those estimated for minor operators are distributed resulting in implied emission factors for the other sources of emissions than transmission and distribution.

In the following box, 2016 implied emission factors for transmission and distribution sources are reported:

Implied emission factors for transmission in 2016

LNG regassification	0.69 Mm^3 NG / Gm^3 NG imported
Pipeline compression station	0.16 Mm^3 NG / Gm^3 NG transported
Pipeline transmission	600 - 700 m^3/km (as reported in the previous table for high pressure pipelines)
Venting and other accidental losses	0.037 Mm^3 NG / Gm^3 NG transported (SNAM) 0.129 Mm^3 NG / Gm^3 NG transported (other)

Implied emission factors for distribution in 2016

Pipeline distribution	As reported in the previous table for medium and low pressure pipelines
Venting and other accidental losses	0.095 Mm^3 NG / Gm^3 NG distributed (Italgas) 0.183 Mm^3 NG / Gm^3 NG distributed (Enel) 0.223 Mm^3 NG / Gm^3 NG distributed (Other)

Furthermore fugitive emissions due to the use of natural gas at home are considered and estimated with an emission factor equal to *36 kg CH_4 / TJ* natural gas distributed.

The estimation model used to estimate fugitive emissions is updated every year considering data published by AEEG on pipelines and it is calibrated with annual leakage data published by main operators in their environmental reports.
The next graph shows the CH_4 emission factors time series since 1990 for natural gas transmission and distribution:

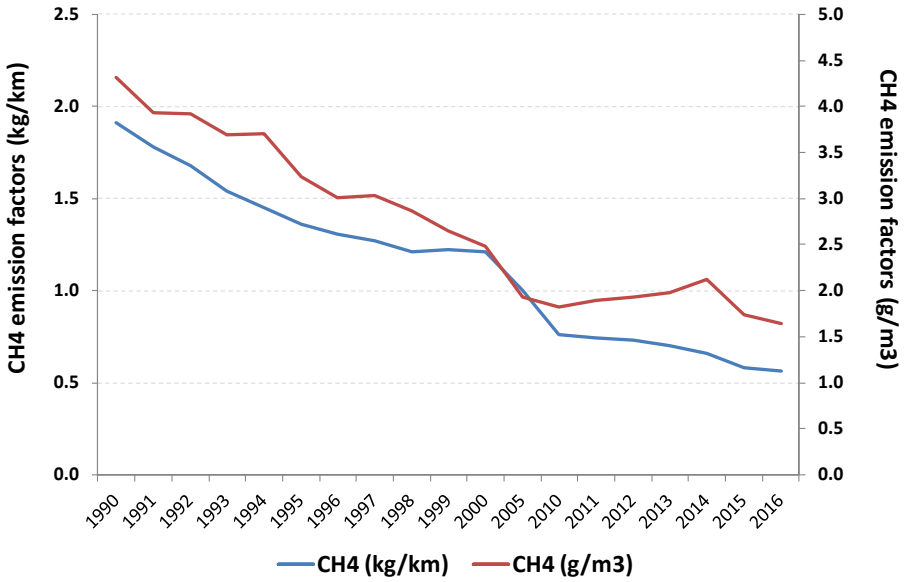

Figure 3.1 Trend of CH_4 emission factors for natural gas transmission and distribution

The different trends are explained by different composition of natural gas along the time series as CH_4 content and average density.

3.9.3 Uncertainty and time-series consistency

The uncertainty in CO_2, CH_4, and N_2O emissions is quite differentiated for sources as shown in Table 3.45.

Table 3.45 Activity data (AD) and emission factor (EF) uncertainties for CO_2, CH_4, and N_2O emissions

	CO_2		CH_4		N_2O	
	AD	**EF**	**AD**	**EF**	**AD**	**EF**
Solid fuels	3%	10%	3%	50%	NA	NA
Oil and natural gas - Oil					3%	50%
Oil and natural gas – Natural gas					NA	NA
Oil and natural gas – Venting and flaring	50%	10%	50%	50%	50%	50%
Oil and natural gas – Flaring in refineries						

Montecarlo analysis was applied to estimate uncertainty of CH_4 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 CO_2 equivalent, account for 2.1% out of the total emissions in the energy sector in 2016. CH_4, CO_2, and N_2O emissions show a reduction from 1990 to 2016 by 46.6%, 38.1%, and 21.8% respectively.
The overall decrease of CO_2 fugitive emissions is mainly driven by the reduction in crude oil losses in refineries.

The trend of CH_4 and CO_2 fugitive emissions from solid fuels is related to the extraction of coal and lignite that in Italy is quite low. The decrease of CH_4 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, and flaring in refineries N_2O emissions, in CO_2 equivalent, account for 0.13% out of fugitive emissions, with a reduction since 1990 by 21.8%.
Fugitive emissions since 1990 are reported in Table 3.46.

Table 3.46 Fugitive emissions from solid fuels and oil & gas (Gg CO_2 eq.)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
						Gg CO_2 eq.					
CO_2											
Solid fuels	0.4	0.1	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.0
Oil and natural gas	4,013	3,970	3,236	2,537	2,600	2,593	2,506	2,678	2,500	2,574	2,483
CH_4											
Solid fuels	132	74	97	90	86	91	80	58	57	44	42
Oil and natural gas	8,720	8,070	7,473	6,740	6,121	5,994	5,968	5,752	5,485	4,923	4,686
N_2O											
Oil and natural gas	12	12	12	13	12	11	11	10	9	10	9
Total emissions	**12,877**	**12,126**	**10,818**	**9,380**	**8,818**	**8,690**	**8,565**	**8,498**	**8,050**	**7,551**	**7,221**

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 [a]), gas operators (ENI, several years [b]; EDISON, several years; SNAM, several years), and industrial association for oil and gas (UP, several years).
Concerning CO_2 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]).
CH_4 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

Recalculations lightly affected emission estimates of the sector for 2014 and 2015. The recalculations are due to the updated data, as for liquid fuel distribution, and some typo, as for amounts of solid fuels storage and production. Consequently the calculation of CO_2 and CH_4 emissions has been revised for solid fuels and oil & natural gas sources.

3.9.6 Source-specific planned improvements

No further improvements are planned for the next submission.

4 INDUSTRIAL PROCESSES AND PRODUCT USE [CRF sector 2]

4.1 Sector overview

By-products or fugitive emissions, which originate from industrial processes, are included in this sector. 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 SO_2 emissions are estimated.
CO_2 emissions related to NMVOC from solvent use in paint application, degreasing and dry cleaning, chemical products manufacturing or processing and other use, are estimated.
N_2O emissions are also estimated. These emissions arise from chemical industry (2B) and from "other product manufacture and use (2G). As for CRF sector 2G, the use of N_2O occurs in medical applications, such as anaesthesia, and in the food industry, where N_2O is used as a propelling agent in aerosol cans, specifically those for whipped cream. Emissions from the use of N_2O in explosives are also included.

In 2016 industrial processes and product use account for 4.21% of CO_2 emissions, 0.11% of CH_4, 3.07% of N_2O, 100% of PFCs, HFCs, SF_6 and NF_3. In terms of CO_2 equivalent, industrial processes and product use share 7.5% 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 CO_2, CH_4 and N_2O and in Gg of CO_2 equivalent for F-gases.

An increase in HFC emissions is observed from 1990 to 2016, while CO_2 emissions from chemical and metal industry reduced sharply in the period.

Table 4.1 Trend in GHG emissions from the industrial processes and product use sector, 1990-2016 (Gg)

GAS/SUBSOURCE	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
CO_2 (Gg)	29,385	27,338	25,904	28,772	21,783	21,336	18,052	16,370	15,678	15,000	14,761
2A. Mineral Products	20,720	20,240	20,749	23,305	17,379	16,736	13,724	12,298	11,606	11,212	10,607
2B. Chemical Industry	2,577	1632	1,421	1,697	1,434	1,405	1,342	1,336	1,416	1,256	1,463
2C. Metal Production	4,378	3,903	2,302	2,419	1,834	2,044	1,918	1,678	1,637	1,563	1,710
2D. Non-energy products from fuels and solvent use	1,710	1,564	1,432	1,350	1,135	1,151	1,068	1,058	1,020	969	980
CH_4 (Gg)	5.16	5.36	2.92	2.97	2.39	2.65	2.53	2.03	1.92	1.70	1.91
2B. Chemical Industry	2.45	2.65	0.31	0.25	0.22	0.18	0.17	0.15	0.13	0.17	0.17
2C. Metal Production	2.71	2.71	2.61	2.72	2.17	2.47	2.36	1.88	1.79	1.53	1.73
N_2O (Gg)	24.16	25.84	28.85	27.69	4.11	2.81	2.78	2.59	2.12	2.06	1.93
2B. Chemical Industry	21.54	23.35	25.54	25.03	2.09	0.95	0.76	0.74	0.38	0.49	0.39
2G. Other product manufacture and use	2.62	2.49	3.31	2.66	2.02	1.86	2.02	1.85	1.74	1.57	1.54
HFCs (Gg CO_2 eq.)	444	820	2,105	6,060	9,581	10,154	10,687	11,383	11,928	12,264	14,681
2B. Chemical Industry	444	549	26	24	1	1	1	1	1	1	1
2C. Metal Production	-	-	-	-	2	4	5	6	8	10	10
2E. Electronics Industry	-	6	9	7	11	11	7	8	9	9	10
2F. Product Uses as Substitutes of ODS	-	314	2,444	7,057	11,343	12,226	12,847	13,464	14,073	14,447	14,660
PFCs (Gg CO_2 eq.)	2,907	1,492	1,488	1,940	1,520	1,661	1,499	1,705	1,564	1,688	1,629
2B. Chemical	932	1,041	991	1,547	1,301	1,439	1,345	1,574	1,404	1,552	1,493

GAS/SUBSOURCE	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Industry											
2C. Metal Production	1,975	350	231	212	99	95	39	-	-	-	-
2E. Electronics Industry	-	101	266	180	121	128	116	131	160	136	136
SF_6 (Gg CO_2 eq.)	410	681	605	550	394	441	445	421	359	441	377
2B. Chemical Industry	114	114	-	-	-	-	-	-	-	-	-
2C. Metal Production	-	-	164	81	17	-	-	-	-	-	-
2E. Electronics Industry	-	15	62	57	31	51	46	44	38	47	45
2G. Other Products Manufacture and Use	296	552	379	412	346	391	399	378	321	394	332
NF_3 (Gg CO_2 eq.)	-	77	13	33	20	28	25	26	28	28	28
2E. Electronics Industry	-	77	13	33	20	28	25	26	28	28	28

Fourteen key categories have been identified for this sector, for level and trend assessment, using both the Approach 1 and Approach 2. The results for 2016 are reported in the following box.

Key-category identification in the industrial processes sector with the IPCC Approach 1 and Approach 2 for 2016

KEY CATEGORIES			without LULUCF	with LULUCF
2A	CO_2	Emissions from cement production	L, T	L, T
2A	CO_2	Emissions from lime production	L1	L1
2A	CO_2	Emissions from other process uses of carbonates	T1	T1
2B	CO_2	Emissions from ammonia production	T1	T1
2B	N_2O	Emissions from adipic acid	T	T
2B	N2O	Emissions from nitric acid production	T	T1
2B	HFCs	Emissions from fluorochemical productions	T2	-
2B	PFCs	Emissions from fluorochemical productions	L, T	L, T
2C	CO_2	Emissions from iron and steel production	T1	T1
2C	PFC	Emissions from Aluminium production	T	T1
2D	CO_2	Emissions Non-Energy products from fuels and solvent use	L2, T2	-
2F	HFCs	Emissions from substitutes for ODS- Refrigeration and air conditioning	L, T	L, T
2F	HFCs	Emissions from substitutes for ODS- Foam blowing agents	L2, T2	T2
2F	HFCs	Emissions from substitutes for ODS- Fire protection	L, T	L, T

CO_2 emissions from cement, lime and other carbonate uses are included in category 2A; N_2O emissions from adipic acid, nitric acid and CO_2 emissions from ammonia refer to 2B; CO_2 emissions from iron and steel production and PFC emissions from aluminium production are included in 2C; CO_2 emissions from non-energy products from fuels and solvent use are included in 2D; HFCs from substitutes for ODS are included in 2F and HFC and PFC emissions from fluorchemical production are included in 2B. Methane emissions from the sector are not a key source.
Most of these categories are also key categories in the 1990 assessment.

For the industrial processes sector, emissions and backgroung data collected in the framework of the European Emissions Trading Scheme, the National Pollutant Release and Transfer Register (Italian PRTR) have been used either directly in the estimation process or as verification of emission estimates, improving national emissions factors as well as activity data.
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). 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. The guidelines for reporting under ETS are aligned to the 2006 IPCC Guidelines.

The Italian legislation implementing EPER Decision included a legislative decree and a Ministry decree providing guidelines for reporting by the Italian EPER facilities. The Italian legislation implementing Regulation (EC) 166/2006 is a Decree of the President of the Republic (DPR n.157/2011). Annexed to the DPR is a guideline for the reporting by the Italian PRTR facilities.
Both guidelines for the reporting by the Italian EPER/PRTR facilities provide the list and description of the information to be reported, which includes: activity data (mandatory), total releases exceeding the reporting threshold values (mandatory); total off-site transfers of pollutant exceeding the reporting thresholds (mandatory); total off site transfers of waste exceeding the reporting thresholds (mandatory).
Releases/transfers information to be reported by facility operators can be based (in compliance with national and EU legislation) on measurement, calculation, estimation. In the case that operators report information based on measurements/calculation they are requested to communicate also what methodology has been applied to measure/calculate total releases/transfers.
As for activity data reporting under the national PRTR, no detailed requirements have been included in the national PRTR legislation and guidelines, although some general guidance is provided and followed by operators. The operator is expected to report the best available information concerning activity data for each reporting year, basically the amount produced, manufactured or treated in the reporting year shall be reported. It is appropriate to consider also that the largest majority of facilities in the scope of EPER/PRTR are also in the scope of EU and national legislation concerning the permitting procedures, monitoring and control obligation for the larger industrial facilities. The quality of information reported by the facilities under the national EPER/PRTR is assessed by the competent authorities, the same authorities are usually involved also in the permitting procedure of these facilities, thus cross checks of information concerning AD and emissions are expected by the national legal framework.
Since emissions data reported under the national EPRTR can be measured, calculated or estimated, the European PRTR Guidance Document and the national guideline for reporting to the national PRTR include also references to the IPCC Guidelines methodologies.

The collection of facility reports under the national EPER/PRTR is a task that ISPRA has to carry out by law. The national inventory team is in the same unit of ISPRA where the national EPER/PRTR is managed, the inventory team has full access to the whole national dataset of the Italian EPER/PRTR without restrictions on the type of information (AD and emissions of each reporting facilities are available for the inventory team). Italian EPER/PRTR data (emissions and transfers of pollutants, transfers of wastes) are publically available on the internet at the European PRTR website http://prtr.ec.europa.eu/ (in compliance with the legislation activity data of the reporting facilities are not disclosed to the public).

Data from the ETS and EPRTR databases are incorporated into the national inventory whenever the sectoral coverage is complete; in fact, not always data entirely cover the relevant categories whereas national statistics provide the complete basic data needed for the Italian emission inventory. Nevertheless, these data are entirely used to develop country-specific emission factors and check activity data levels.

4.2 Mineral Products (2A)

4.2.1 Source category description

In this sector CO_2 emissions from the following processes are estimated and reported: cement production, glass production, lime production and other processes uses of carbonates.

Cement
Cement production (2A1) is the main source of CO_2 emissions in this sector. As already mentioned, it is a key source both at level and trend assessment with and without LULUCF, also considering uncertainty, and accounts for 2.19% 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 to facilities closedowns and many conversions from full cycle to grinding plants. Since 2011 Italy has become the second cement producer country in the EU 28 as a consequence of the reduction of clinker production in the last years which has been confirmed also in 2015.
The picture of the cement sector in 2016 have 24 companies (62 plants of which: 33 full cycle and 29 grinding plants; i.e. in 2016 about 4 less full cycle plants were closed or converted to grinding plants and 2 grinding plants were closed compared to 2015) operating in Italy: multinational companies and small and medium size enterprises (operating at national or only at local level) are present in the country.
The operating plants are located as follows: 42% is in northern Italy, 16% is in the central regions of the country and 42% is in the southern regions and in the islands. The active sintering rotary kilns belong to the "dry" or of "semidry" types.

In Italy different types of cement are produced; as for 2016 AITEC, the national cement association, has characterised the national production as follows: 70.4% is CEM II (Portland composite cement); 12% is CEM I (ordinary Portland cement); 11.4% is CEM IV (pozzolanic cement) and 3.1% is CEM III (blastfurnace cement). Clinker production has been decreasing since 2007 (about -4.9% in 2016 compared to 2015) and clinker demand in cement production was about 76% in 2016 (consumption of clinker out of production of cement).

Lime
In 2016, CO_2 emissions from lime production is key category at level assessment, with and without LULUCF, following the Approach1.
CO_2 emissions occuring from processes where lime is produced account for 0.47% 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 CO_2 emissions according to the following reaction:

$$CaCO_3 + MgCO_3 + heat \rightarrow CaO + MgO + 2CO_2$$

CO_2 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 $Ca(OH)_2$.
CO_2 emissions estimation is related to lime production in mineral industry and it also includes the production of lime to feed other industrial processes (e.g. iron and steel making facilities).
The number of lime producing facilities has been relevantly changing through the years as shown in the following box:

	1990	**2003**	**2010**	**2012**	**2013**	**2014**	**2015**	**2016**
Lime facilities (n.)	85	46	35	35	34	39	25	26

figures from 2010 onwards are based on the number of facilities reporting under the EU-ETS.
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.

Other processes uses of carbonates (limestone and dolomite use in brick and tiles; fine ceramics; paper industry and power plants)

This category is key category in 2016 at trend assessment, with and without LULUCF, following the Approach 1.
CO_2 emissions are also related to the use of carbonates in different industrial processes, and they account for 0.22% 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. Mineral (stone) wool production which occurred in Italy along the years 1993-2009 is included in emission estimates for the energy sector. Stone wool has not been produced in Italy since 2009. Since the last submission, this category includes also the whole timeseries for CO_2 emissions from other uses of soda ash.

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, CO_2; occasionally and depending on the specific production process, heavy metals, fluorides and chlorides gases could be released. CO_2 emissions are mainly related to the decarbonisation of carbonates used in the process (soda ash, limestone, dolomite) during the melting phase, accounting for 0.15% 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 (COREVE, several years).

Rate of glass recycling

GLASS PRODUCTION	**1998**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Rate of glass recycling (%)	38.8	46.9	57.2	58.4	62.9	61.8	62.4	61.4	58.5	57.1

4.2.2 Methodological issues

IPCC Guidelines are used to estimate emissions from this sector (IPCC, 1997; IPCC, 2000; IPCC, 2006).
Activity data are supplied by industries and/or provided in the national statistical yearbooks (ISTAT, several years [a]). Emission factors are those provided by the IPCC Guidelines (IPCC, 1997; IPCC, 2000; IPCC,

2006), by other international Guidebooks (EMEP/EEA, 2013; USEPA, 1997), or they are derived by data communicated at plant level.

Cement

CO_2 emissions from cement production are estimated using the IPCC Tier 2 approach.

Activity data comprise data on clinker production provided by the Italian ministry of the economic development (MISE, several years). More in details from 1990 to 2008 official statistics provided by ISTAT have been used (ISTAT, several years [a]). Since 2009, ISTAT clinker and cement statistics have not been provided in time for the official submission anymore so a different source of information has been used. In particular, data on clinker and cement productions, based on a plant by plant monthly collection, are officially provided by the Italian Ministry for the Economic Development, at national and regional level, and available at the following website:
http://www.sviluppoeconomico.gov.it/index.php/it/per-i-media/statistiche/2009708-statistiche-produzione-cementi.

These production data are cross checked with EPRTR and ETS data and with ISTAT statistics when available. Clinker production provided by the Ministry for the Economic Development seems to be more reliable than statistics published by ISTAT that are based on a sample survey with quite a low response and data gaps are estimated by linear interpolation.

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 release and transfer register (E-PRTR) and the European emissions trading scheme (EU-ETS). In this latter context, cement production facilities reported fuel consumption, raw materials and emissions, split between combustion process and decarbonising process and complying with a clinker kiln input method which is based on IPCC methodology.

From 1990 to 2000 the resulting emission factor for cement production is equal to 532 kg CO_2/t clinker, based on the average CaO content in the clinker and taking into account the contribute of carbonates and additives. This value was assumed as representative of the Italian clinker manufacturing process by AITEC (AITEC, 2004) and officially reported to the Italian Ministry of Environment, Land and Sea in order to set the national circumstances for the implementation of the European-Emissions Trading Scheme (EU-ETS) in our country. The value was calculated by the industrial association 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/files/ghgp/tools/co2_CSI_Cement_Protocol-V2.0.pdf and data from some big Italian plants.

From 2001 to 2004, emission factors are the result of a linear interpolation of CO_2 IEF for 2000 and 2005.

From 2005, emission factors are based on the data reported within the frame of the EPER/EPRTR and EU-ETS. Based on emissions and activity data (which includes the average CaO content in the clinker produced and the use of carbonates and additives) reported and verified under the EU-ETS the resulting emission factor has been fluctuating for the last ten years as shown in Figure 4.1: it resulted in a minimum equal to 518 kg CO_2/t clinker in 2008, and a maximum in the period equal to 531 kg CO_2/t clinker in 2007 and a value around 525 kg CO_2/t in the last years. The average emission factor varies year per year also as a consequence of the different operating circumstances (e.g. quality of the raw materials and operating conditions) at the Italian clinker facilities.

The information related to activity data and emissions for the clinker facilities reporting to the national ETS system have been processed. The range of uncertainty calculated on the basis of data communicated by the plants is about 5% in the period 2005-2009 and it is about 4% in the period 2010-2015 and about 6% in 2016.

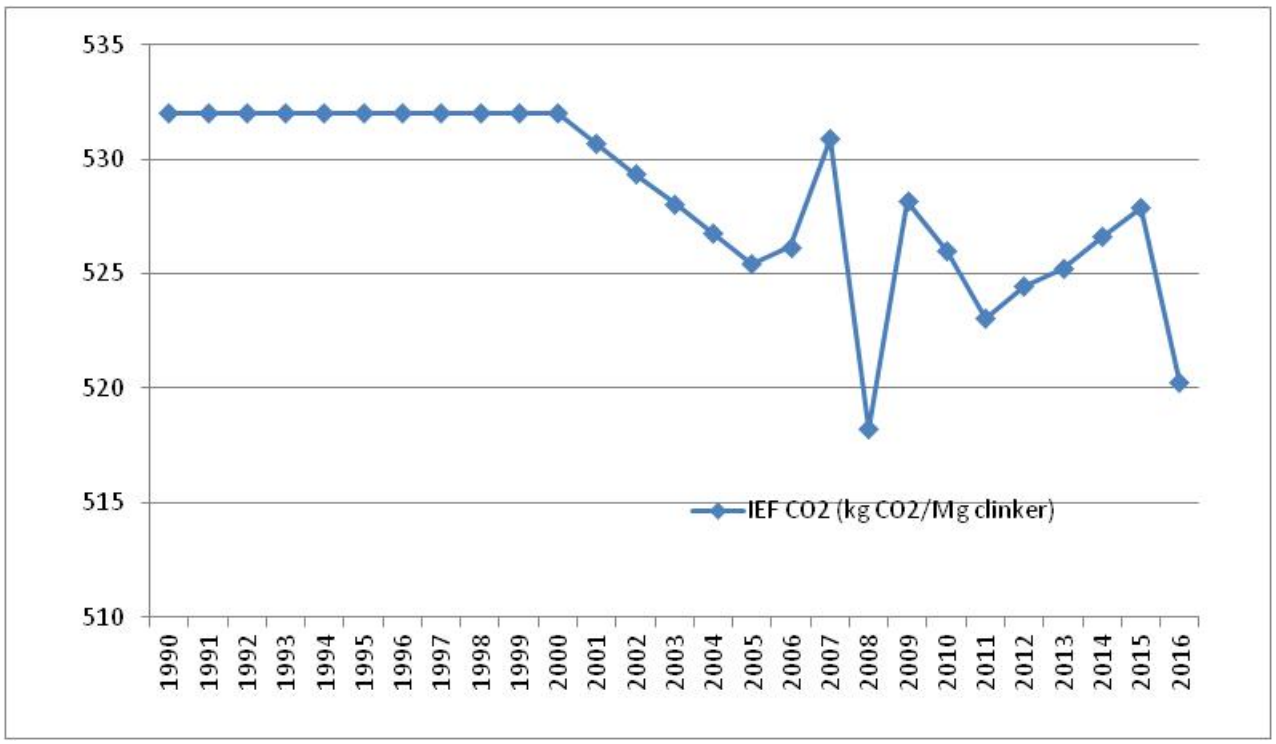

Figure 4.1 CO_2 IEF from decarbonation in clinker production, 1990-2016

In addition to this, AITEC has been reporting the overall consumption of natural raw materials by the national cement industry and also the replacement of natural raw material (either in the raw meal for the clinker manufacture or in the ground mix for the different cement types) with alternative materials in the Italian cement facilities, so:

- Specific consumption of natural raw materials has been varying for the last years;
- The rate of replacement of natural raw materials has been varying for the last years.

In 2016 approximately 6.7% of natural raw material was replaced by about 1.53 Mt non raw materials (0.86 Mt non hazardous wastes and 0.67 Mt secondary raw material) (AITEC, 2017). Most of the alternative materials consist of already decarbonised materials. The use of decarbonised material in amounts varying year by year in clinker kilns contributes explaining the fluctuations in the trend of the CO_2 IEF from decarbonisation.

In the following box the amounts of natural raw material consumption for the years 2009-2015 have been reported together with the amounts of secondary raw materials and the replacement rates in the same years.

Replacement of natural raw materials by secondary raw materials at the Italian cement facilities

RAW MATERIALS DEMAND	2009	2010	2011	2012	2013	2014	2015	2016
Natural raw materials (Mt)	43.6	43.4	40.4	34.2	29.8	25.1	23.5	22.8
Secondary raw materials (Mt)	1.9	1.8	1.9	2.3	1.9	1.7	1.5	1.5
Natural raw material/ clinker (t/t)	1.726	1.719	1.681	1.780	1.763	1.59	1.51	1.54
Replacement of natural raw material (%)	4.0	4.3	4.3	6.8	6.7	6.3	6.5	6.7

(source: AITEC, several years)

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 data reported under the national PRTR and also to 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 following box the number of clinker facilities reporting under EPRTR and ETS are shown together with the corresponding number of operating facilities according to the cement association (AITEC).

Clinker facilities	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Reporting to the national PRTR (n)	52	53	53	54	53	50	50	51	47	37	34	32
Reporting under the national ETS (n)	52	53	54	54	52	52	51	51	48	39	36	32
Number of clinker manufacturers in Italy (AITEC)	59	59	60	60	58	58	57	56	50	40	37	33
PRTR/AITEC (%)	88	90	88	90	91	86	88	91	94	93	92	97
ETS/AITEC (%)	88	90	90	90	90	90	89	91	96	98	97	97

In the framework of both the EU-ETS and the EPRTR registers 32 plants out of 33 reported data referred to 2016, representing more than 95% of total national clinker production. Generally, when the number of ETS clinker facilities is lower than AITEC figure, information concerning localization and production capacity are available for the facilities out of the scope of EU-ETS. AITEC reports every year the number of operating cement/clinker facilities in Italy and the cement production of the whole sector. 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 which are constituents of the raw meal complying with a "clinker kiln input" approach; both activity data and emissions are independently verified and certified as requested by the EU-ETS directive. The implied CO_2 emission factor is applied to the total national clinker production.

Basically, CO_2 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- 2009 and 2012-2016 due to the effects of the economic crisis and the significant reduction in the number of authorizations to build between 2005 and 2015 (-84%). Practically, the same variations can be observed in CO_2 emissions trend. In order to enhance the transparency of the inventory, in Figure 4.2 clinker production and CO_2 emissions time series are shown.

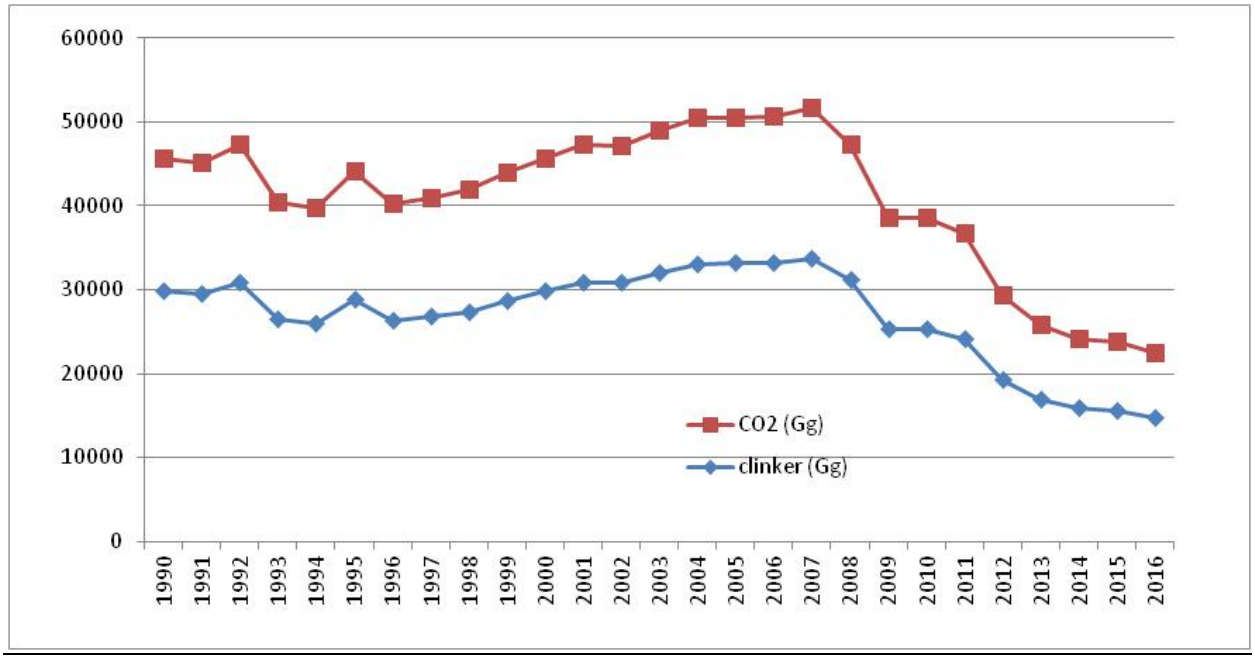

Figure 4.2 Trend of clinker production and CO_2 emissions 1990-2016 (Gg)

Lime

CO_2 emissions from lime have been estimated on the basis of production activity data supplied by ISTAT up to 2008 (ISTAT, several years [a]) and by operators in the frame of the ETS reporting obligations from 2009.
ISTAT reported till 2005 lime production data on the national Statistical Yearbook with the footnote explaining that the figure covered 80% of the national total lime production and not including auto produced lime in sugar mills and in the iron and steel plants.
From 2005 to 2008 lime productions has been provided to ISPRA for the emission inventory but not published. For the inventory purpose these statistics have been used, properly adjusted as indicated by ISTAT, adding non-marketed lime productions.
From 2009, only production indexes have been supplied by ISTAT; no other information has been published by ISTAT till 2014 when lime productions for the last years were made available but these data seems not consistent with the production index supplied by the same institute for the same years. For these reasons ETS data has been used from 2009.
All the national lime production plants are part of the EU-ETS and their production data is certified while data published by ISTAT are based, as for clinker and cement production, on a sample survey including production and economical information with quite a low response index and data for not responding plants are estimated by linear interpolation. There is no evidence of lime facilities not included in the ETS, with exception of plants located at sugar mills which are included in the estimates.

CO_2 emissions from lime production and use in other industrial processes (e.g. iron and steel production, sugar mills) have been also considered. Emission factors have been estimated on the basis of detailed information supplied by lime facilities in the framework of the European emission trading scheme and by the national lime industrial association (CAGEMA, 2005). Specifically, the value of the emission factor from 1990-2000 has been officially supplied to the Italian Ministry of Environment, Land and Sea by the industrial association (CAGEMA, 2005), in order to set the national circumstances for the implementation of the European-Emissions Trading Scheme (EU-ETS).
From 2001 to 2004, emission factors are the result of a linear interpolation of CO_2 IEF for 2000 and 2005.
From 2005, information available in the frame of the ETS reporting obligation has made activity data (including fuels and raw materials such as carbonates and additives, in compliance with a “lime kiln input” approach) available for the Italian lime industry at facility level together with CO_2 emissions data (combustion and process emissions). Both activity data and CO_2 emissions are certified and independently verified as requested by the EU-ETS legislation. In the present submission the amount of lime manufactured in 2015 has been updated.
The CO_2 implied emission factor varies year by year because of the natural raw material fed to the kilns at facility level including different CaO and MgO contents. In the following box, CaO and MgO contents for the years 2009-2016 are reported; these figures refer only to the production plants, excluding autoproduction.

CaO and MgO oxides content for lime production (%)

LIME PRODUCTION	2009	2010	2011	2012	2013	2014	2015	2016
CaO content (%)	96.9	96.7	96.2	93.6	94.4	89.8	90.7	97.1
MgO content (%)	3.1	3.3	3.8	6.4	5.6	10.2	9.3	2.9

Other processes uses of carbonates (Limestone and dolomite)

CO_2 emissions from other process uses of carbonates 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 Italy only limestone is used for the activities included in this category, brick and tiles, fine ceramic, and pulp and paper production and power plant flue gases treatment, while no dolomite use is documented. In the present submission the whole timeseries for CO_2 emissions from other uses of soda ash are included and allocated under this category, based on the activity data and emissions information reported by facilities in the scope of the national ETS. In 2016 about 78.8% of the total carbonates accounted for in this category has been used in the production processes of bricks and tiles, about 6.9% for the fine ceramic material, 13.1% in the treatment of flue gases in the power plants, about 0.3% in the paper industry and 0.8% is the share of the other uses of soda ash.
CO_2 emissions have been estimated for the whole time series on the basis of the IPCC default value for limestone equal to 0.44 t/t; the overall CO_2 emission time series is mainly driven by the CO_2 emissions from the use of limestone in the bricks and tiles sector.

In the CRFs the total amount of carbonates accounted for in this category used in these processes is reported. Detailed production, consumption, 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, Confindustria Ceramica, several years). Even though the EU ETS has not been in operation for the whole time-series relevant information concerning the use of carbonates was made available in the communications to the Italian Ministry for Environment, Land and Sea to get the overview of the sector for the national ETS to be implemented.

Mineral (stone) wool production has been also taken into account and CO_2 emissions have been estimated but they are included under Energy sector because it is not possible to identify the share of emissions related to the process aspects and the share of emissions related to the energy aspects (the IPCC 2006 Guidelines do not provide any indications concerning this issue). Mineral wool production in Italy took place in Sardinia at one facility during the years from 1993 to 2009 where the production was considered not profitable any more and the facility was closed down.

Glass

CO_2 emissions from glass production have been estimated taking into account, from 1990 to 2004, production data published by ISTAT on the National Statistical Yearbooks (ISTAT, several years [a]); from 2005 ISTAT statistics have not been available anymore and consistent figures published by the national glass industry association have been used (Assovetro, several years). Glass wool production is included for the whole time series.
In the following box, the complete time series of the national inventory for glass production is reported for the different types of glass.

Glass production time series (Mg)

Type	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2013**	**2014**	**2015**	**2016**
Flat glass	816,406	879,750	1,009,367	1,183,310	921,619	884,242	729,586	793,211	838,019	887,125
Container glass	2,609,826	3,094,893	3,417,851	3,716,509	3,656,425	3,535,707	3,593,471	3,627,489	3,936,885	4,061,931
Glass wool	105,029	119,120	139,421	129,958	115,332	95,770	81,486	81,357	86,929	86,498
Other glass	247,684	165,213	362,970	298,000	369,730	364,000	366,800	369,500	381,900	311,263

Since 2000, information provided by operators under the national ETS has been used to develop emissions estimation and relevant CO_2 emission factors. CO_2 emissions from the decarbonation, taking into account the national circumstances concerning the use of cullets (recycled scrap glass which does not cause CO_2 emissions) in the production processes, have been estimated.

In 2016, CO_2 emission factor has been estimated equal to 96 t CO_2/t, on the basis of information supplied, under the European emissions trading scheme, by 49 out of 52 facilities.

4.2.3 Uncertainty and time-series consistency

The uncertainty in CO_2 emissions from cement, lime, other process uses of carbonates 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 CO_2 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 CO_2 emission trend is reported.

Table 4.2 Production of mineral products, 1990 – 2016 (Gg)

ACTIVITY DATA	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
	(Gg)										
Cement production (decarbonizing)	29,786	28,778	29,816	33,122	25,239	24,057	19,204	16,902	15,833	15,527	14,762
Glass (decarbonising)	3,779	4,259	4,930	5,328	5,063	5,188	4,880	4,771	4,872	5,244	5,347
Lime (decarbonizing)	2,583	2,873	2,760	3,447	2,789	2,970	2,906	2,647	2,562	2,339	2,320
Other processes use of carbonates (Limestone and dolomite use)	5,765	5,275	5,127	6,071	3,487	3,340	2,411	2,214	1,940	1,886	1,712

Table 4.3 CO_2 emissions from mineral products, 1990 – 2016 (Gg)

CO_2 EMISSIONS	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
	(Gg)										
Cement production (decarbonizing)	15,846	15,310	15,862	17,403	13,276	12,583	10,071	8,877	8,339	8,196	7,680
Glass (decarbonizing)	453	511	611	768	559	584	547	546	562	534	512
Lime (decarbonizing)	1,877	2,090	2,013	2,456	1,969	2,092	2,038	1,892	1,841	1,652	1661
Other processes use of carbonates (Limestone and dolomite use)	2,544	2,328	2,263	2,678	1,575	1,476	1,067	984	864	830	753

Emission trends are generally related to the production level, which has been decreasing for the last years mainly because of the economic recession.

4.2.4 Source-specific QA/QC and verification

CO_2 emissions have been checked with the relevant industrial associations.
Both activity data and average emission factors are also compared every year with data reported in the national EPER/E-PRTR registry and in the European emissions trading scheme (EU-ETS).
Under the EU-ETS, operators are requested to report activity data and CO_2 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/EPRTR 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.
Information reported under the EU-ETS has allowed for estimating CO_2 emissions from other uses of soda ash, the whole timeseries is included in the present submission and allocated under the “Other processes use of carbonates” category.

4.2.5 Source-specific recalculations

Recalculations occurred in the current submissions for CO_2 emissions from the category “Lime” in 2015 (-5.22%) due to the update of the activity data in 2015 for this source category.
Negligible recalculations occurred also in the current submission for CO_2 emissions from the category “Glass” in 2015 (-0.001%) due to the update of activity data.

4.2.6 Source-specific planned improvements

Further investigations concerning the replacement of natural raw material in clinker manufacture and in lime production are planned.

4.3 Chemical industry (2B)

4.3.1 Source category description

CO_2, CH_4, N_2O, HFCs and PFCs emissions from chemical productions are estimated and included in this sector.

<u>*Adipic acid*</u>
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:

$$C_6H_{11}OH+2HNO_3 \rightarrow HOOC(CH_2)_4COOH+N_2O+2H_2O+energy$$

Adipic acid is then used to produce nylon or is fed to other production processes. Together with adipic acid, N_2O is produced and CO_2 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 N_2O, in 2016, adipic acid is a key category at trend assessment, both with Approach 1 and Approach 2, with and without LULUCF. These emissions account for 21% of total N_2O emissions in 2005, 2.4% in 2010, 0.6% in 2015 and 0.4% in 2016; the notable decrease in share is due to the fact that the technology to reduce N_2O emissions has become fully operational at the existing producing facility since 2007.

N_2O 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 N_2O 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 N_2O; 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 N_2O emissions. Since 2007 the operating time has been about 11 months (about one month was needed for maintenance operations) and the N_2O 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:

- the number of scheduled outages of the adipic acid production process is reduced (from about 1/month to 2/year);
- 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 N_2O 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 CO_2 emissions are estimated from this source.

<u>*Ammonia production*</u>
In 2016 CO_2 emissions from ammonia production are also a key category, at trend assessment with the Approach 1, with and without LULUCF.

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. CO_2 is also contained in the synthesis gas, but it is removed in the decarbonising step within the ammonia production process. Part of CO_2 is recovered as a by-product and part is released to atmosphere. Recovered CO_2 can either be used as input for different production processes (e.g. urea or calcium nitrate lines; liquefaction of CO_2 plant) on site or can be sold to technical gas manufacturers. The results of the investigation concerning the recovered CO_2 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). The amount of recovered CO_2 from ammonia production (which is fed to urea production processes) has been also reported in the CRF since the last submission for the whole timeseries.

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 NH_3 to NO_2 and subsequent reaction with water. Currently the reactions involved take place in low and medium pressure processes.
In 2016, N_2O emissions from nitric acid production are key source for trend assessment, without LULUCF, and trend with Approach 1, with LULUCF, as they show a relevant decrease in emissions from 1990 due to a reduction in production. Moreover, as far as YARA facility is concerned, the decrease in N_2O emissions is also related to the implementation of catalytic N_2O decomposition in the oxidation reactors a YARA De-N_2O patented technology, based on the use of CeO_2 catalyst (YARA, several years), while the improvements in the monitoring system of N_2O emissions at the other facility has been affecting N_2O emissions estimation timeseries for the very last 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, H_2, H_2O, NO_x, SO_x and H_2S; it is generally burnt to reduce the emissions to air and to recover energy to be used in the production process.
CO_2 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 (the parent company name changed intoVersalis in 2012) has become the main producer for those products in Italy, while it has been the main producer of styrene since 2002.

Titanium dioxide

CO_2 emissions from dioxide titanium production have been estimated on the basis of information (activity data and CO_2 emissions level) supplied directly by the Italian manufacturer in the framework of the reporting obligation to the EPRTR and EU-ETS registers. TiO_2 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 cycloexane. The process releases N_2O.
N_2O emissions from caprolactame production have been estimated and reported and are related to only one producing plant, which closed in 2003.

Calcium carbide production and use
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:

$$CaO+3C \rightarrow CaC_2+CO$$

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. CO_2 emissions from manufacture and use of calcium carbide have been estimated and accounted for along the whole timeseries.

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. CO_2 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.

Fluorochemical production
The sub-sector fluorochemical production consists of two sources, “By-product emissions” and “Fugitive emissions”.
PFC emissions from fluorochemical production is a key source at level and trend assessment, both using Approach 1 and Approach 2 with and without LULUCF; also HFC emissions is a key source at trend assessment, only using Approach 2 assessment and without LULUCF.
The production of halocarbons and SF_6 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 SF_6 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 HCFC22 is produced.
Within by-product emissions, HFC23 emissions are released from HCFC22 manufacture, CF_4 emissions are released from SF_6 and HCFC22/TFM productions, whereas C_2F_6 and HFC143a emissions are released from the production of C_3F_6 (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 SF_6 any longer.
Production of HFC125, HFC134a, HFC227ea and SF_6 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 fluorochemical production in the national total of F-gases was 39.6 % in the base-year (1990), and 8.9% in 2016.

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, N_2O emissions from adipic acid production (category 2B3) have been estimated using the default IPCC emission factor equal to 0.30 kg N_2O/kg adipic acid produced, from 1990 to 2003.
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 kgN_2O/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 N_2O 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 N_2O/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 N_2O/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 N_2O emissions since 2009 (Radici Chimica, 2013): in 2010 the average emission factor was 0.019 kg N_2O/kg adipic acid produced while in 2011-2013 the average EF is around 0.005 kg N_2O/kg adipic acid produced with the abatement rate exceeding 98%.
In 2015 the average EF is around 0.0043 kg N_2O/kg adipic acid while in 2016 is 0.0026 kg N_2O/kg adipic acid.

Thus, both for the period 1990-2005 and from 2006 up to 2011 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 N_2O emissions related to this production; adipic production and N_2O emissions have been also reported by the operator to the national competent authority for the ETS (the facility was included in the ETS system in 2013) together with additional information such as abatement rates and operating times. Since 2011 the implementation of a new monitoring system has enabled also the reporting of better quality emissions data in terms of nitrogen and nitrous oxides emissions.

Based on information from the national PRTR and ETS, 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 kgN_2O /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 from 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 along those years.

N_2O 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

$$(1-A*T)*EFp = EFs$$

Where:
A= Abatement rate provided by the operator
EFp= N_2O Emission Factor for Adipic Acid production (kg N_2O /kg adipic acid prod)
T = operating time of the abatement system/ operating time of the adipic acid production line
EFs = N_2O actually released Emission Factor submitted (kg N_2O released/kg adipic acid prod)

CO_2 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 [a]) and from 2002 they have been checked with information reported in the national EPER/E-PRTR registry. More in detail for 1990-1999 the amount of ammonia produced was published on the UN "Industrial Commodity Statistics Yearbook" (UN, several years), while for the years 2000 and 2001 production indexes published by ISTAT were applied. Since 2002 national production of ammonia in Italy has been collected at facility level. The number of ammonia facilities in Italy is known along the whole timeseries so it is possible to make sure that the national emissions estimation from this source is consistent to the sum of emissions from the ammonia facilities. Since 2009 only one facility has been producing ammonia in Italy and reporting data to the national PRTR.

Recovered CO_2 has been investigated with the cooperation of the operators and the resulting information has been used to revise the whole CO_2 emission time series and the emission factors. The analysis has allowed understanding that CO_2 emissions recovered from ammonia production are used to produce urea and technical gases. According to 2006 IPCC Guidelines the CO_2 recovered for technical gases should be accounted for emission and included in the estimate while that for producing urea should be reported in the relevant consumption categories. In particular, for the years 1990-2001, CO_2 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 CO_2 recovered since the beginning of the recovery operations. CO_2 reported to the national EPER/E-PRTR registry has been used for the previous years under the assumption, verified with the operator, that no change in technology at facilities have occurred along the period (YARA, 2007). Since 2002, the average emission factors result from data reported by the plants in the national EPER/E-PRTR and calculated taking in account the gas consumed for the reforming process; the plant supplies the recovered CO_2 detailed data allowing the proper application of the IPCC methodology. The following box shows the time series for the average CO_2 emission factor.

Ammonia production, time series for the average CO_2 EF (t CO_2/t ammonia production)

AMMONIA PRODUCTION	1990-2001	2002	2005	2010	2011	2012	2013	2014	2015	2016
EF (t CO_2/t ammonia production)	1.30	1.34	1.32	1.27	1.18	1.08	1.16	1.17	1.25	1.14

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 [a]), while at plant level they have been collected from industry (Norsk Hydro, several years; YARA, several years; Radici Chimica, several years). The number of nitric acid facilities in Italy is known along the whole timeseries so it is possible to make sure that the national emissions estimation from this source is consistent to the sum of emissions from the nitric acid facilities. 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 N_2O 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, N_2O 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/EPRTR 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/EPRTR register. The implied emission factor varies year by year depending on the operating circumstances at the production facilities, the values for the emission factor are shown in the following box for the years from 2007 onwards.

Nitric acid production, time series for the average N_2O EF (kgN_2O/t nitric acid production)

NITRIC ACID PRODUCTION	1990	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
EF (kg N_2O/Mg nitric acid)	6.49	7.08	2.29	2.94	1.21	1.32	1.11	0.86	0.40	0.31	0.39

Relevant reductions in N_2O emissions have been observed since 2008. Specifically, in 2008 the implementation of catalyst N_2O 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 N_2O 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 N_2O/Mg nitric acid production (the abatement rate in one plant was 82% so far); in 2010 the implied emission factor is 1.21 kg N_2O/Mg nitric acid production and in 2016 it is 0.39 kg N_2O/Mg nitric acid; the relevant decrease is due to the installation of the abatement technology in the other unit of the same producing facility (YARA, several years) and to the technical improvements implemented in 2011 as far as monitoring of emissions is concerned at the second nitric acid facility (Radici Chimica, 2013). Sampling circumstances at the facility may affect the reported N_2O emission values: sampling in times very close to catalyst exhaustion generally leads to higher N_2O concentration in the process flue gases, this seems to have occurred for N_2O emissions in 2011 according to the operator (Radici Chimica, several years).

Caprolactame

N_2O emissions from caprolactame have been estimated on the basis of information supplied by the only plant present in Italy, production activity data published by ISTAT (ISTAT, several years [a]) and production and emission data reported in the national EPER/E-PRTR registry. For the years 2002 and 2003 activity data and emissions were reported by the operators to the national EPER register. For 1990-2001 no facility level specific information was available for the inventory team, only the amount of caprolactame manufactured in Italy was known. Based on the 2002 emission factor and after discussion with the technical expert at the facility an emission factor equal to 0.3 kg N_2O/Mg caprolactame production was assumed for 1990-2001. The plant closed in 2003.

Carbon Black

CO_2 and CH_4 emissions from carbon black production process have been estimated with a Tier 2 approach and plant specific data. Plant specific information (AD and emissions) has been supplied by the Italian production facilities in the framework of the national EPER/E-PRTR registry and the European emissions trading scheme, total AD and total emissions allow for calculating the EFs values to be used in the estimation process. As for CO_2 emissions the following equation is used:

$$CO_2 \text{ emissions} = AD * EF$$

In 1996 a change in the production technology in the existing plants caused a reduction of CH_4, NMVOC, NO_x, SO_x and PM_{10} emissions. As for CH_4 emissions, in the present submission 2006 IPCC Guidelines default value for CH_4 emission factor (manufacturing process with thermal treatment) has been applied for this category and considered for the years since 1996 due to the performance of additional QA/QC procedures (specifically, the results of the technical review in the framework of Article 19(1) of the European Regulation No 525/2013). The following box include the values of the implied emission factor for CO_2 (t CO_2/t carbon black production) from 2005 to 2016.

Carbon black production, time series for the average CO_2 EF (t CO_2/t carbon black production)

CARBON BLACK PRODUCTION	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
EF (t CO_2/t Carbon black)	2.56	2.57	2.51	2.59	2.49	2.48	2.45	2.46	2.32	2.23	2.25	2.35

Ethylene, Ethylene oxide, Propylene, Styrene

Ethylene, ethylene oxide, propylene and styrene productions belong to the organic chemical processes, which are source of methane emissions.

For ethylene activity data have been provided by the Italian producers, specifically: for 1990-2001 by the sectoral industrial association (Unione Petrolifera, several years) and since 2002 by the manufacturing companies (Syndial, several years; Polimeri Europa/Versalis, several years). For ethilene oxide activity data

have been provided by the manufacturing company for the whole timeseries (Enichem, several years); this production stopped in 2001. Propylene production activity data are reported in the UN "Industrial Commodity Statistics Yearbook" (UN, several years) for the years 1990-1994; since 1995 data have been provided by the manufacturing companies (Enichem, several years; Syndial, several years; Polimeri Europa/Versalis, several years). Regarding Styrene, for the years 1990-1994, UN international statistics have been used (UN, several years). From 1995 the amount of styrene is supplied every year to the inventory team by the Italian producer at plant level (Enichem, several years; Polimeri Europa/Versalis, several years).
For ethylene and propylene production, CH_4 emission factor is calculated, for the whole time series, on the basis of the EPRTR data submitted by the plants. In the framework of the E-PRTR registry, facilities manufacturing ethylene in Italy reported activity data and emissions following the E-PRTR classification. In particular, for these plants, CH_4 emissions, for these productions, were below the reporting threshold (which for methane is set to 100 t/year). Assuming that emissions of each plants were equal to the maximum value (threshold), 100 t/year, the emission factor resulted in 0.085 kg/t; this value has been used along the whole timeseries.
For Styrene CH_4 emissions, no specific information concerning the years 1990-1994 was available, so the EMEP/CORINAIR default emission factor (EMEP/EEA, 2007) has been applied (0.025 kg/t equal to 10% of total VOC emissions). Based on the information included in the Environmental Reports by the Italian producer (Enichem, several years), and confirmed by the operators, CH_4 emissions did not occur from 1995.
Methane emission factor for ethylene oxide production used for the whole timeseries (1990-2001) is equal to 6.841 kg/t as supplied by the air and waste management association (APEM, 1992).

Titanium dioxide
In Italy there is only one facility where this production occurs.
Emissions are estimated according to the Tier 2 approach and plant specific data are used to develop the estimates. The plant operator supplies the amount of TiO_2 produced and the emissions levels, so the average EF can be calculated and used for the inventory purposes:

CO_2 emissions= AD*EF.

The operator provide data in the framework of the EPRTR register. The data are supplied in compliance with the methodologies indicated in the EPRTR Guidance Document (and to the national PRTR guidance).
The facility concerned is also in the scope of the environmental permitting process; the competent authorities set a control and monitoring plan (stating which parameters and how have to be monitored), the operators have to comply with the plan and the information resulting from the data collection for the plan are also used for the reporting to EPRTR. IPCC methodologies are referenced within the guidance documents as part of the methodologies to measure/calculate/estimate the information to the EPRTR.
Information related only to the boiler activity is reported to the EU-ETS.

Calcium carbide
CO_2 emissions from calcium carbide production process and use have been estimated on the basis of the activity data provided by the sole Italian producer/retailer (CARBITALIA SPA, 2017). Activity data relating to the manufacture of calcium carbide are referred to the years from 1990 to 1995 when the production stopped; activity data concerning the use of calcium carbide have been provided for the whole timeseries too. The default IPCC CO_2 emission factors (IPCC, 2006) have been used to estimate the emissions from manufacture and use along the whole timeseries.

Soda ash
CO_2 emissions from soda ash production have been estimated on account of information available about the Solvay process (Solvay, 2003), which is the technology applied for the production of soda ash in Italy, whereas those from soda ash use are included in glass production.
Soda ash production has been carried out at one facility in Italy; the facility is included in the scope of the national EPER/PRTR so the information concerning activity data and emissions of this facility has been made available for the years from 2002 up to now. For 1990-2001 the amount of soda ash produced was published on the UN "Industrial Commodity Statistics Yearbook" (UN, several years).
The CO_2 emission factor for those years is based on the estimation process of the GHG emissions inventory of Spain and on the information that Solvay has made available to the Spanish inventory team for a plant with the same technology as the Italian one. Since 2002 the emission factor is based on the data reported

yearly by the Italian operator under the national EPER/PRTR and under ETS (preliminary data for years 2005-2009 and official data since 2013).

Fluorochemical production

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 CF_4 emissions to the national PRTR register for four years since 2007. CF_4 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 CF_4 emissions from HCFC22 production properly. The industrial site of Spinetta Merengo hosts not only Solvay but also other Companies and is in the scope of EPRTR, IPPC permitting procedure and Seveso European Legislation. At the facility the monitoring system has 27 devices to perform gas chromatography analysis and about 540 monitoring points at the site. The resulting monitoring data flow, which regard other pollutants, is sent via web to the regional agency for the environmental protection (ARPA Piemonte).

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 pyrolisis of HCFC22 at 600 °C), the TFM has been then used to produce TFE (tetrafluoroethylene, C_2F_4) 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), specifically designed for the Spinetta Marengo plant, working at a temperature of 1400 °C with a residence time of the gases minor of 2 seconds. 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 CF_4 is still present (65% of CF_4 released to air pass through the abatement system untreated for thermodynamic reasons; 35% of CF_4 released to air is formed during the reactions occurring in the abatement unit). Estimations of CF_4 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. CF_4 emission factor for 2007 was set constant in order to estimate the CF_4 time series over the years from 1990 to 2006. CF_4 emissions time series have been then included in the estimates under the CRF category 2.B.9.a.1 (By-product emissions from production of HCFC22).

In order to provide detailed information on the methodology applied for this category, CF_4 emissions estimation from HCFC22 can be summarised as follows:

1) For the years 2007-2010 by-product CF_4 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 CF_4 emission has been calculated.
2) CF_4 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 CF_4 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 whithin 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 CF_4 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 facilty 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 close to zero. The operator communicated that for a HCFC22 production of 30,000 tons, HFC23 theorical residual emissions are less than 100 kg; a monitoring analysis has measured about 10 kg of HFC 23 in one year (Spinetta Marengo, 2011).
C_2F_6 and HFC143a emissions are released from the production of C_3F_6 (and also CFC115) and HFC134a, respectively. Fluorochemical were produced in one plant (Porto Marghera) and progressively stopped in the last years. More in details C_3F_6 (and also CFC115) production stopped in 1998 while HFC134a production stopped in 2007. Data production and emission figures have been provided by the company (Solvay Fluor, several years).
Production of HFC125, HFC134a, HFC227ea and SF_6 lead to fugitive emissions of the same gases. In particular, production of HFC227ea only occurred in 1999. Emissions figures have been communicated by the operator (Solvay Fluor, several years).

4.3.3 Uncertainty and time-series consistency

The uncertainty in N_2O emissions from adipic and nitric acid and caprolactame production and in CO_2 emissions from ammonia and for other chemical production is estimated by 10.4%, for each activity, as combination of uncertainties 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 N_2O emissions and for CO_2 emissions from other industrial processes.
The uncertainty in F-gas emissions from fluorocarbons production is estimated to be about 50% in annual emissions, 5% and 50% concerning respectively activity data and emission factors.
In Tables 4.4 and 4.5, the production of chemical industry, including non-key sources, and emission trends are reported. An overview of the emissions per compound from fluorochemical production is given for the 1990-2016 period.
In general, total emission trends for all the chemical productions have been affected by fluctuations in productions along the timeseries (and 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 2012 an increase in ammonia and soda ash productions determined an increase in CO_2 emissions estimates compared to previous year.

Table 4.4 Production of chemical industry, 1990 – 2016 (Gg)

ACTIVITY DATA	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
					(Gg)						
2B.1 - Ammonia	1,455	592	414	607	505	476	576	555	606	396	564
2B.2 - Nitric acid	1,037	588	556	572	417	437	432	433	443	390	426
2B.3 - Adipic acid	49	64	71	75	85	83	79	80	80	86	83
2B.4 - Caprolactame	120	120	111	-	-	-	-	-	-	-	-
2B.5 - Calcium carbide production	12	7	7	7	6	6	5	5	4	4	4
2B.6 - Titanium dioxide	58	69	72	60	70	69	51	51	50	60	61
2B.7 - Soda ash production and use	610	1,070	1,000	915	620	726	824	780	873	880	916
2B.8b - Ethylene	1,466	1,807	1,771	1,721	1,551	1,254	1,166	1,117	890	1187	1191
2B.8d - Ethylene oxide	61	54	13	-	-	-	-	-	-	-	-
2B.8f - Carbon black	184	208	221	214	206	217	179	183	203	205	212
2B.8g - Styrene	365	484	613	520	524	477	518	494	468	547	479
2B.8g.i - Propylene	774	693	690	1,037	880	716	673	575	552	630	683
2B.9 – HCFC 22 production.	20	23	26	27	21	25	24	27	25	26	24

Table 4.5 CO_2, CH_4 and N_2O emissions from chemical industry, 1990 – 2016 (Gg) and HFCs, PFCs per compound 1990 - 2016 (Gg CO_2 eq.)

EMISSIONS	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
CO_2 (Gg)											
Ammonia	1,891.50	769.60	537.91	802.29	639.77	562.08	624.30	642.91	711.46	495.54	642.73
Calcium carbide	26.28	14.24	7.70	8.01	6.63	6.33	5.42	5.02	4.88	4.59	4.57
Carbon black	422.05	477.48	508.83	548.22	510.38	531.45	440.06	424.65	453.07	462.39	496.94
Titanium dioxide	52.80	48.11	64.70	62.01	72.39	40.50	30.73	30.73	38.12	36.33	35.60
Adipic acid	1.33	1.72	1.93	1.50	1.76	1.70	1.62	1.74	1.82	1.82	1.85
Soda ash production and use	183.00	321.00	300.00	275.00	203.33	262.55	240.02	230.58	206.41	255.35	281.79
CH_4 (Gg)											
Carbon black	1.84	2.08	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ethylene	0.12	0.15	0.15	0.15	0.13	0.11	0.10	0.09	0.08	0.10	0.10
Propylene	0.07	0.06	0.06	0.09	0.07	0.06	0.06	0.05	0.05	0.05	0.06
Styrene	0.01	-	-	-	-	-	-	-	-	-	-
Ethylene oxide	0.42	0.37	0.09	-	-	-	-	-	-	-	-
N_2O (Gg)											
Nitric acid	6.73	4.22	4.09	5.44	0.51	0.58	0.48	0.37	0.18	0.12	0.17
Adipic acid	14.77	19.09	21.42	19.59	1.58	0.38	0.28	0.37	0.20	0.37	0.22
Caprolactame	0.04	0.04	0.03	-	-	-	-	-	-	-	-
Gg CO_2 eq.											
HFC 23	444.0	444.0	1.3	1.3	1.0	1.2	1.2	1.3	1.2	1.3	1.2
HFC 143a	-	26.8	4.5	4.9	-	-	-	-	-	-	-
CF4	882.9	992.6	991.5	1,547.4	1,300.6	1,438.8	1,345.0	1,574.1	1,404.1	1,551.9	1,492.8
PFC C2÷C3 (C2F6)	48.8	48.8	-	-	-	-	-	-	-	-	-
Total F-gas by product emissions	*1,376*	*1,512*	*997*	*1,554*	*1,302*	*1,440*	*1,346*	*1,575*	*1,405*	*1,553*	*1,494*
HFC 125	-	35.0	3.5	4.2	-	-	-	-	-	-	-
HFC 134a	-	42.9	17.2	13.9	-	-	-	-	-	-	-
HFC 227ea	-	-	-	-	-	-	-	-	-	-	-
SF_6	114.0	114.0	-	-	-	-	-	-	-	-	-
Total F-gas fugitive emissions	*114.0*	*191.9*	*20.7*	*18.1*	-	-	-	-	-	-	-
Total F-gas emissions from florochemical production	1,490	1,704	1,018	1,572	1,302	1,440	1,346	1,575	1,405	1,553	1,494

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 under 100 kg (E.F. 3.3 g of HFC23/t of HCFC22). CF_4 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 (C_2F_6) by-product emissions and SF_6 fugitive emissions were constant from 1990 to 1995 (4 t/y for C_2F_6 emissions; 5 t/y for SF_6 emissions) and from 1996 to 1998 (1 t/y for C_2F_6 emissions; 2 t/y for SF_6 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, SF_6 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.

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, the resulting consistency of both emissions and activity data for those sectors is the outcome of this control. Additional QA/QC was performed on the inventory of CO_2 and CH_4 emissions from the production of carbon black (Aether ltd, 2013) thus leading to the improvements of the emissions estimate in 2014 submission. CH_4 emissions from carbon black manufacturing have been revised in the current submission, from 1996 onwards, as an outcome of the technical expert review performed at EU level in the framework of the internal EU inventory review process.
Emissions from fluorochemical production have been checked with data reported to the national EPER/E-PRTR registry. CF_4 emissions have been then accounted for along the whole time series for category 2B9.

4.3.5 Source-specific recalculations

Minor recalculation occurred for the production of HCFC22 because of the updating of data communicated: as a consequence, the IEF has changed.

4.3.6 Source-specific planned improvements

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 five sources: iron and steel production, ferroalloys production, aluminium production, magnesium foundries and zinc/lead production; CO_2 emissions from iron and steel production are key sources at level assessment with the Tier 1 approach for 1990 and at trend assessment with the Tier1 , PFC emissions from aluminium production are key sources only at trend assessment. Considering LULUCF, CO_2 emissions from iron and steel production are key sources at level assessment with the Tier 1 approach for 1990 and at trend assessment with the Tier1 too, whereas PFC emissions from aluminium production is a key category at trend assessment with the Tier 1 approach.

In 2016, the share of CO_2 emissions from metal production accounts for 0.5% of the national total CO_2 emissions, and 12.0% of the total CO_2 from industrial processes.
The share of CH_4 emissions is, in 2016, equal to 0.10% of the national total CH_4 emissions while N_2O emissions do not occur.

The share of F-gas emissions from metal production out of the national total F-gas levels was 52.5% in the base-year and has decreased to 0.06% in the year 2016.

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, but the recent stringent legislation and the adoption of BAT (Best Available Techniques) in scrap management allow an input with better product characteristics.

The iron and steel cycle is closed by rolling mills with production of long products, flat products and pipes.

In 1990, there were six integrated iron and steel plants in Italy. In 2014, there were only three of the above mentioned plants, one of which lacking sintering facilities and another one not equipped with a BOF. Since 2015 there are only two plants because the plant without sinter production has been closed. Oxygen steel production represents about 24.3% of the total production and the arc furnace steel the remaining 75.7% (FEDERACCIAI, several years).

Currently, long products represent about 44% of steel production in Italy, flat products about 44% and pipes the remaining 12%. In 2016 long production has been equal to 11.6 Tg with a decrease of 4.1% over the previous year and still below 30.1% compared to 2008; flat production has been equal to 11.6 Tg with an increase of 9.7% on the previous year but a decrease of 17.2% compared to 2008 level. Most of the 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 predominantly (e.g. carbon steel, stainless steels) and seamless pipes (only one plant) (FEDERACCIAI, several years).

CO_2 emissions from steel production refer to carbonates used in basic oxygen furnaces and crude iron, carbonates, *coals* and electrodes in electric arc furnaces. CO_2 emissions from pig iron production refer to carbonates used in sinter and pig iron production. CO_2 emissions from iron and steel production due to the fuel consumption in combustion processes are estimated and reported in the energy sector (1A2a) to avoid double counting.

CH_4 emissions from steel production refer to blast furnace charging, basic oxygen furnace, electric furnaces and rolling mills. CH_4 emissions from coke production are fugitive emissions during solid fuel transformation and have been reported under 1B1b category while CH_4 emissions from the combustion of fuels are allocated in the energy sector.

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 CO_2 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 but in 2015 the facility did not work.

Aluminium
From primary aluminium production CO_2 and PFCs (CF_4 and C_2F_6) 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 until 2012 (99.5 kt of primary aluminium). In 1990, primary aluminium production was 232 kt. In 2016 the plant did not produce primary aluminium.

Magnesium foundries
In the magnesium foundries, SF_6 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, SF_6 has been replaced by HFC125, due to the enforcement of fluorinated gases regulations (EC, 2006; UE, 2014) which, however, allows for the use of SF_6 in annual amounts less than 1 Mg. HFC125 emissions also occured and, in 2010, they were equal to 605 kg. Since 2011 HFC125 has been replaced by HFC134a (7, 251 kg in 2016).

Zinc production
Since 1998, in Italy there is just an integrated plant for the zinc and lead production which cover the entire production of zinc and of primary lead. In 2013, this plant began to submit data in the framework of ETS reporting data subdivided in combustion and process emissions; consequently a survey has been started to investigate time series for process emissions resulting in CO_2 emissions from 1990 to 2016. CO_2 emissions are referred both to zinc and lead production.

4.4.2 Methodological issues

CO_2 and CH_4 emissions from the sector have been estimated on the basis of activity data published in the national statistical yearbooks (ISTAT, several years [a]), 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
CO_2 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, carbonates, *coals* and graphite electrodes consumed in electric arc furnaces.
Basic information for this sector derives from different sources in the period 1990-2016.
Activity data are supplied by official statistics published in the national statistics yearbook (ISTAT, several years [a]) 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, CO_2 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 CO_2 emissions. For 2002-2016 data have also been supplied by all the 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. Finally, in 2017, national experts have also been involved in the process of elaboration of the "monitoring and control plan" for the largest integrated plant in Italy in the framework of IPPC permit, allowing other terms of comparison and verification.
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. In fact carbonates have been substituted by autoproduced lime avoiding CO_2 emissions. 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 because of the economic recession; in the following years lime production increased again up to 390,000 but in the last years it decreased because the plant went into receveirship. Emissions from lime production in steel making industries are reported in 1.A.2 Manufacturing Industries and Construction category and in 2.A Mineral production respectively for the combustion and processes emissions.
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 and applied for the period 1990 - 2003. Since 2004, the same scheme as the previous period has been followed but using data becoming from ETS and related to the amounts of pig iron, metallurgical coke, graphite, anthracite, dolomite, limestone and electrodes for 35 plants on 35 in 2016. The availability of data for each plant has allowed also the application, for a first attempt, of the Tier 3 methodology (IPCC, 2006) that demonstrated the soundness of estimates.
On account of the amount of carbonates estimated in sinter plants, average emission factor was equal in 1990 to 0.15 t CO_2/t pig iron production, while in 2016 it reduced to 0.08 t CO_2/t pig iron production. The reduction is driven by the increase in the use of lime instead of carbonates in sinter and blast furnaces in the Italian plants. Emissions are reported under pig iron because they are emitted as CO_2 in the blast furnaces producing pig iron.
CO_2 average emission factor in basic oxygen furnaces results in 1990 equal to 0.079 t CO_2/t steel production, while from 2003 is null.
CO_2 average emission factor in electric arc furnaces, equal to 0.035 t CO_2/t steel production, has been calculated on the basis of the Tier 2 of the 2006 IPCC Guidelines (IPCC, 2006) 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 period1990 - 2003. Since 2004 ETS data have been used, in this way it has been possible to evaluate the contribute of anthracite and metallurgical coke producing an emission factor equal 0.054 t CO_2/t of steel in 2016. The amount of carbon stored in steel produced with EAF has been considered and subtracted from the carbon balance (see Annex 3). Implied emission factors for steel production reduced from 0.053 to 0.041 t CO_2/t steel production, from 1990 to 2016, due to the reduction in the basic oxygen furnaces.
CO_2 emissions due to the consumption of coke, coal or other reducing agents used in the iron and steel industry have been accounted for as fuel consumption and reported in the energy sector, including fuel consumption of derived gases; in Annex 3, the energy and carbon balance in the iron and steel sector, with detailed explanation, is reported.

During the last in country review, Italy reported on the results of a survey which found that there is no accurate information by which to disaggregate the emissions between energy and process. Coke is the only irreplaceable material in the blast furnace as it has several roles:

- the combustion of coke produces carbon monoxide which is responsible for the reduction of iron ores;
- the combustion of coke generates the heat needed to melt the iron ore;

- coke mechanically supports the charge allowing the crossing of the reducing gas;
- coke allows the process of carburation of liquid iron by lowering its melting point.

These are intrinsic properties of the coke and can not be separated one from the other, all the coke when burning simultaneously produces energy in the form of heat and CO as a reducing agent.
As any arbitrary disaggregation would not reflect the real situation, the ERT agreed that leaving the total emissions from the use of coke in the iron and steel industry in the energy sector is appropriate. Ultimately, carbon plays the dual role of fuel and reductant and it is very important not to double-count the carbon from the consumption of coke or other reducing agents if this is already accounted for as fuelconsumption in the energy sector. For this reason 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 (see Annex 3).
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 of CO_2 in 1990 and equal to 15,466 Mg in 2016.
CH_4 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
CO_2 emissions from ferroalloys have been estimated on the basis of activity data published in the national statistical yearbooks (ISTAT, several years [a]) 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	2010	2011	2012	2013	2014	2016	IPCC 2006 EF
Ferroalloy											kg/t
FeCr	0.30	0.26	-	-	-	-	-	-	-	-	1,300
FeMn	0.24	0.10	0.28	0.50	0.40	0.60	0.36	0.29	0.61	-	1,500
FeSi	0.02	-	-	-	-	-	-	-	-	-	4,800
SiMn	0.32	0.53	0.62	0.50	0.60	0.40	0.64	0.71	0.39	-	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 CO_2/t ferroalloys production, from 1990 to 2014 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 16 kt) has resulted in CO_2 emissions decreasing from 395 Gg in 1990 to 24 Gg in 2014. Since2015 the plant did not work.

Primary 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 CF_4 and C_2F_6, have been calculated on the basis of information provided by national statistics (ENIRISORSE, several years; ASSOMET, several years) and the national primary aluminium producer (ALCOA, several years), with reference to the documents drawn up by the International Aluminium Institute (IAI, 2003; IAI 2006) and the IPCC Guidelines (IPCC, 2006).

Tier 1 method has been used to calculate PFC emissions related to the entire period 1990-1999. The emission factors for CF_4 and C_2F_6 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 (CF_4) 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 (C_2F_6) 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 (CF_4 and C_2F_6 emissions) and default coefficients (slope coefficients for CF_4 and C_2F_6) 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 CF_4 and C_2F_6 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 CF_4 and C_2F_6 Slope Coefficients (IAI, 2006)

Type of Cell	CF_4	C_2F_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	2012
Primary Aluminium Plant	0.96	0.87	0.74	1.00	0.55	0.81	0.60	0.53	0.31

CO_2 emissions from aluminium production have been also estimated on the basis of activity data provided by industrial association (ENIRISORSE, several years; ASSOMET, several years) and default emission factor reported by industry (ALCOA, 2004) and by the IPCC Guidelines (IPCC, 1997) which refer to the prebaked anode process.

Emission factor has been assumed equal to 1.55 t CO_2/t primary 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/EPRTR registry (emissions and productions). Therefore, thanks to the availability of this additional information, CO_2 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 CO_2 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 CO_2 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 CO_2 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 Production

For SF_6 used in magnesium foundries, according to the IPCC Guidelines (IPCC, 2006), emissions are estimated from consumption data made available by the company (Magnesium products of Italy, several years), assuming that all SF_6 used is emitted. In 2007, SF_6 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 SF_6 in annual amounts less than 850 kg starting from 1 January 2008; for this reason SF_6 was still reported together with HFC 125 emissions for the years 2008, 2009 while for 2010 only HFC125 was reported. Since 2011 HFC134a was replaced HFC125.

Zinc production

Until the 2016 submission, emissions from lead and zinc production have been reported only in 1.A.2 because of the lack of information about process emissions. Since 2013, ETS data contain info about the sole integrated plant in Italy but, as it is an integrated plant, it is not possible to distinguish zinc from lead emissions, so in CRF tables IE is reported for category 2.C.5 Lead production and CO2 emissions are reported in 2.C.6 Zinc production.

Starting from ETS activity and CO_2 emissions data for the period 2013 – 2016, it has been possible to reconstruct the time series on the basis of different sources as this plant already submitted its data to INES/E-PRTR register since 2002 (but without the distinction between combustion and process) and on the basis of activity data and info on the technological evolution provided by industrial association (ENIRISORSE, several years; ASSOMET, several years). In the period 1990 – 2016 activity data and CO_2 emissions show a decreasing trend, in particular emissions decrease from 500 Mg in 1990 to 237 Mg in 2016 and the IEF change from 1.56 to 1.22 $kgCO_2/Mg$ of Pb and Zn.

4.4.3 Uncertainty and time-series consistency

The combined uncertainty in PFC emissions from primary aluminium production is estimated to be about 20% in annual emissions, 3% and 20% concerning respectively activity data and emission factors; the uncertainty for HFC emissions from magnesium foundries is estimated to be about 20%, 3% for activity data and 20% for emission factors. The uncertainty in emissions from iron and steel, ferroalloys and zinc production is estimated to be 10.4%.

In Table 4.11 emission trends of CO_2, CH_4 and F-gases from metal production are reported. The decreasing of CO_2 emissions from iron and steel sector is driven by the use of lime instead of limestone and dolomite to remove impurities in pig iron and steel and by the production level while CO_2 emissions from aluminium, zinc and ferroalloys are driven mainly 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 SF_6 consumption in the magnesium foundry from 2003 is due to the abandonment of recycling plant and the optimisation of mixing parameters.

Table 4.11 CO_2, CH_4 and F-gas emissions from metal production, 1990 – 2016 (Gg)

EMISSIONS	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
CO_2 (Gg)											
Iron and steel	3,124	2,897	1,280	1,656	1,343	1,580	1,526	1,441	1,391	1,327	1,473
Aluminium production	359	276	295	299	250	240	159	-	-	-	-
Ferroalloys	395	230	229	89	77	74	70	35	24	-	-
Zinc production	500	500	498	375	164	151	162	203	222	236	237
CH_4 (Gg)											
Pig iron	2.13	2.10	2.02	2.06	1.54	1.77	1.70	1.25	1.16	0.91	1.09
Steel	0.58	0.60	0.60	0.67	0.63	0.70	0.67	0.63	0.63	0.62	0.64
PFC (Gg CO_2 eq.)											
Aluminium production	1,975	350	231	212	99	95	39	-	-	-	-
SF_6 (Gg)											
Magnesium foundries	-	-	0.007	0.004	0.001	-	-	-	-	-	-
HFC125 - (Gg)											
Magnesium foundries	-	-	-	-	0.001	-	-	-	-	-	-
HFC134a - (Gg)											

EMISSIONS	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Magnesium foundries	-	-	-	-	-	0.003	0.003	0.004	0.006	0.007	0.007

Table 4.12 F-gas emissions per compound from metal production in Gg CO_2 equivalent, 1990 – 2016

COMPOUND	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Gg CO_2 eq.											
CF_4 (PFC-14)	1,465.8	268.1	192.4	176.8	82.7	79.0	32.2	-	-	-	-
C_2F_6 (PFC-16)	509.4	81.8	38.4	35.3	16.5	15.8	6.4	-	-	-	-
Total PFC emissions from aluminium production	*1,975.1*	*349.9*	*230.8*	*212.1*	*99.2*	*94.8*	*38.6*	-	-	-	-
SF_6 emissions from magnesium foundries	-	-	164.2	80.8	16.7	-	-	-	-	-	-
HFC-125 emissions from magnesium foundries	-	-	-	-	2.12	-	-	-	-	-	-
HFC-134a emissions from magnesium foundries	-	-	-	-	-	4.3	4.6	5.8	8.0	10.2	10.4
Total F-gas emissions from metal production	**1,975.1**	**349.9**	**395.0**	**292.9**	**118.0**	**99.1**	**43.2**	**5.8**	**8.0**	**10.2**	**10.4**

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 CF_4 and C_2F_6 default emission factors (Tier 1) and slope coefficient data (Tier 2) by technology are reported, distinguished for different reference sources.

Table 4.13 Default CF_4 and C_2F_6 Emission Factors

	CF_4 (kg/t)				C_2F_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 CF_4 and C_2F_6 Slope Coefficients

	CF_4 (kg PFC / t Al / AE minutes/cell day)				C_2F_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 Guidelines (IPCC, 2006) 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 CF_4 over the period 2000-2012 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 CF_4 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.

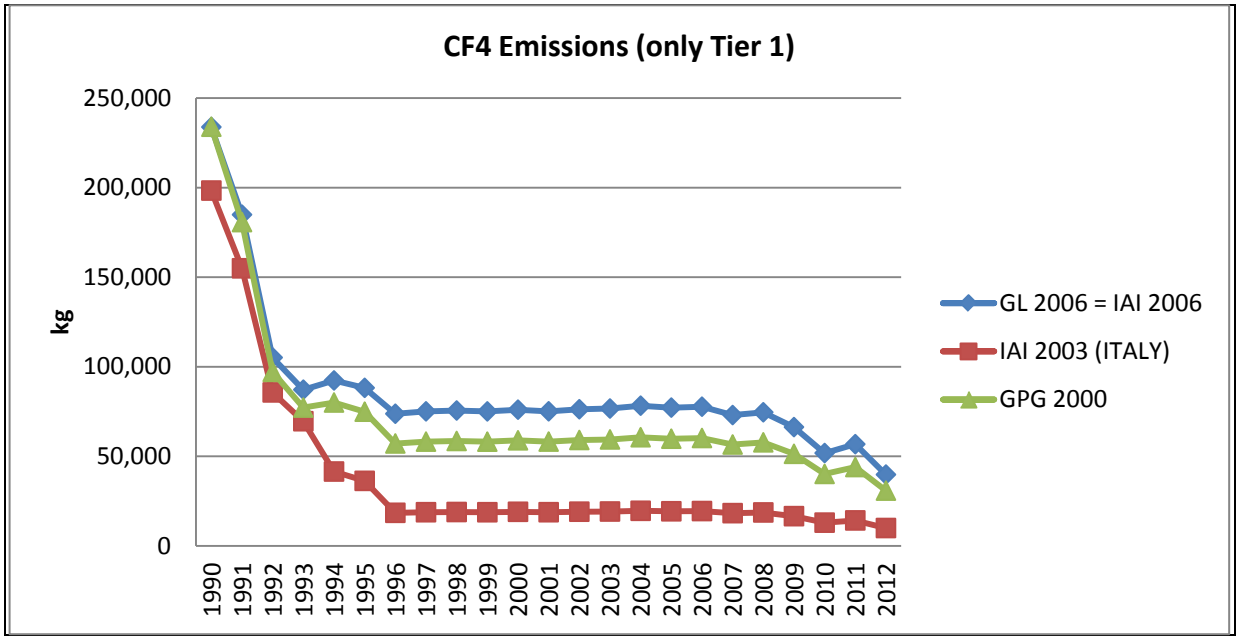

Figure 4.2 CF_4 emissions (only Tier 1)

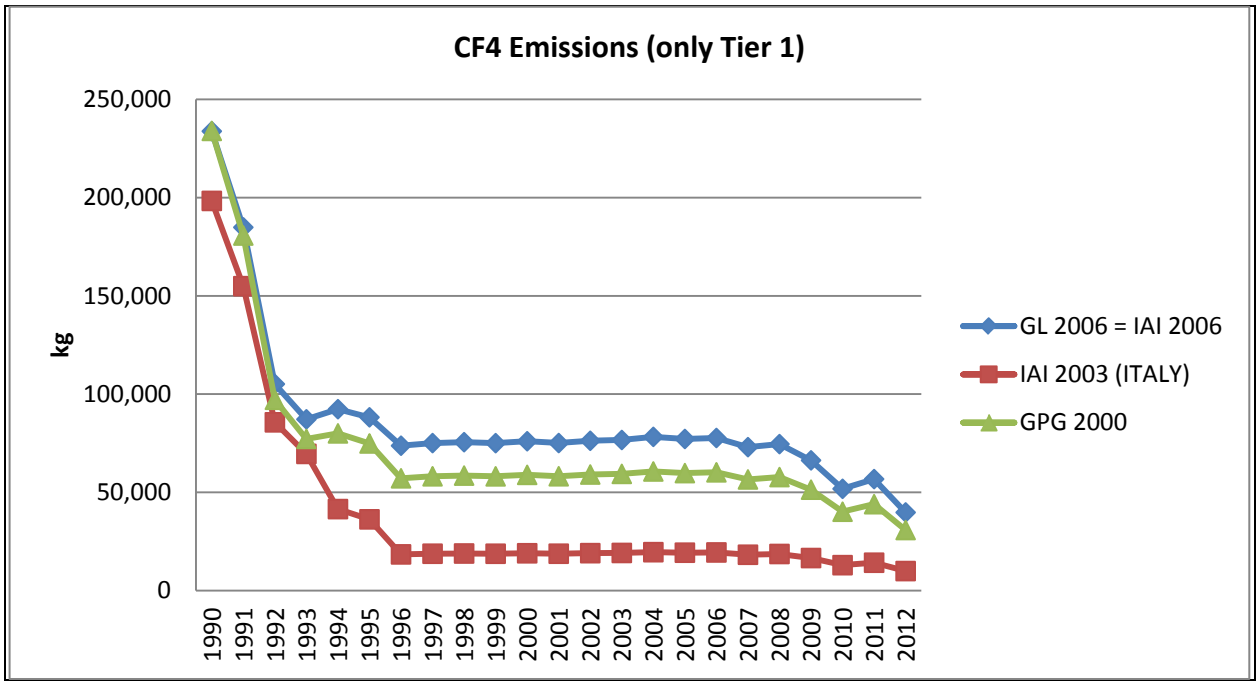

Figure 4.3 CF_4 emissions (Tier 1+Tier 2)

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 CF_4 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 (2000-2012) 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 CF_4 over the period 2000-2012 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

Minor recalculations occurred in 2014 and 2015 because of update of 2014-2015 steel production activity data.

4.4.6 Source-specific planned improvements

Further improvements about zinc/lead production have been planned.

4.5 Non-energy products from fuels and solvent use (2D)

4.5.1 Source category description

The sub-sector comprises the following sources: lubricant use, paraffin wax, and other categories which include the use of urea, asphalt roofing and paving with asphalt and solvent use. CO_2 emissions from this category is a key source at level and trend assessment with approach 2 considering the uncertainty; in 1990 it was a key category at level assessment.

Lubricant use
Lubricants are mostly used in industrial and transportation applications. Lubricants are produced either at refineries through separation from crude oil or at petrochemical facilities. Under this category emissions originated by lubricant use in industry and white lubricants and lubricants used for insulating purposes have been considered, CO_2 and NMVOC emissions have been estimated for the whole time series. Emissions from lubricant use in vehicles have been accounted for in the Energy Sector.

Paraffin wax
Paraffin waxes are separated from crude oil during the production of light (distillate) lubricating oils. Paraffin waxes are categorised by oil content and the amount of refinement. About 60-70% of the total amount of paraffin waxes produced in the EU area is used to manufacture candles. Nowdays about 95% of candles are paraffin wax candles; 3% are stearic candles and the remaining 2% is made of beeswax. Slack oils could enter the manufacturing process thus potentially resulting into the emissions of SOx and PAH.

Use of urea
Urea can be used in Selective Catalyst Reduction (SCR) systems to reduce NOx emissions from combustion. SCR systems are generally applied to engines (vehicles) and also to industrial combustion (e.g. Power Plants).
CO_2 emissions originated by the use of urea in SCR systems have been estimated and reported in this sub-sector.

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.

Solvent use
The use of solvents manufactured using fossil fuels as feedstocks can lead to evaporative emissions of various NMVOC and CO_2 emissions, after oxidation of NMVOC in the atmosphere.
Methodologies for estimating NMVOC emissions can be found in the EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2009). Also some indications on the subcategories to include in the 'solvent use' category are reported in the 2006 IPCC guidelines (IPCC, 2006), which are the following: solvent use in paint application, degreasing and dry cleaning, manufacture and processing of chemical products, other solvent use, such as printing industry, glues application, use of domestic products.

4.5.2 Methodological issues

Lubricant use
The use of lubricants in industrial engines is primarily for their lubricating properties and associated emissions are therefore considered as non-combustion emissions to be reported in the IPPU Sector.

NMVOC and CO_2 emissions are reported for this category.
CO_2 emissions for the whole timeseries are calculated based on a Tier 1 approach considering the average Lower Heating Value (LHV) of lubricants, the average ODU factor and the average carbon content of lubricants (Equation 5.2 IPCC Guidelines 2006):

$$CO_2\ Emissions = LC \bullet CC_{Lubricant} \bullet ODU_{Lubricant} \bullet 44/12$$

where

LC= lubricant consumption
$CC_{lubricant}$= carbon content
$ODU_{lubricant}$= oxidation factor
44/12= mass ratio CO_2/C

Statistics related to the total amount of lubricants consumed in Italy are officially provided by MSE every year in the petrochemical bulletin (MSE, several years [b]) but no details concerning different kind of lubricants are available thus allowing us only for a Tier 1 approach; LHV, Carbon Content and ODU factors used are the default values included in the IPCC 2006 Guidelines are taken. The activity data for this subcategory is the total consumption of lubricants minus the amount of lubricants used in 2-stroke engines (which is derived from reversing COPERT equation to estimate CO_2 emissions in 2-stroke engines).
Emissions from the use of lubricants in 2-stroke engines have been accounted for in the Energy Sector.
NMVOC emissions for the whole timeseries have been estimated too, based on the total lubricants consumption and a NMVOC EF= 28 kg NMVOC/tons of lubricant (EMEP/EEA, 2013). The whole timeseries for NMVOC emissions has been revised in the present submission as a consequence of the review of the activity data time series.

Paraffin wax
In Italy paraffin waxes are mostly used in the manufacture of candles, although a number of different applications (e.g. food production and many others) could have paraffin waxes as an input. Emissions from the use of waxes derive primarily when the waxes or derivatives of paraffins are combusted during use (e.g., candles). No other use of paraffin wax in products implying wax combustion during the product use is known in Italy. In order to estimate CO_2 emissions for the whole timeseries it has been assumed that 65% of total amount of paraffin wax is destined to the manufacture of candles on account of information provided by the industrial association (Assocandele, 2015). Total paraffin wax consumption is included in "Bollettino Petrolifero" provided by the MISE and publicly available on the MISE website at the follwoing link: http://dgsaie.mise.gov.it/dgerm/bollettino.asp. Default values for carbon content of paraffin wax as weel as ODU factor and LHV have been assumed (2006 IPCC Guidelines) and applied to the activity data according to a Tier 1 approach as in Equation 5.4 of the 2006 IPCC Guidelines:

$$CO_2\ Emissions = PW \bullet CC_{Wax} \bullet ODU_{Wax} \bullet 44/12$$

where:

CO_2 Emissions = CO_2 emissions from waxes, tonne CO_2
PW = total wax consumption, TJ
CC_{Wax} = carbon content of paraffin wax (default), tonne C/TJ (= kg C/GJ)
ODU_{Wax} = ODU factor for paraffin wax, fraction
44/12 = mass ratio of CO_2/C

Use of urea
Emissions of CO_2 originated by the use of urea in SCR systems in engines and Power plants have been estimated and reported in this sub-sector.
Concerning vehicles, SCR systems were introduced in Italy in 2006 so CO_2 emissions related to SCR systems can be traced back in the timeseries up to 2006. The amount of urea and CO_2 emitted using urea can be estimated by COPERT, which is the model used by Italy to estimate emissions for road transport. For further details see paragraph 3.5.3 in the energy chapter.
Concerning power plants, the amount of urea used in SCR systems has been reported by operators under the Italian ETS together with CO_2 emissions since 1997.

Asphalt roofing and road paving

NMVOC 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).

NMVOC emissions from road paving operations have been estimated based on the amount of asphalt mix produced for each year (ISTAT, several years [a]; Siteb, several years) and the emission factors also derived from data supplied by Siteb (EPA, 2000; Siteb, several years).

Solvent use

Emissions of NMVOC from solvent use have been estimated according to the methodology reported in the EMEP/EEA guidebook, applying both national and international emission factors (Vetrella, 1994; EMEP/CORINAIR, 2007, EMEP/EEA, 2013). Country specific emission factors provided by several accredited sources have been used extensively, together with data from the national EPER/EPRTR Registry; in particular, for paint application (Offredi, several years; FIAT, several years [b]), 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/EEA 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 CO_2 emissions has been carried out considering the carbon content value. In the previous submission carbon content was set equal to 85% as indicated by the European Environmental Agency for the CORINAIR project (EEA, 1997); as a result of the technical review in the framework of Article 19(1) of the European Regulation No 525/2013 it was recommended to use a fossil carbon content equal to 65% as indicated in the 2006 IPCC Guidelines (chapter 5.5.4).

4.5.3 Uncertainty and time-series consistency

The combined uncertainty in CO_2 emissions from non energy products from fuels and solvent use is estimated equal to 58% due to an uncertainty of 30% and 50% in activity data and emission factors, respectively.

In 2016, CO_2 derive mainly from the subcategory 'Other', which accounts for 76% of the sectoral emissions; specifically emissions from the use of solvent share 75%. The second source of sectoral emissions is the use of lubricants contributing to 23% of the total.

Table 4.15 shows CO_2 emission trend from 1990 to 2016.

Table 4.15 Trend in CO_2 emissions from the non energy products from fuels and solvent use category (Gg)

GAS/SUBSOURCE	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
CO_2 (Gg)											
2D. Non-energy products from fuels. Other	**1,709.51**	**1,563.76**	**1,431.91**	**1,350.40**	**1,135.32**	**1,151.28**	**1,067.81**	**1,057.52**	**1,019.72**	**969.41**	**980.49**
2D1. Lubricant use	361.65	322.04	326.73	285.67	220.12	214.15	181.34	192.58	214.64	210.61	226.42
2D2. Paraffin wax use	19	20	21	14	13	9	10	10	13	15	12
2D.3. Other	1,329	1,222	1,084	1,051	902	929	876	855	792	744	742

GAS/SUBSOURCE	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
2D3a. Urea (emissions abatement in engines)	-	-	-	-	32.23	37.51	39.79	41.97	44.72	46.72	51.42
2D3b. Urea (emissions abatement in power plants)	-	-	2.38	2.35	11.71	11.45	11.30	6.63	6.73	7.34	7.04
2D3c. Road paving	-	-	-	-	-	-	-	-	-	-	-
2D3d. Asphalt roofing	-	-	-	-	-	-	-	-	-	-	-
2D3e. Solvent	1,329	1,222	1,082	1,049	858	880	825	806	741	690	683
Paint application	595	555	497	471	345	387	362	381	330	286	288
Degreasing and dry cleaning	125	75	58	51	45	43	42	41	40	39	38
Other	170	189	182	131	121	120	115	117	113	109	112
Chemical products	439	402	345	395	348	329	306	267	257	256	245

The decrease observed in emission levels from 1990 to 2016 about 49%, is to be attributed to the reduction in emissions from solvent use, mainly for the reduction 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 about 38% from 1990, is due to the implementation of Italian Legislative Decree 161/2006. Other European directives applies to the solvent use category, which represents the main source of NMVOC emissions at national level (34.4% of the total NMVOC); for istance, the European Directives (EC, 1999; EC, 2004) regarding NMVOC emission reduction in paint application entered into force, in Italy, in January 2004 and in March 2006, establishing a reduction of the solvent content in products.

4.5.4 Source-specific QA/QC and verification

For the solvent use category, different QA/QC and verification activities are carried out. 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 in 2012, 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).

4.5.5 Source-specific recalculations

Significant recalculation occurred along the whole timeseries for CO_2 emissions from Lubricant use (2.D.1) due to the use of updated activity data timeseries and also in 2.D.3.
As for CO_2 emissions from lubricants use, recalculations occurred along the whole timeseries due to the update of the data resulting from COPERT model, as shown in the following box:

Subsource/Gas		**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
2D1 - Lubricants - CO_2	%	-5.4	-6.0	-6.5	-7.7	-8.4	-8.3	-9.1	-9.6	-9.7	-9.5	-7.4	-7.9

Subsource/Gas		**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
2D1 - Lubricants - CO_2	%	-7.2	-6.8	-6.3	-6.6	-5.4	-3.9	-3.7	-3.9	-2.5	-2.2	-2.1	-1.7	-1.2	-0.8

Significant recalculations for CO_2 emissions occurred from the use of urea in engines (years from 2006 to 2015) due to the update of the data resulting from COPERT model.

GAS/SUBSOURCE	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
CO_2									
2D.3.a UREA in SCR systems (vehicles)	-14660.4	-244.1	-139.9	-117.9	-102.2	-87.0	-74.8	-63.7	-60.8

Minor recalculations occurred along the last years of the timeseries in 2.D.3 solvent use (paint application, and other) mainly due to the update of emission factors in paint application for domestic and other use (car repairing, construction and buildings) and the update of some activity data in 'Other' (glass wool enduction and fat edible and non edible oil extraction).

GAS/SUBSOURCE	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
CO_2							
2D.3.e Solvent	**0.4%**	**0.1%**	**0.4%**	**0.4%**	**-0.1%**	**-2.1%**	**-11.1%**
Paint application	0.9%	0.3%	0.9%	0.8%	-0.1%	-3.4%	-22.1%
Other	0.2%	0.1%	0.2%	0.2%	0.0%	-0.7%	-4.4%

4.5.6 Source-specific planned improvements

No further improvements are planned.

4.6 Electronics Industry Emissions (2E)

4.6.1 Source category description

Fluorocarbons emissions from this sub-sector are from semiconductor manufacturing industry (2.E.1).
Actually in Italy, there are three national plants of semiconductor manufacturing, owned by two company, ST Microelectronics (in the past purchased for a couple of years by Numonyx) and LFoundry (ex Micron Technology): in particular, ST Microelectronic is active from 1995, while LFoundry from 1998..

The semiconductor manufacturing companies supply yearly consumption and emission data for each plant (ST Microelectronics, several years; Micron, several years; Numonyx, several years; LFoundry, several years).
F-gas emissions from semiconductor manufacturing are estimated using the Tier 2a methodology of the new 2006 IPCC Guidelines (IPCC, 2006).
At present, fluorinated compounds emissions from heat transfer fluids are not estimated. However, Italy is investigating with the semiconductor industry, which is collecting data. Anyway, the industry communicated that emissions are negligible. In fact, they accounts at least the 7% of the total F-gases emissions from semiconductor industry and because these emissions results below 0.05% of the national total GHG emissions, and minor than 500 kt CO_2 eq., they can be considered insignificant.

As concern photovoltaic (PV) manufacturing, actually in Italy there is no production of PV cells, but only assembly. Before 2011, PV cells production occurred but no fluorinated compounds have been used for the process (Lux, 2015; Solsonica, 2015).
Finally, no thin-film-transistor flat panel display (TFT-FPD) production occurs in Italy (Linde Gas, 2015).
The share of F-gas emissions from the electronics industry in the national total of F-gases accounts for 1.31% in 2016.

4.6.2 Methodological issues

F-gas emissions from semiconductor manufacturing are estimated using the Tier 2a methodology of the 2006 IPCC Guidelines (IPCC, 2006). As reported in the Guidelines, total emissions are equal to the sum of emissions from the gas FCi used in the production process plus the emissions of by-product calculated with equation 6.3/6.4/6.5/6.6.
Companies involved in the semiconductor manufacturing provide yearly data on consumption and emissions (ST Microelectronics, several years; Micron, several years; Numonyx, several years; LFoundry, several years), calculated on the basis of the following equation, accepted by the World Semiconductor Council (WSC). The formula gathers the IPCC Guidelines equations (combining equations 6.2/6.3/6.4/6.5/6.6 of the Guidelines) and includes both direct and by-product emissions)

$$\textbf{Emissions for PFC}_i = \textbf{PFC}_i*(1-h)[(1-C_i)(1-A_i)*GWP_i + B_i*GWP_{(byproduct)}*(1-A_{(byproduct)}]$$

where:

h = fraction of gas_i remaining in container (heel)
PFC_i = purchases of gas_i = kgs_i
kgs_i = mass of gas_i purchased
GWP_i = 100 yr global warming potential of gas_i
C_i = average utilization factor of gas_i (average for all etch and CVD processes) =1-EF_i
EF_i = average emission factor of gas_i (average for all etch and CVD processes)
B_i = mass of CF_4 created per unit mass of PFC_i transformed
A_i = fraction of PFC_i destroyed by abatement = $a_{i,j}*V_a$

By product formation
A_{CF4} = fraction of PFC_i converted to CF_4 and destroyed by abatement = $a_{CF4}*V_a$
$a_{i,i}$ = average destruction efficiency of abatement $tool_i$ for gas_i
a_{CF4} = average destruction efficiency of abatement $tool_i$ for CF_4
V_a = fraction of gas_i that is fed into the abatement tools
A_{CF4} = fraction of PFC_i converted to CF_4 and destroyed by abatement = $a_{CF4}*V_a$
$a_{i,i}$ = average destruction efficiency of abatement $tool_i$ for gas_i
a_{CF4} = average destruction efficiency of abatement $tool_i$ for CF_4
$\boldsymbol{A_{C2F6}}$ = fraction of PFC_i that is converted to C_2F_6 and destroyed by abatement = $a_{C2F6}*Va$

a_{C2F6} = average destruction efficiency of abatement $tool_i$ for C_2F_6

A_{C3F8} = fraction of PFC_i that is converted to C_3F_8 and destroyed by abatement = a_{C3F8}*Va

a_{C3F8} = average destruction efficiency of abatement $tool_i$ for C_3F_8

V_a = fraction of gas_i that is fed into the abatement tools

Emissions are calculated for the following fluorinated gases: HFC 23, HFC 32, HFC 134a, C_2F_6, CF_4, C_3F_8, C_4F_8, SF_6 and NF_3. From 2012, according with World Semiconductor Council (WSC), data on CH_2F_2, C_4F_6, C_5F_8 are gathered.
From 2000, emissions are calculated considering the contribution of abatement systems.
ST Microelectronics provided emissions for each gas (CF_4, C_2F_6 , HFC 23, C_2F_6, C_3F_8, C_4F_8, SF_6 and NF_3) for the year 1995 and from 2001 onwards. For the years 1996-2000 the company was not able to provide detailed data but only aggregated total emissions confirming that they occurred for all the gases and emissions of each gas have been estimated proportionally taking in account their distribution in 1995 and 2001. Moreover, on the basis of the 2001 emission factors (emission gas_i /consumption gas_i), consumption data have been extrapolated for the missing years.

For what concern Heat Transfer Fluids, during the manufacture of semiconductor devices, HTFs serve as coolants in chillers, removing excess heat during many manufacturing processes. During semiconductor device testing, containers of HTFs are cooled or heated to a desired temperature into which the devices are immersed to test their integrity. In addition, when testing the function of devices, HTFs are used to remove the heat the devices generate while being tested. HTFs are also used to attach semiconductor devices to circuit boards via solder, which may be melted by the vapor of an HTF heated to its boiling point. HTFs may also serve to cool semiconductor devices and other devices or systems that generate high heat during operation (EPA, 2006). Semiconductor industry is collecting data but they communicated that emissions are insignificant.
On the basis of a study carried out by the U.S. Semiconductor Industry Association, fluorinated gases emissions from the contribution of heat transfer fluids should accounts for 7% of the F-gases total from semiconductor manufacturing for wafer size <= 200mm, whereas should accounts for 29% of the F-gases total for wafer size >= 300mm. National semiconductor fabrication plants produce wafers with a diameter <= 200mm (SIA, 2015).

4.6.3 Uncertainty and time-series consistency

The combined uncertainty in F-gas emissions for PFC, HFC, SF_6 and NF_3 emissions from semiconductor manufacturing is estimated to be about 20.6% in annual emissions, 5% and 20% concerning respectively activity data and emission factors.
In Table 4.16 emissions from semiconductor manufacturing are reported.

Table 4.16 Fluorocarbon emissions from semiconductor industry, 1990 – 2016 (kt CO_2 eq.)

GAS	1990	1995	2000	2005	2010	2015	2016
HFC 23	NO	6.1	8.7	7.2	10.7	9.4	9.8
HFC 32	NO	NO	NO	NO	NO	0.114	0.059
HFC 134a	NO	NO	0.057	NO	NO	NO	NO
CF_4	NO	65.3	131.9	84.9	66.5	95.0	95.3
C_2F_6	NO	17.1	121.1	81.2	27.5	21.4	21.1
C_3F_8	NO	8.6	11.8	4.3	0.03	0.2	0.3
C_4F_8	NO	10.0	1.5	10.0	26.5	19.8	19.1
SF_6	NO	14.9	61.9	57.2	30.6	47.3	45.3
NF_3	NO	76.6	13.3	33.4	20.2	28.4	27.8
F-gas emissions (kt CO_2 eq.)	**NO**	**198.5**	**350.1**	**278.2**	**182.0**	**221.6**	**218.7**

4.6.4 Source-specific QA/QC and verification

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

4.6.5 Source-specific recalculations

No recalculation has occurred.

4.6.6 Source-specific planned improvements

Emissions from the use of heat transfer fluids in the semiconductor industry is under investigation. The national industry is part of the European Semiconductor Industry Association (ESIA) and is involved in the activity of WSC (World Semiconductor Council), including gathered emissions from the use of heat transfer fluids.

4.7 Emissions of fluorinated substitutes for ozone depleting substances (2F)

4.7.1 Source category description

The sub-sector Emissions of fluorinated substitutes for ozone depleting substances consists of the following sub-applications:

2.F.1 – Emissions from Refrigeration and Air Conditioning
2.F.2 – Emissions from Foam blowing Agents
2.F.3 – Emissions from Fire Protection
2.F.4 – Emissions from Aerosols

For category 2.F.5. Solvents, at the moment there is no evidence that these emissions occur in Italy although further work is on going to verify it.
Collected data, according to Article 19 of Regulation EU 517/2014, have been analyzed. Only one company has declared for the past years a small quantities of HFC preparation placed on Community market for the first time for the years 2008, 2009, 2010, 2011 and 2013 for solvents applications. As the substances declared are HFC 134a, R507 and R 410a, not usually used as solvents, Italy is checking for the correctness of these data with the company. Anyway, a preliminary emissions estimation has been done and results in less of 10,000 tons of CO_2 equivalent, much more below 0.05% of the national total GHG emissions.

HFC emissions from Refrigeration and Air Conditioning and from Fire Protection are a key categories at level and trend assessment, both using Tier 1 and Tier 2, with and without LULUCF, in 2016.
HFC emissions from foam blowing agents is a key category, only including uncertainty, at level and trend assessment without LULUCF and at trend assessment with LULUCF.
The share of F-gas emissions of fluorinated substitutes for ozone depleting substances in the national total of F-gases is 87.71% in 2016.

4.7.2 Methodological issues

The methods used to calculate F-gas emissions of fluorinated substitutes for ozone depleting substances are presented in the following box:

Sub-sources of F-gas emissions and calculation methods

Source category	Sub-application	Calculation method
Refrigeration and Air Conditioning	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

Total emissions have been calculated as the sum of Manufacturing emissions, Use emissions and Disposal emissions. For the reporting of “Recovery” simple approach “Recovery” = “amount remaining in products at decommissioning” minus “Disposal emissions” has been assumed.

The Legislative Decree n. 151/05 has implemented in Italy the EU Directive on Waste from Electric and Electronic Equipments. According to this Decree when equipments are disposed of it is by law required to recover the remaining F-gas and either reuse or destruct it, but F-gases data are not available at the moment; although the number of authorized centres for the treatment of WEEE is known, there are many small authorized centres which do not have to report about their activities.
Because of lack of data, for the subcategories Foam blowing and Fire extinguishers, emissions from disposal are included into the emissions during the product’s life for the whole time series. The assumption implies that the F-gas charged into the equipments is emitted completely during the lifetime of the equipments. So at decommissioning there is not F-gas charge left and no emissions or recovery do occur.

IPCC Tier 2a implies the availability of either number of applications/equipments using the individual gas or the amounts of the gas used in the different sectors. Based on the availability of the amount of individual gas produced in Italy and the sectoral uses of the gas we carry out the estimation of emissions according to IPCC Tier 2a. The estimates are based on single gas consumptions data supplied by the only national refrigerants producer (Solvay, several years) and by industry and not on equipment consumption estimates except for Domestic refrigeration, where emissions have been calculated on the basis of appliances produced and placed on the market. The methodology applied, although is not a balance of chemical sales, uses specific emission factors for each consumption type.

In 2016 and 2017, ISPRA signed two agreements with the Ministry of the Environment, Land and Sea for a survey, at a national level, about HFCs alternative substances with low GWP, natural refrigerants and alternative technologies made in Italy. In the meanwhile, an historic global climate deal was reached in Kigali, Rwanda, at the Twenty-Eighth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer (MOP28). The so called Kigali Amendment which amends the 1987 Montreal Protocol aims to phase out Hydrofluorocarbons (HFCs), by the late 2040s.
In this framework ISPRA is in contact with air conditioning and refrigeration national associations, major import/export F-gas companies, and the major experts of the sector, as well as companies, in order to better understand the market evolution in terms of HFCs substitutes. Data are collecting, both regarding HFCs and substitutes, but at present they are not enough to make a balance of chemical sales and use a top down approach to cross check emission estimates.

As reported in the last year submission, in the paragraph 4.7.6 source-specific planned improvements (NIR, 2017), for the sub-sector Domestic refrigeration, emissions have been completely revised. Domestic refrigerigeration appliances started to use HFC 134a from 1994 (RAEE, 2017), as a consequence of the ban of CFC forced by the Law n. 549/1993, reportig the measures to protect the stratospheric ozone and the environment (Law 28th of December 1993). CECED represents the manufacturers of the Domestic and Professional Appliance sector in Italy and supplied production data of fridges and freezers from 1987 to 2002 (CECED, several years), as well as the trend of the production for the years 2014 – 2016. The National Statistical Institute has published production data for the years 2011 – 2013 (ISTAT, several years [c]). Data for the other years have been interpolated. Production data have been used to estimate emissions from manufacturing.
Emissons from stocks have been estimated using the number of appliances placed on the market each year. Data have been supplied by CECED for the year 1993 (CECED, several years), even if for the year 1993 the appliances placed on the market still used CFCs; a survey conducted by ENEA (ENEA, 2010), the Italian National Agency for New Technologies, Energy and Sustainable Economic Developmentv, provided data for the years 2001 – 2009, whereas data from 2010 to 2014 for Italy are reported in a study by ADEME, the French Environment and Energy Management Agency, “Energy efficiency of White Goods in Europe: monitoring the market with sales data” (ADEME, 2016). From 2015 no appliances contained HFC 134a are sold anymore. Data for the other years have been interpolated.
CECED supplied also data on HFCs coverage on the total of sales, the average charge of appliances and the lifetime (CECED, several years).
Finally, professional appliances, such as blast chillers, that were included in the domestic refrigeration category, from this submission are reported in Commercial refrigeration.

DOMESTIC REFRIGERATION	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Production (units*1000)										
Fridges	5,751	7,139	5,971	3,417	2,173	2,545	2,348	2,331	2,518	2,452
Freezers	1,782	2,240	1,852	900	911	186	466	451	487	474
Sales (units*1000)										
Fridges	1,586	1,501	1,506	1,593	1,558	1,473	1,466	1,452	1,486	1,500
Freezers	368	324	375	318	290	262	270	275	300	315
Average lifetime (years)	13	13	13	13	13	13	13	13	13	13
Average charge (g)	137.5	137.5	110	110	110	110	110	110	110	110
% of appliances containing HFC 134a	70	60	20	7	5	3	2	1	0	0

For the mobile air conditioning equipment the national motor company and the agent's union of foreign motor-cars vehicles have provided HFC 134a yearly consumptions (FIAT, several years [a]; IVECO, several years; UNRAE, several years; CNH, several years.
For the other refrigeration and 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; Istituto De Angeli, several years).
Finally, improvements have been regarded fire extinguishers sub source, because of the revision of emission estimates, including emissions from HFC 125 and HFC 23. The European Association for Responsible Use of HFCs in Fire Fighting was contacted (ASSURE, 2005), as well as the Consortium of fire protection systems (Clean Gas, 2001). More in details HFC227ea partial consumptions for fire extinguishers along the whole time series has been provided by Consorzio Clean Gas. Because other Consortium of fire protection systems are present in the Country, consumption data provided by Clean Gas have been multiplied for a factor equal to five according to expert judgment. HFC 227ea consumption levels have been supplied for the years 1990-2000 together with projections of consumptions for the years 2005 and 2010. Data from 2000 to 2005 has been assumed constant. After 2010 there are no detailed consumption data available but according to information supplied by industry (Gastec Vesta, 2017) the amount of HFC 227ea decreased from 2010 to 2016, replaced by the new chemical NOVEC in the measure of 20%, for the entering in force of the Regulation n. 517/2014 (UE, 2014). On the basis of expert judgment and ASSURE, because of HFC 227ea covers the 90% of the fire extinguishers market, consumption data of HFC 125 and HFC 23 have been estimated, considering that HFC 125 is 2/3 of the remaining quota.

In the following box, the sources of activity data and emissions factors are summarized.

CRF Category	Category	Substance	Activity Data References	Emission Factors References
2.F.1.b	Domestic Refrigeration	HFC 134a	CECED, ISTAT, ENEA	Expert Judgement
2.F.1.a	Commercial Refrigeration	HFC 23 HFC 125 HFC 134a HFC 143a	Solvay	Expert Judgement
2.F.1.f	Stationary Air Conditioning	HFC 32 HFC 125 HFC 134a	Solvay	Expert Judgement
2.F.1.e	Mobile Air Conditioning	HFC 134a	FIAT, IVECO, UNRAE, CNH	IPCC
2.F.2.a	Foam blowing	HFC 245fa HFC 134a	Solvay	IPCC
2.F.4	Metered Dose Inhalers	HFC 134a	Menarini, Chiesi, Sanofi Aventis, GSK, Lusofarmaco, Istituto De Angeli, Boehringer	Chiesi
2.F.3	Fire Extinguishers	HFC 227ea	Clean Gas, Gastec Vesta, Expert judgment	ASSURE

Due to the methodology used to estimate emissions, based on the consumption of the F-gases in the different categories, where relevant, the estimated consumption include also the amount of fluid contained in the imported products. As an example, the amount of F-gases used in the air conditioning devices mounted on vehicles manufactured abroad and imported in Italy is part of the information we use in the estimation process. UNRAE, which is the Association of foreign car makers, provide us every year with the amount of F-gases used in the imported vehicles.
As for aerosols (i.e. MDI), every year the relevant operators at national level provide us with the consumption of F-gases used in the national production process. Some of the reporting operators manufacture the MDI at Italian facilities as well as export the products, while some others just market in Italy imported MDI.

Industrial Refrigeration and Transport Refrigeration estimations are included in Commercial Refrigeration because no detailed information is available to split consumptions and emissions in the different sectors.
Solvay, which was the only national refrigerants producer, has supplied gas consumptions data with the indication of the relevant use sector, as reported in the following box.

Refrigerant	Final Use	Equipment typology
R 404	Refrigeration	Large Commercial Refrigeration Equipments
R 507	Refrigeration	Large Commercial Refrigeration Equipments
R 407c	Air Conditioning	Chillers
R 410a	Air Conditioning	Chillers
HFC 23	Refrigeration	Small Commercial Refrigeration Equipments
HFC 134a (pure)	Refrigeration	Domestic Refrigeration Equipments

Appropriate losses rates have been applied for each gas, taking into account the equipment where refrigerants are generally used, as suggested by a pool of experts during a specific meeting held at the Ministry of the Environment, Land and Sea (ISPRA-MATTM, 2013), in order to assess F-gas emissions from refrigeration and air conditioning, with a focus on commercial refrigeration. These experts represent the following national associations of refrigeration and air conditioning:

- COAER-ANIMA (Air Conditioning) - Association of Manufacturers of aerodynamic equipment and systems under the Federation of National Associations of Mechanical and Engineering similar (ANIMA), which is the sectoral industrial association within Confindustria (Confederation of Italian Industry) representing companies in this sector.
- ASSOFOODTEC-ANIMA (Commercial Refrigeration) - Association of Italian manufacturers of machinery, plant, equipment for the production, processing and preservation of food, under the ANIMA Federation.
- AICARR – Italian Association of Air Conditioning, Heating and Refrigeration.
- CECED (Domestic Refrigeration) - It represents the manufacturers of the Domestic and Professional Appliance sector in Italy; CECED is a member of ANIE Federation (The National Federation of Italian Electrotechnical, Electronics and ICT Companies) and Confindustria.

For the years 1990-1999 leakage rates were supplied by the industrial associations of manufacturers as the best available country specific information for the years concerned. Industrial associations have revised the leakage rates for the years from 2000 to take into consideration the changes in technology which have been occurring in the manufacturing of the equipments concerned.
The year 2000 has been taken as a turning point in terms of changes of technologies and good practice in the regrigerants handling, because of the transition from the use of CFCs and HCFCs towards the use fo HFCs.
The Regulation (EC) n. 2037/2000 of the European Parliament and of the Council of 29 June 2000 on substances that deplete the ozone layer (EC, 2000) entered into force in 2000, introducing the phase out of CFC and the phase down of HCFC and restriction in handling these substances.
As a consequence of the legislation, the relevant operational procedures in manufacturing, during installation and in exercise, e.g for split charging or appliances maintenance, changed resulting in a turning point of leakage rates.
The appropriate emission factors are reported in the following box, distinguished in two different periods of the time series.

	1990-1999		2000-2013	
	Leakage rate (%)		Leakage rate (%)	
Equipment	Manufacturing	Product life	Manufacturing	Product life
Small Commercial Refrigeration	0.5%	5.0%	0.5%	5.0%
Chillers	3.0%	5.0%	0.5%	2.0%
Large Commercial Refrigeration	3.0%	15.0%	0.5%	12.0%
Domestic Refrigeration	3.0%	0.7%	0.5%	0.7%

As some procedures used in manufacturing or during the installation of the RAC systems has changed in 2000, also F-gases market price has influenced losses control. In fact, since the F-gases are also expensive material in the manufacturing process it was a matter of concern of the manufacturers to succeed in limiting losses in that stage and that was achieved by setting higher levels in the acceptance testing procedures. According to the information supplied by the industry reported above, year 2000 is considered a turning point for the sector market.

As for the other sources of emissions of substitutes for ozone depleting substances, the following emission factors have been used, for the whole time series.

	Leakage rate (%)	
	Manufacturing	Product life
Mobile Air Conditioning – new vehicles	4%	10%
Mobile Air Conditioning – retrofit vehicles	8%	20%
Metered Dose Inhalers	1.95%	50%
Foam	10%	4.5%
Fire Protection	0%	5%

Finally, the following average lifetimes and the percentage of recovered gas at decommissioning have been applied, based on default values from 2006 IPCC Guidelines and expert judgment.

	Average Lifetimes (years)	**Recovery at decommissioning (%)**
Small Commercial Refrigeration	12	85%
Chillers	20	90%
Large Commercial Refrigeration	12	90%
Domestic Refrigeration	13	85%
MAC	14	0%
Metered Dose Inhalers	2	0%

Emissions estimation from MAC systems is based on gas consumption provided by the relevant national operators. These data have been used to estimate the quantity accumulated every year. Emissions from equipment disposal are already included into the emission during the product's life for the whole time series. According to the IPCC default values for MAC systems, leakage rates product life are equal to 10-20%. The lower bounds of the ranges are usually to be used for new vehicles, the upper bound values for retrofit vehicles. From early 2000s all the new vehicles are equipped with AC and no more vehicles needed to be retrofitted. Emission factor for the first fill have been provided by manufacturers and are in line with the default value in the IPCC Guidelines (4-5%).

Emissions from MDI are estimated on the basis of HFC consumptions and losses rates provided by the relevant operators in Italy, using the Equation 7.6 of the 2006 IPCC Guidelines. Specifically, losses rate during manufacturing is set at 1.95% while it is assumed that 50% of the chemical charge escapes within the first year and the remaining charge escapes during the second year, according to 2006 IPCC Guidelines.
Concerning fire extinguishers, the European association for responsible use of HFCs in fire fighting (ASSURE), provided us with the information concerning losses rates in manufacturing of fire fighting systems (0%) and during the average lifetime of the fire extinguishers (less than 5%). The whole gas is considered emitted and not recovered as required by the latest European and National legislation.

The Regulation n. 842/2006 of the European Parliament and of the Coucil of 17 May 2006 on certain fluorinated greenhouse gases (EC, 2006), has been transposed into a national decree in 2012, by the Decree of the President of the Republic 27 January 2012, n. 43 (DPR 43/2012). In particular, the article 3(6) of the Regulation n. 842/2006 has been transposed in the art. 16 of the national Decree, still into force, although the mentioned regulation has been replaced by the new Regulation n. 517/2014 (UE, 2014), where is stated that

every year by the 31 May, the operator of the refrigeration, air conditioning and heat pump equipment, as well as fire protection systems, which contain more than 3 kg of fluorinated greenhouse gases, must submit to ISPRA data on emissions referred to those applications.
ISPRA has developed a specific website, where each operator requests username and password and compiles the Declaration.

The year 2012 has been the first year of the data collection, and actually ISPRA has started the new 2018 collection (data collected will refer to the year 2017). Data are still of course not complete, and consequently not comparable with inventory data, but a preliminary analysis has been done, on data collected for 2013, resulting in product life factor for the commercial appliances much far lower compare to product life factors reported in the IPCC GPG and Guidelines, as enhanced in the following box.

	National DB			2006 IPCC GL	
Charge class (kg)	**Total charge (kg)**	**Total annual release (kg)**	**Product life factor (%)**	**Charge class (kg)**	**EF in operation (%)**
3 - 6	2,518	54	2.14	0.2 - 6	1 - 15
6 - 50	28,863	725	2.51	0.5 - 100	1 - 10
> 50 kg	271,442	2,170	0.80	50 - 2000	10 - 35
Total	*302,823*	*2,949*	*0.97*		

A report concerning 2013 F-gas data has been recently published by the ISPRA (ISPRA, 2016).

4.7.3 Uncertainty and time-series consistency

The combined uncertainty in F-gas emissions for HFC emissions from refrigeration and air conditioning is estimated to be about 58% in annual emissions, 30% and 50%, concerning activity data and emission factors, respectively.
In Table 4.17 an overview of the emissions from the sub-sector is given for the 1990-2016 period, per compound.

HFC emissions from refrigeration and air conditioning equipment increased from 1994 driven by the increase of their consumptions, HFC total consumptions started to decrease from 2015 due to the reduction of the quantity of hydrofluorocarbons placed on the market as well as the restrictions for some products and equipments derived from the entering in force of the European F-gases Regulation (UE, 2014). Because of the methodology approach followed, emissions reduction will occur in the following years..

Table 4.17 HFC emissions per sub-application from the use of fluorinated substitutes for ozone depleting substances in tons, 1990-2016.

COMPOUND (t)	1990	1995	2000	2005	2010	2015	2016
2.F.1.a - Commercial Refrigeration							
HFC 23	0.0	0.4	2.3	5.4	8.2	9.1	9.2
HFC 125	0.0	1.5	84.5	379.2	668.5	877.2	889.7
HFC 134a	0.0	0.1	169.0	411.1	631.5	893.6	901.9
HFC 143a	0.0	1.6	96.8	435.4	768.2	1,008.2	1,022.6
Total HFC emissions from Commercial Refrigeration	*0.0*	*3.5*	*352.5*	*1,231.1*	*2,076.5*	*2,788.1*	*2,823.5*
2.F.1.b - Domestic Refrigeration							
HFC 134a	0.0	23.7	31.6	15.9	36.3	18.5	15.2
Total HFC emissions from Domestic Refrigeration	*0.0*	*23.7*	*31.6*	*15.9*	*36.3*	*18.5*	*15.2*
2.F.1.e - Mobile Air Conditioning							
HFC 134a	0.0	172.5	656.6	831.0	939.5	938.2	931.3
Total HFC emissions from MAC	*0.0*	*172.5*	*656.6*	*831.0*	*939.5*	*938.2*	*931.3*

COMPOUND (t)	1990	1995	2000	2005	2010	2015	2016
2.F.1.f - Stationary Air Conditioning							
HFC 32	0.0	0.0	16.8	86.7	182.1	285.6	301.5
HFC 125	0.0	0.0	17.7	91.1	190.8	297.9	314.5
HFC 134a	0.0	0.0	23.1	114.4	226.8	321.0	337.8
Total HFC emissions from Stationary Air Conditioning	*0.0*	*0.0*	*57.5*	*292.3*	*599.6*	*904.6*	*953.8*
2.F.2.a - Foam blowing (closed cell)							
HFC 245fa	0.0	0.0	0.0	140.6	229.1	302.0	304.7
HFC 134a	0.0	0.0	49.4	180.1	213.8	234.7	235.4
Total HFC emissions from Foam Blowing	*0.0*	*0.0*	*49.4*	*320.6*	*443.0*	*536.8*	*540.1*
2.F.3 - Fire Extinguishers							
HFC 227ea	0.0	12.5	129.5	510.8	963.4	1,254.9	1,292.6
HFC 23	0.0	2.1	22.0	87.0	164.0	206.9	196.6
HFC 125	0.0	1.0	10.4	41.1	77.6	101.0	104.1
Total HFC emissions from Fire Extinguishers	*0.0*	*12.5*	*129.5*	*510.8*	*963.4*	*1,254.9*	*1,292.6*
2.F.4 - Aerosol							
HFC 134a	0.0	0.0	116.6	322.2	287.0	185.1	164.4
Total HFC emissions from Aerosols	*0.0*	*0.0*	*116.6*	*322.2*	*287.0*	*185.1*	*164.4*
Total emissions from 2.F subsector	**0.0**	**212.3**	**1,393.8**	**3,524.0**	**5,345.3**	**6,626.1**	**6,720.7**

4.7.4 Source-specific QA/QC and verification

This source category is covered by the general QA/QC procedures. Refrigeration and air conditioning category has been analyzed with experts of the national associations, in the framework of the study planned by the agreements with the Ministry of the Environment, Land and Sea for a survey, about HFCs alternative substances with low GWP, natural refrigerants and alternative technologies.

Information from the reporting (EC, several years) under article 6 of the Regulation n. 842/2006 (EC, 2006) and article 19 Regulation n. 517/2014 (UE, 2014), as well information from the National Database of the refrigeration, air conditioning and fire protection systems, established by the article 16 of DPR 43/2012, has been analyzed.

Information from the reporting above is checked with import and export data directly from the companies: in fact, from the beginning of 2017 ISPRA is sending letters to the companies involved in the reporting system, asking to provide data on import/export both from/to European countries and not European countries, and, where available, sales data distinguished for application, at a country level.

4.7.5 Source-specific recalculations

Recalculation has occurred, because of the revision of Domestic refrigeration and Fire protection sub-sources. Commercial refrigeration sub-source has been changed because professional appliances, such as blast chillers, that were included in the domestic refrigeration category, are considered as commercial appliances.

Minor recalculation occurred for the updating of activity data in Mobile Air Conditioning.

The following table shows the differences in percentage between the current submission and last year submission for what concern Commercial and Domestic refrigeration and Fire protection.

COMPOUND (t)	1990	1995	2000	2005	2010	2015
Submissions 2017						
2.F.1.a - Commercial Refrigeration						
HFC 23						
HFC 125						
HFC 134a	0.0	0.1	6.1	28.1	49.9	65.5
HFC 143a						
Total HFC emissions from Commercial Refrigeration	*0.0*	*3.5*	*189.7*	*848.2*	*1,494.8*	*1,960.0*
2.F.1.b - Domestic Refrigeration						
HFC 134a	0.0	0.0	31.0	60.2	91.8	219.9
Total HFC emissions from Domestic Refrigeration	*0.0*	*0.0*	*31.0*	*60.2*	*91.8*	*219.9*
Submissions 2018						
2.F.1.a - Commercial Refrigeration						
HFC 23						
HFC 125						
HFC 134a	0.0	0.1	169.0	411.1	631.5	893.6
HFC 143a						
Total HFC emissions from Commercial Refrigeration	*0.0*	*3.5*	*352.5*	*1,231.1*	*2,076.5*	*2,788.1*
2.F.1.b - Domestic Refrigeration						
HFC 134a	0.0	23.7	31.6	15.9	36.3	18.5
Total HFC emissions from Domestic Refrigeration	*0.0*	*23.7*	*31.6*	*15.9*	*36.3*	*18.5*

COMPOUND (t)	1990	1995	2000	2005	2010	2015
Submissions 2017						
2.F.3 - Fire Extinguishers						
HFC 227ea	0.0	0.0	6.8	29.3	56.6	77.7
HFC 23	NO	NO	NO	NO	NO	NO
HFC 125	NO	NO	NO	NO	NO	NO
Total HFC emissions from Fire Extinguishers	*0.0*	*0.0*	*6.8*	*29.3*	*56.6*	*77.7*
Submissions 2018						
2.F.3 - Fire Extinguishers						
HFC 227ea	0.0	12.5	129.5	510.8	963.4	1,254.9
HFC 23	0.0	2.1	22.0	87.0	164.0	206.9
HFC 125	0.0	1.0	10.4	41.1	77.6	101.0
Total HFC emissions from Fire Extinguishers	*0.0*	*12.5*	*129.5*	*510.8*	*963.4*	*1,254.9*

4.7.6 Source-specific planned improvements

Improvements in the air conditioning sub-category are planned for the next submission. Detailed data on air conditioning equipments production and sales are being collected, distinguished by the typology of the equipment (i.e. chillers, roof top, etc.), power capacity, as well as the charge and the type of HFC refrigerant. Data should be available from 2000 to 2017 but we are in contact with the national association COAER-ANIMA in order to obtain additional information on detailed emission factors and other topic items.
Other improvements for the 2F sector are expected from the collection of emission data as requested by the article 16 of the Decree of the President of the Republic 27 January 2012, n. 43 which receipt the article 3(6) of the EC Fluorinated Gas Regulation and from the study in the framework of the agreements with the Ministry of the Environment, Land and Sea for a survey, about HFCs alternative substances with low GWP, natural refrigerants and alternative technologies.

Further investigation is planned to improve the evaluation of disposal and recovered emissions, also checking data reported in the National Database. A top down approach to cross check emission estimates is also in program.
For the category 2.F.5. Solvents, activity data, based on Fgas consumption for each industrial sector, supplied by Solvay Solexis for Italy, do not include any HFCs or PFCs used in the solvent sector. Data from the reporting under F-Gas Regulation 842/2006 and 517/2014 have been analysed resulting in only one company that has reported small quantity (value comprises from 0.2 to 4 tons each year) of HFC 134a and R507 placed in the market for solvents from 2008 to 2011. The plant has been contacted and detailed data on sales of these gases in Italy has been collected but they result allocated in a more general 'Chemistry' sector and not specifically for the solvent. We are collecting additional information in order to evaluate changes in the emission inventory; at the moment, there is no evidence that these emissions occur.

4.8 Other production (2G)

4.8.1 Source category description

The sub-sector Other product manufacture and use consists of the following sub-applications:

2.G.1 – SF_6 Emissions from electrical equipment
2.G.2 – SF_6 used in equipment in university and research particle accelerators
2.G.3 – N_2O from product uses

The share of SF_6 emissions from the sector in the national total of SF_6 was 72% in the base-year 1990, and 88% in 2016, whereas in the national total of F-gases, the share of SF_6 emissions from the sector was 7.86% in 1990 and 1.99% in 2016. N_2O accounts for only 2.6% of the national total N_2O emissions.

4.8.2 Methodological issues

Electrical Equipment (SF6)
As regard SF_6 emissions from electrical equipment, these have been estimated according to the IPCC Tier 2 approach. Concerning manufacturing and installation emissions, since 1995 the methodology used is largely in accordance with the IPCC Tier 3 methodology. In 1997, the ANIE Federation has began a statistical survey within their associated companies, in accordance with ISPRA, in order to monitorate yearly SF_6 used in electrical equipment > 1kV, and thus SF_6 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 SF_6 in the electrical sector, from the SF_6 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 following box the summary sheet used for manufacturing inventory is reported (ANIE, several years).

SF_6 inventory at manufacturing level (ANIE, reporting year 2016)

INVENTORY'S CATEGORIES					**Year 2016 (Kg)**
1. Purchased amount	1.1 In Italy		Weight of SF_6 contained in the tanks		39,174
	1.2 Abroad		Weight of SF_6 contained in the tanks		75,450
				TOTAL 1.	**114,624**
2. Amount contained in the equipment at the terms of sale	2.1 In Italy	2.1.1 ENEL	Weight of SF_6 contained in the equipments and in the tanks		26,015

INVENTORY'S CATEGORIES					Year 2016 (Kg)
		2.1.2 Energy industry and railways	Weight of SF_6 contained in the equipments and in the tanks		9,636
		2.1.3 Others (Industry, Tertiary, Private, ecc.)	Weight of SF_6 contained in the equipments and in the tanks		8,972
	2.2 Abroad		Weight of SF_6 contained in the equipments and in the tanks		42,409
				TOTAL 2.	**87,032**
3. Amount contained in the equipment returned to the manufacturer			Weight of SF_6 contained in the equipments and in the tanks	**TOTAL 3.**	**1,809**
4. a) Destroyed amount			Weight of SF_6 in the equipments sent to authorized disposal treatment		427
4. b) Amount returned to the manufacturer			Weight of SF_6 returned to manufacturer for authorized recycling		26,665
				TOTAL 4.	**27,092**
5. Annual stock changes				**TOTAL 5.**	**625**
SF_6 emissions from manufacturing	**Balance input-output (1+3-5)-(2+4)**				**1,684**

From 1990 to 1994 emissions have been estimated on the basis of leakage rate during manufacturing and installation and the amount of SF_6 contained in the equipments sold to the end users, because, for this period, only data referred to point 1 and point 2 of the box, are available from ANIE.

The loss rates during manufacturing and installation of the equipments, used to estimate the SF_6 emissions, are reported in Table 4.18. Leakage rates have been derived from ANIE Federation expert judgement.

Table 4.18 Leakage rates used to estimate SF_6 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 4.19, SF_6 emissions from manufacturing (which include installation), use and disposal are reported. Emissons from manufacturing were about 14 tons in 1995, whereas in 2016 are only 1.68 tons, due to the great increase of the SF_6 recycled..

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 SF_6.

Table 4.19 SF_6 emissions from manufacturing, use and disposal

SF_6 EMISSIONS (Mg)	1990	1995	2000	2005	2010	2015	2016
Manufacuring	8.470	14.657	5.637	3.562	3.185	1.259	1.684
Use	0.460	4.886	6.469	9.592	10.302	11.648	10.868
Disposal	0.000	0.623	0.464	0.199	0.059	0.037	0.054
Total	**8.930**	**20.165**	**12.571**	**13.353**	**13.546**	**12.945**	**12.606**

SF_6 use emissions are those from Closed Pressure Systems, including hight voltage equipment that requires refilling with gas during its lifetime. Equipment use emissions are estimating by multiplying the quantity of SF_6 yearly accumulated by a use emission factor. The quantity of SF_6 accumulated is estimated using SF_6 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 electricicy monopoly);
- emissions from electricity utilities and the national railways company;
- emissions from industries and other private operators.

Since 1994, refilling data of SF_6 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; EDISON, several years; ENDESA, 2004; ENDESA, several years [a] and [b]; ENEL, several years; TERNA, several years).
The leakage rate used to estimate the SF_6 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, SF_6 disposal emissions from electrical equipments are estimating by multiplying the quantity of SF_6 contained in retired equipments by the fraction of SF_6 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 4.20. 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 SF_6 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 4.20 Disposal rates and leakage rate at disposal used to estimate SF_6 emissions from disposal, 1990-2016

	1990	1995	2000	2005	2010	2015	2016
Disposal rate	0	0	0.01	0.02	0.03	0.03	0.03
Leakage rate at disposal	0.15	0.15	0.11	0.07	0.03	0.03	0.03

As for fluctuation in emissions within the years, Figure 4.4 is reported for a better understanding.
As regard the years from 1995 to 2000, please consider that the total SF_6 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 SF_6 emissions are those from manufacturing and operating.

Data between 1995 an 2000 are consistent and come from the SF_6 mass balance.
In Figure 4.4 the time series for SF_6 purchased amounts and of the three contributions to SF_6 emissions from electrical equipments are illustrated. It could be noted that the trend of the amounts of SF_6 estimated for “manufacturing” is driven by the trend of purchased SF_6.

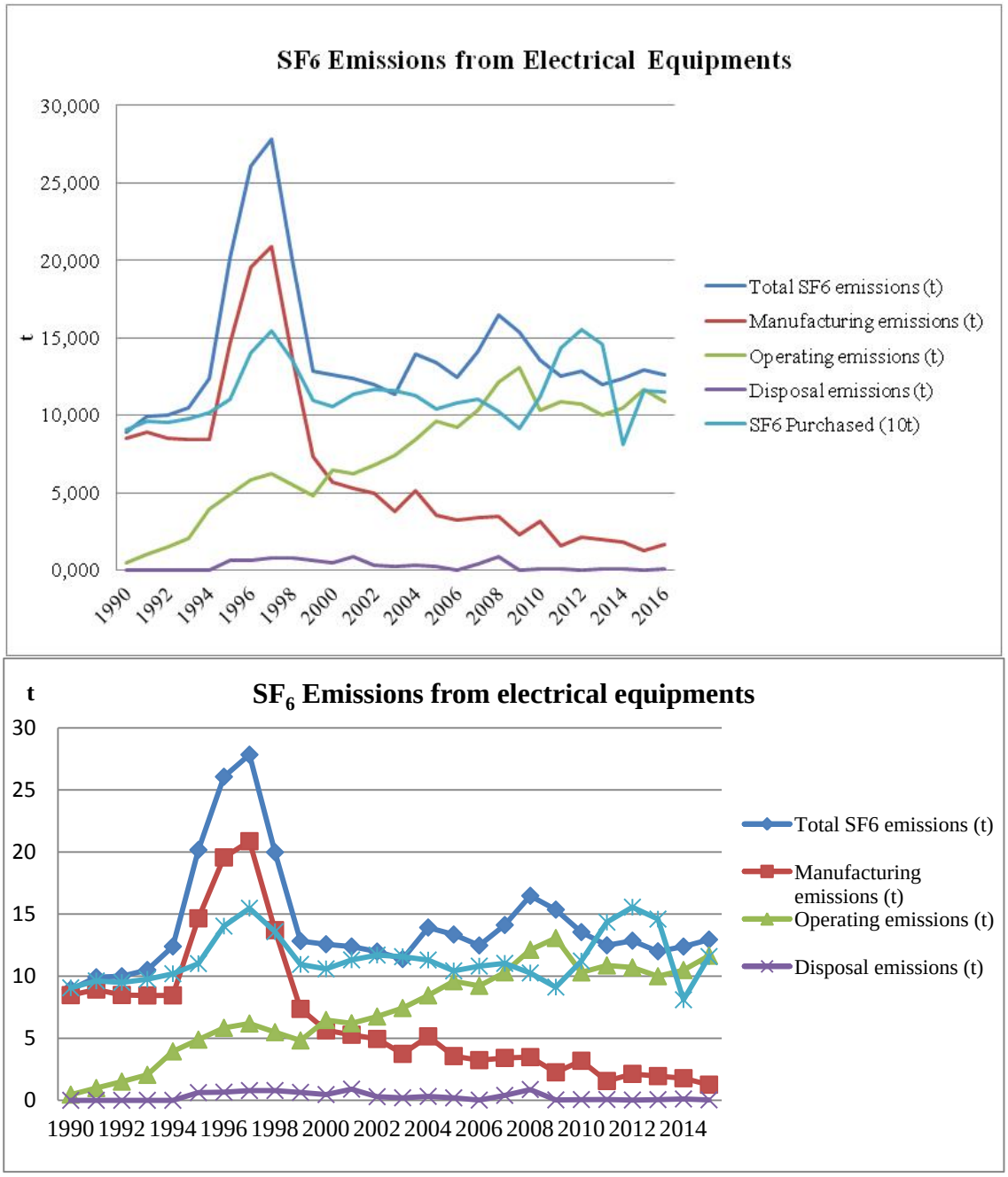

Figure 4.4 Time series for SF_6 purchased amounts and emissions from electrical equipments

SF_6 and PFC from other product use

SF_6 Emissions from research particle accelerators have been estimated from 1990. A survey on the particle accelerators used for research purpose has been carried on, asking directly information to the national research institutes: INFN, the National Institute for Nuclear Physics and INAF the National Insitute of Astrophysic..

INFS has supplied refilling data of SF_6 for four particle accelerators located in three laboratories, Catania, Legnaro and Firenze (INFN, several years), for the entire time series (1990 – 2016). These particle accelerators uses SF_6 from 1984, 1981, 1976 and 2004respectevely. INAF doesn't use SF_6 in their research activities.

SF_6 emissions from industrial and medical particle accelerators have been estimated from 1990 too. As for research particle accelerators, a survey on the accelerators used for medical purposes has been carried on.

In Italy particle accelerators for medical purposes are supplied by only three companies, Siemens Healthcare, Varian Medical System and Elekta. Data on the number of accelerators and the charge of SF_6 have been communicated from 1990 (Siemens, 2017; Varian, 2017).

N_2O from product use

N_2O emissions from the use of N_2O for anaesthesia, aerosol cans and explosives are estimated.

Emissions of N_2O have been estimated taking into account information available by industrial associations. Specifically, the manufacturers and distributors association of N_2O products has supplied data on the use of N_2O for anaesthesia from 1994 (Assogastecnici, several years). For previous years, data have been estimated by the number of surgical beds published by national statistics (ISTAT, several years [a]). It is assumed that all N_2O used will eventually be released to the atmosphere, therefore the emission factor for anaesthesia is equal to 1 Mg N_2O/Mg product use.

Moreover, the Italian Association of Aerosol Producers (AIA, several years [a] and [b]) has provided data on the annual production of aerosol cans used for whipped cream which contain N_2O as propellant. Emission factor used is 0.025 Mg N_2O/Mg product use, because the N_2O content is assumed to be 2.5% on average (Co.Da.P., 2005). The association provides also the number of aerosol cans for other uses (cosmetics, household and cleaning products, pharmaceutical products) and the propellants (LPG and HFC 134a for pharmaceutical products); relevant emissions are estimated in domestic solvent use category as NMVOC and in HFC 134a emissions from aerosols/metered dose inhalers category.

For the estimation of N_2O 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 N_2O emissions represent the theoretically maximum emittable amount; in fact, no figures are available on the amount of N_2O emissions actually emitted upon detonations and the value of 3,400 Mg N_2O/Mg explosive use is provided by a German reference (Benndford, 1999) which corresponds to the assumption of 68 g N_2O per kg ammonium nitrate.

N_2O emissions have been calculated multiplying activity data, total quantity of N_2O used for anaesthesia, total aerosol cans and explosives, by the related emission factors.

4.8.3 Uncertainty and time series consistency

The uncertainty in SF_6 emissions from electrical equipment and particle accelerators is estimated to be 20.6% in annual emissions, 5% and 20% concerning respectively activity data and emission factors.

In Table 4.21 an overview of SF_6 emissions from electrical equipment and particle accelerators is given for the 1990-2016 period.

SF_6 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 4.21 SF_6 emissions from other product manufacture and use in tons, 1990-2016.

COMPOUND (t)	1990	1995	2000	2005	2010	2015	2016
2.G.1							
SF_6 emissions from electrical equipment	8.9	20.2	12.6	13.4	13.5	12.9	12.6
2.G.2.b							
SF_6 emissions from research particle accelerators	4.0	4.0	4.0	4.7	1.6	4.3	1.9
Total SF_6 emissions from 2G sector	**13.0**	**24.2**	**16.6**	**18.1**	**15.2**	**17.3**	**14.6**

The combined uncertainty in N_2O emissions is estimated equal to 51% due to an uncertainty in activity data of 50% and 10% in the emission factor. N_2O 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 N_2O that has been replaced by halogen gas. Table 4.22 shows the N_2O emission trend from 1990 to 2016.

Table 4.22 Trend in N_2O emissions from product uses, 1990 – 2016 (Gg)

GAS/SUBSOURCE	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
2G.3 Other product manufacture and use											
N_2O (Gg)											
N_2O from product uses (use of N_2O for anaesthesia, aerosol cans and explosives)	2.62	2.49	3.31	2.66	2.02	1.86	2.02	1.85	1.74	1.57	1.54

4.8.4 Source-specific QA/QC and verification

This source category is covered by the general QA/QC procedures. Where information is available SF_6 data for refilling have been checked with data reported to the national EPER/E-PRTR registry.
For N_2O emissions from anaesthesia and aerosol cans, emission factors and emissions are also shared with the relevant industrial associations.
Other relevant uses of SF_6, as listed in the IPCC Guidelines, have been investigated to study the occurrence at national level. Some of these applications could be excluded, such as car tyres, sound proof windows and shoes soles also due to manufacturing additional costs. With regard to the other potential sources of emissions there is no evidence but investigations are still going on.

4.8.5 Source-specific recalculation

Recalculation occurred due to the improvements of the identification of remaining applications in this sector. In particular, data on SF_6 consumption in particle accelerators used for medical purposes have been collected and consequently emission estimates have been added to the sector. In the following Table, differences in emissions from particle accelerators are reported.

COMPOUND (t)	1990	1995	2000	2005	2010	2015	2016
Submission 2017							
SF_6 emissions from research particle accelerators	3.9	3.9	3.9	4.6	1.5	3.8	
Submission 2018							
SF_6 emissions from research and medical particle accelerators	4.0	4.0	4.0	4.7	1.6	4.3	1.9

4.8.6 Source-specific planned improvements

A revision of the article 16 of the Decree of the President of the Republic 27 January 2012, n. 43,isgoing to be adopteddue to the enter into force of the F-Gases Regulation n. 517/2014 (EU, 2014), including in its scope also electrical equipments, which will improve the control and monitoring system of the appliances.
Improvements in the SF_6 emissions from electrical equipment are expected because ENEA, the Italian National Agency for New Technologies, Energy and Sustainable Economic Development, should provide information about their laboratories.

4.9 Other production (2H)

4.9.1 Source category description

Only indirect gases and SO_2 emissions occur from these sources.
In this sector, non-energy emissions from pulp and paper as well as food and drink production, especially wine and bread, are reported. CO_2 from food and drink production (e.g. CO_2 added to water or beverages)

can be of biogenic or non-biogenic origin but only information on CO_2 emissions of non-biogenic origin should be reported in the CRF.
According to the information provided by industrial associations, CO_2 emissions do not occur, but only NMVOC emissions originate from these activities.
CO_2 emissions from food and 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 SO_2 are estimated. NO_X and SO_2 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.

5 AGRICULTURE [CRF sector 3]

5.1 Sector overview

In this chapter information on the estimation of greenhouse gas (GHG) emissions from the Agriculture sector, as reported under the IPCC Category 3 in the Common Reporting Format (CRF), is given. Emissions from enteric fermentation (3A), manure management (3B), rice cultivation (3C), agriculture soils (3D), field burning of agriculture residues (3F), liming (3G) and urea application (3H) are included in this sector. Methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) emissions are estimated and reported. Savannas areas (3E) are not present in Italy. Emissions from other carbon-containing fertilizers (3I) and other sources (3J) do not occur. Also 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 the total a Utilized Agricultural Area (UAA) pointed out from Farm Structure Survey (FSS) 2007 (ISTAT, 2008[a], 2012). Comparing the data from the last four censuses (see box below), it can be noted as 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)[3] (EUROSTAT, 2007[a], [b], 2012; ISTAT, 2008[a]).
Updated figures of the agriculture sector such as added value, employment, productivity are available (INEA, 2014).

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

On the basis of the 2013 Farm Structure Survey, the number of farms and the utilized agricultural area decreased by 9.2% and 3.3% respectively, compared to the figure recorded in the last agricultural census. Therefore the average size of the agricultural holdings increases from 7.9 to 8.4 hectares.
In 2013 the number of organic farms exceeded 47 thousand units (equivalent to 3.2% of the total farms and 5.8% of the total utilized agricultural area), an increase of 4.7%, compared to the 2010 Census.

5.1.1 Emission trends

Emission trends per gas
In 2016, 7.1% of the Italian GHG emissions, excluding emissions and removals from LULUCF, (6.8% in 1990) originated from the agriculture sector, which is the third source of emissions, after the energy and IPPU sector which accounts for 81.1% and 7.5%, respectively. For the agriculture sector, the trend of GHGs from 1990 to 2016 shows a decrease of 13.4% due to the reduction of the activity data, such as the number of animals and cultivated surface/crop production, the amount of synthetic nitrogen fertilisers applied, the recovery of biogas and changes in manure management systems (see Figure 5.1). CH_4, N_2O and CO_2 emissions account for 62.1%, 36.1% and 1.8% respectively and in the period 1990-2016, CH_4 and N_2O emissions have decreased by 11.5%, 17.4% respectively while CO_2 emissions have increased by 15.7% (see

[3] Agricultural Census data are available at the link http://dati-censimentoagricoltura.istat.it/

Table 5.1). In 2016, the agriculture sector has been the first source for CH_4 sharing 44.0% of national CH_4 levels and for N_2O accounting for 61.2% of national N_2O emissions. As for CO_2, the agriculture sector represents 0.2% of national CO_2 emissions.

Table 5.1 GHG emissions and trend from 1990 to 2016 for the agriculture sector (Gg CO_2 eq.)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
CH_4	21,323	21,072	20,452	19,089	18,971	18,821	18,749	18,521	18,268	18,475	18,871
N_2O	13,289	13,407	13,280	12,473	10,740	11,132	11,600	10,762	10,551	10,522	10,984
CO_2	466	513	527	521	353	376	567	465	423	438	539
Total	**35,078**	**34,992**	**34,259**	**32,083**	**30,065**	**30,329**	**30,916**	**29,747**	**29,243**	**29,435**	**30,394**

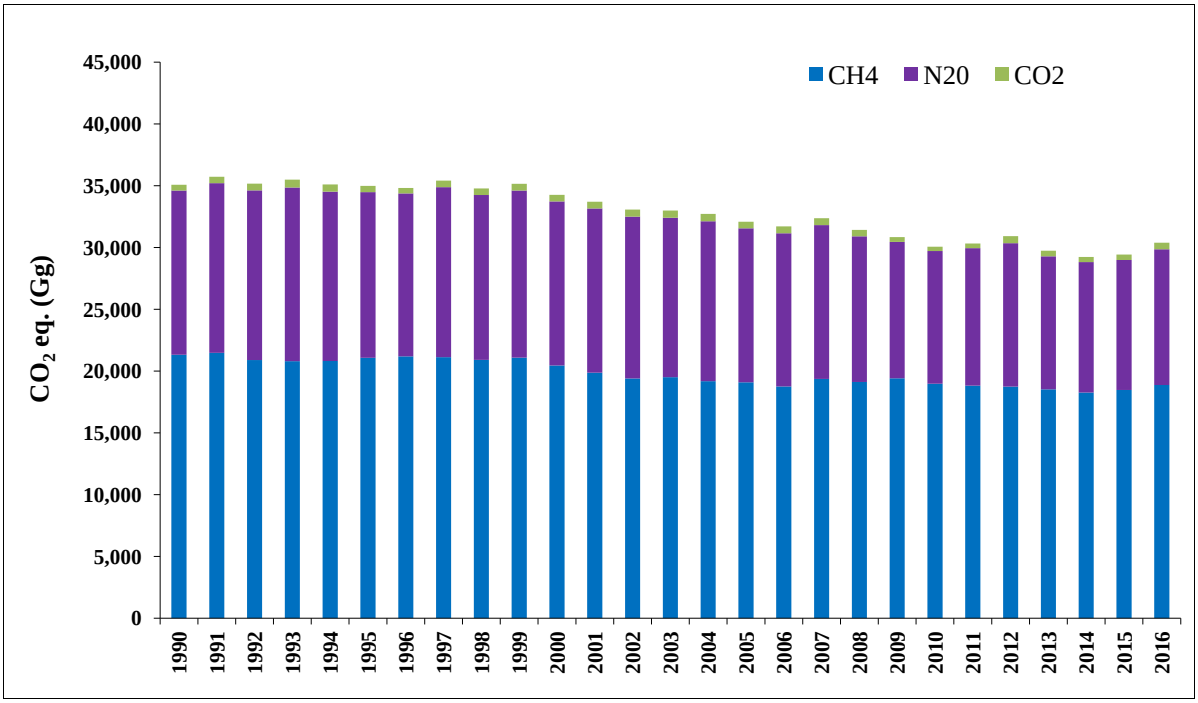

Figure 5.1 Trend of GHG emissions for the agriculture sector from 1990 to 2016 (Gg CO_2 eq.)

Emission trends per sector

Total GHG emissions and trends by sub category from 1990 to 2016 are presented in Table 5.2 (expressed in Gg. CO_2 eq.). CH_4 emissions from enteric fermentation (3A) and N_2O emissions from direct managed soils (3D) are the most relevant categories. In 2016, their individual share in national GHG emissions excluding LULUCF was 3.3% and 2.1%, respectively.

Table 5.2 Total GHG emissions from 1990 to 2016 for the agriculture sector (Gg CO_2 eq.)

	GHG emissions (Gg CO_2 eq.) by sub category						
Year	**3A**	**3B**	**3C**	**3D**	**3F**	**3G-H**	**TOTAL**
1990	15,497	6,824	1,876	10,396	19	466	**35,078.0**
1995	15,319	6,439	1,989	10,713	18	513	**34,992.1**
2000	15,048	6,373	1,656	10,636	18	527	**34,259.1**
2005	13,709	6,055	1,752	10,026	20	521	**32,083.3**
2010	13,530	5,988	1,822	8,352	19	353	**30,064.9**
2011	13,542	5,758	1,805	8,829	19	376	**30,329.2**
2012	13,521	5,702	1,789	9,318	20	567	**30,916.3**
2013	13,684	5,295	1,661	8,623	19	465	**29,747.2**
2014	13,577	5,125	1,613	8,486	19	423	**29,242.6**
2015	13,696	5,179	1,668	8,434	20	438	**29,434.9**
2016	14,039	5,228	1,710	8,857	21	539	**30,394.0**

5.1.2 Key categories

In 2016, CH_4 emissions from enteric fermentation and manure management, indirect N_2O emissions from manure management, direct and indirect N_2O emissions from managed soils, were ranked among the level key sources with the Approach 2, including the uncertainty (L2). Including LULUCF sector in the analysis, indirect N_2O emissions from manure management are not key category. CH_4 emissions from enteric fermentation and direct N_2O emissions from managed soils were ranked among the trend key sources with Approach 2, including the uncertainty (T2). Including LULUCF sector in the analysis, CH_4 emissions from enteric fermentation and direct N_2O emissions from managed soils are key sources at trend assessment with Approach 2. 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-sources identification in the agriculture sector with the IPCC Approach 1 and Approach 2 for 2016

			excluding LULUCF	*including LULUCF*
3A	CH_4	Emissions from enteric fermentation	Key (L, T)	Key (L, T)
3B	CH_4	Emissions from manure management	Key (L)	Key (L)
3Bb	N_2O	Indirect emissions from manure management	Key (L2)	Non-key
3C	CH_4	Rice cultivation	Key (L1)	Key (L1)
3Da	N_2O	Direct emissions from managed soils	Key (L, T2)	Key (L, T)
3Db	N_2O	Indirect emissions from managed soils	Key (L)	Key (L)
3Ba	N_2O	Direct emissions from manure management	Non-key	Non-key
3F	CH_4	Emissions from field burning of agriculture residues	Non-key	Non-key
3F	N_2O	Emissions from field burning of agriculture residues	Non-key	Non-key
3G	CO_2	Liming	Non-key	Non-key
3H	CO_2	Urea application	Non-key	Non-key

5.1.3 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, several years [a]). Moreover, an internal report describes the procedure for preparing the agriculture UNFCCC/CLRTAP national emission inventory, and projections (Cóndor and Di Cristofaro, several 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], UNFCCC, several years; ISPRA, several years [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.
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 (Cóndor *et al.*, 2008[b]). A database with the time series for all sectors and pollutants is available (ISPRA, 2018; ISPRA, 2009; ISPRA, several years [b]). Methodologies used for the inventory, emission scenarios and projections are similar (MATTM, 2007; MATTM, 2009; MATTM, 2013).

5.1.4 Agricultural statistics

The Italian National Statistical System (SISTAN[4]) revises every year the National Statistical Plan that covers three years and includes, among others, the system of agricultural statistics. In this framework, the

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

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 surveys[5] (survey on the area and production of the cultivation, livestock number, milk production, slaughter, fertilizers, etc.);
- General Agricultural Census[6], carried out every 10 years (1990, 2000, 2010).

Detailed information on the agriculture sector is found every two years in the Farm Structure Survey, FSS[7] (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]) and a report on the assessment of the quality of the agricultural census data (ISTAT, 2013). 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 5.3; 5.4; 5.6; 5.8	http://agri.istat.it/jsp/Introduzione.jsp
Milk production	Table 5.3	http://agri.istat.it/jsp/Introduzione.jsp
Fertilizers	Table 5.26; 5.33	http://agri.istat.it/jsp/Introduzione.jsp
Crops production/surface	Table 5.35; Tables A.7.4-9	http://agri.istat.it/jsp/Introduzione.jsp

Differences on some animal populations data are found comparing national statistics and FAOSTAT[8] data. 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 database[9] (EUROSTAT). Whenever outliers are identified, ISTAT and category associations are contacted. Slight differences in the livestock number (cattle and other swine) are found comparing conjunctural surveys (used for emissions estimation) and theAgricultural census for the year 2010, while differences are more significant[10] (ISTAT, 2012) for the other categories. The verification of statistics is part of the implemented QA/QC procedures. The livestock data represents the number of animals present on the farm at any given time of the year (conventionally 1st of June or 1st of December). Therefore livestock figures do not represent the number of animals produced annually; for animal populations that are alive for only part of a complete year, the annual average population is estimated on the basis of "places" instead of the days of life and the number of cycles.

5.2 Enteric fermentation (3A)

5.2.1 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, in terms of level and trend assessment, for Approach 1 and Approach 2. All livestock categories have been estimated except camels and llamas, which are not present in Italy. Methane emissions from poultry and fur animals do not occur.

[5] http://agri.istat.it/
[6] http://censagr.istat.it/; http://dati-censimentoagricoltura.istat.it/
[7] Indagine sulla struttura e produzione delle aziende agricole (SPA), survey carried out every two years in agricultural farms.
[8] FAOSTAT http://www.fao.org/faostat/en/#home
[9] http://ec.europa.eu/eurostat/data/database
[10] The number of heads of conjunctural surveys of the sows, sheep, goats, mules and asses, broilers, hens categories is on average 15% higher than the census, whereas for other poultry the difference is 30% and for horses and rabbits is more than double.

Emissions from rabbits, mules and asses, goats, buffalo and horses are estimated and included in "Other livestock" as shown in the tables of the CRF reporter.
In 2016, CH_4 emissions from this category were 561.55 Gg which represents 74.4% of CH_4 emissions for the agriculture sector (72.7% in 1990) and 32.7% for national CH_4 emissions excluding LULUCF (32.1% in 1990). Methane emissions from this source consist mainly of cattle emissions: dairy cattle (260.51 Gg) and non-dairy cattle (193.31 Gg). These two sub-categories represented 46.4% (47.4% in 1990) and 34.4% (37.6% in 1990) of total enteric fermentation emissions, respectively.

5.2.2 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], [g]; ISTAT, 1991; 2007[a], [b]). 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 5.21. 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 UNAITALIA (FAO, several years; UNAITALIA, several years).

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/UNAITALIA (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 (UNAITALIA, several years); (c) For 1990 data from the census and reconstruction based on a production index (ISTAT, 2007[b]; ISTAT, several years [k])

Dairy cattle
Methane emissions from enteric fermentation for dairy cattle are estimated using a Tier 2 approach, as suggested in the 2006 IPCC Guidelines (IPCC, 2006). 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

Parameter	Value	Reference	IPCC 2006(*)
Average weight (kg)	602.7	CRPA, 2006[a]	600
Coefficient NE_m (lactating cows)	0.386	NRC, 2001; IPCC, 2006	0.386
Pasture (%)	5	CRPA, 2006[a]; ISTAT, 2003	0(**)
Weight gain (kg day^{-1})	0.051	CRPA, 2006[a]; CRPA, 2004[b]	0
Milk fat content (%)	3.59-3.79	ISTAT, several years[a], [b], [d], [e], [h]	
Hours of work per day	0	CRPA, 2006[a]	0
Portion of cows giving birth	0.97-0.90	AIA, several years[a]	0.9
Milk production (kg $head^{-1}$ day^{-1})	11.5-19.7	CRPA, 2006[a]; OSSLATTE/ISMEA, 2003; ISTAT, several years[a], [b], [c], [d], [e], [f], [h]; OSSLATTE, 2001	16.4
Digestibility of feed (%)	65	CRPA, 2006[a]; CRPA, 2005; IPCC, 2006	65
Methane conversion factor (%)	6.5	CRPA, 2006[a]; IPCC, 2006	6.5
Energy content of methane (MJ/kg methane)	55.65	IPCC, 2006	55.65

(*) Data for estimating tier 1 enteric fermentation CH_4 emission factors for dairy cows (Western Europe); (**) Stall fed (feeding situation)

The coefficient for calculating net energy for maintenance (NE_m) and the methane conversion factor (Y_M) for cattle (lactating cows) have been updated on the basis of the default values published in the 2006 IPCC Guidelines.

Milk production national statistics were analysed. 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, several years[h]). 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, 2006). Therefore, lactating and non-lactating periods are included in the estimation of the CH_4 dairy cattle EF (CRPA, 2006[a]).

In Table 5.3, 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 5.7, the time series of the dairy cattle emission factors (EF) is presented. In 2016, the CH_4 dairy cattle EF was 143.0 kg CH_4 head^{-1} year^{-1} with an average milk production of 7,189 kg head^{-1} year^{-1} (19.7 kg head^{-1} day^{-1}). IPCC Guidelines report a default EF of 117 kg CH_4 head^{-1} year^{-1} with a milk production of 6,000 kg head^{-1} year^{-1} (IPCC, 2006).

Table 5.3 Parameters used for the estimation of the CH_4 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
2005	1,842,004	3.71	0.91	17.2
2010	1,746,140	3.72	0.90	18.8
2011	1,754,981	3.73	0.90	18.5
2012	1,857,004	3.75	0.89	17.7
2013	1,862,127	3.78	0.89	17.5
2014	1,830,990	3.77	0.90	18.7
2015	1,826,484	3.76	0.89	19.1
2016	1,821,764	3.79	0.90	19.7

Non-dairy cattle

For non-dairy cattle, CH_4 emissions from enteric fermentation are estimated with a Tier 2 approach (IPCC, 2006). The estimation of the EF uses country-specific data, disaggregated livestock categories (see Table 5.4), 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, 2006). Emission factors for each category are calculated with equation 10.21 from IPCC (IPCC, 2006, volume 4, chapter 10).

In Table 5.5, 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 5.4. For this reason, the gross energy intake, CH_4 conversion factor and EFs for this category are calculated as a weighted average.

Table 5.4 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			
	for slaughter	others	breeding	for slaughter	breeding	for slaughter	all	breeding	for slaughter	others	**Total**
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**
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**
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**
2012	441,975	1,081,177	21,231	494,860	671,688	177,308	76,035	485,930	54,694	380,708	**3,885,606**
2013	483,556	1,125,354	21,385	498,456	674,431	180,269	88,765	508,504	72,514	331,311	**3,984,545**
2014	495,477	1,122,919	19,647	457,950	637,686	200,131	75,649	531,358	62,128	322,135	**3,925,080**
2015	492,126	1,141,545	19,966	465,391	638,566	205,966	82,304	524,745	64,570	319,685	**3,954,864**
2016	492,461	1,200,405	20,786	484,504	680,427	212,205	83,543	566,277	67,064	300,331	**4,108,003**

Table 5.5 Main parameters used for non-dairy cattle CH_4 emission factor estimations

	<1 year	1-2 years males		1-2 years females		>2 years males	>2 years females		
Parameters	Others (*)	breeding	for slaughter	breeding	for slaughter	all	breeding	for slaughter	Others
Average weight (kg)	236	557	557	405	444	700	540	540	557
Percentage weight ingested	2.1	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 CH_4 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 2017 submission, in response to the UNFCCC review process, additional information on the CH_4 conversion factors is provided. Data on CH_4 conversion factors are based on the Nitrogen Balance Inter-regional Project (CRPA, 2006[a]). The project was carried out in cooperation with the Italian regions having the highest concentration of livestock; data on breeding performance, on food consumption, on the characteristics and composition of rations were analyzed. The production of methane per head was estimated on the basis of the estimate of dry matter intake, calculated as weight percentage, by applying a conversion factor of energy intake into methane. Methane conversion factors were estimated from the values indicated by the IPCC Guidelines and on the basis of the food digestibility, considering food more digestible in the case of animals for fattening and richer in fiber in the case of animals for replacement (CRPA, 2006[a]). Detailed information is reported in Annex 7.

In Table 5.7, Implied Emission Factors (IEF) for non-dairy cattle are shown. In 2016, the non dairy-cattle EF was 47.1 kg CH_4 head^{-1} year^{-1} as IPCC 2006 Guidelines default EF is 57 kg CH_4 head^{-1} year^{-1} (IPCC, 2006). 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 5.4). This last category (calves) has not been considered when estimating methane emissions as they are milk fed. The relevant parameters,for estimating N_2O emissions from manure management, for this category, are the following:

- Average body weight: 157 kg;
- Nitrogen excretion: 11.9 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 Tier 2 approach for the buffalo category (IPCC, 2006). Two different country-specific CH_4 EFs, for cow buffalo and other buffaloes, were developed. Detailed description of the methodology is reported in Cóndor *et al*. (Cóndor *et al*., 2008[a]). In 2016, the cow buffalo CH_4 EF was 85.9 kg CH_4 head^{-1} year^{-1} and for other buffaloes the value was 61.8 kg CH_4 head^{-1} year^{-1}. The CRF IEF is an average value for the two categories (76.7 kg CH_4 head^{-1} year^{-1}). Parameters used for the Tier 2 approach are shown in the following boxes.

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

Parameters	Value	Reference
Average body weight (kg)	630	Infascelli, 2003; Consorzio per la tutela del formaggio mozzarella di bufala campana, 2002
Coefficient NE_m (lactating cows)	0.386	IPCC, 2006
Pasture (%)	2.90	ISTAT, 2003; Zicarelli, 2001; De Rosa and Di Francia, 2006
Weight gain (kg day^{-1})	0.055	Infascelli, 2003; Consorzio per la tutela del formaggio mozzarella di bufala campana, 2002
Milk fat content (%)	7.73-7.38	ISTAT, several years [a], [b], [d], [e], [h]
Hours of work per day	0	De Rosa and Di Francia, 2006
Proportion of calving cows	0.89-0.84	Barile, 2005; De Rosa and Trabalzi, 2004
Milk production (kg head^{-1} day^{-1})	1.91-2.87	OSSLATTE/ISMEA, 2003; OSSLATTE, 2001; ISTAT, several years [a], [b], [c] [d], [e], [f], [h]
Digestibility of feed (%)	65	Infascelli, 2003; Masucci *et al*., 1997, 1999
Methane conversion factor (%)	6.5	CRPA, 2006[a]; IPCC, 2006
Energy content of methane (MJ/kg methane)	55.65	IPCC, 2006

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)	150	405
Dry matter intake (% of body weight head^{-1} day^{-1})	3.0	2.5
Dry matter intake (kg head^{-1} day^{-1})	4.5	10.1
Gross Energy (MJ head^{-1} day^{-1})	82.75	186.58
CH_4 conversion (%)	6.5	6.5
CH_4 emission factor (kg head^{-1} year^{-1})	26.46 (*)	79.54

(*) original CH_4 emission factor was 35.28 kg CH_4 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 26.46 kg CH_4 head^{-1} year^{-1}.

The coefficient for calculating net energy for maintenance (NE_m) and the methane conversion factor (Y_M) for buffalo have been updated on the basis of the default values published in the 2006 IPCC Guidelines.

Sheep

Methane emissions from enteric fermentation for sheep are estimated using a Tier 2 approach, as suggested in the 2006 IPCC Guidelines (IPCC, 2006). Gross energy intake was estimated separately for three sub-categories: mature ewes, growing lambs, other mature sheep. Data of mature ewes and other sheep are provided by ISTAT (as reported in the 5.1.4 *Agricultural statistics*). Growing lambs and other mature sheep were estimated by applying the percentages of 85% and 15% respectively to the total number of other sheep (CRPA, 2006[a]). In Table 5.6, time series of sheep population are shown.

Table 5.6 Sheep population (heads) classified by sub-categories

Year	Mature ewes (head)	Growing lambs (head)	Other mature sheep (head)
1990	7,492,089	1,060,089	187,075
1995	8,518,496	1,827,054	322,421
2000	8,334,000	2,341,750	413,250
2005	7,007,217	804,908	142,043
2010	7,089,123	689,259	121,634
2011	7,123,014	696,683	122,944
2012	6,296,701	611,174	107,854
2013	6,322,871	730,113	128,844
2014	6,203,164	818,428	144,428
2015	6,196,466	809,258	142,810
2016	6,315,172	824,247	145,455

The sharp decline in 2001 was mainly due to the spread of the infectious disease named Bluetongue and a structural decline mainly due to the production system of Sardinia (a region of Italy), which holds the largest number of farms rearing sheep, resulting from a gradual erosion of profit margins.
Parameters used for the calculation of the emission factor are shown in the following box.

Parameters for the calculation of sheep emission factors from enteric fermentation

Parameter	Mature ewes	Growing lambs	Other mature sheep	Reference
Average weight (kg)	51	14	59	CRPA, 2006[a]
Coefficient NE_m	0.217	0.236	0.217-0.250(1)	IPCC, 2006
Pasture (%)(2)	29	31	33	Our estimation
Weight gain (kg day^{-1})(3)		0.019		ARA, 2017; Agraria, 2009; AIA, several years[b]
Milk production (kg $head^{-1}$ day^{-1})	0.30-0.35			ISTAT, several years[h], [l], [b]; ISTAT, 2006[a]
Wool production (kg $head^{-1}$ y^{-1})	1.88-1.29			ISTAT, several years[l]
Portion of ewes giving birth	0.93			AIA, several years[c]
Single birth fraction (%)	70.8-74.0			AIA, several years[b]
Double birth fraction (%)	29.2-26.0			AIA, several years[b]
Digestibility of feed (%)	65	75(4)	65	IPCC, 2006
Methane conversion factor (%)	6.5	4.5(4)	6.5	IPCC, 2006

(1) The value increased by 15% for intact males; (2) Values estimated assuming an average of 11 month on pasture for 8 hours per day; (3) Assumptions made: sex ratio 40% males and 60% females; weight at weaning (30 days) 10 kg; weight at slaughter (90 days) 18 kg for males and 17 kg for females; (4) diets based on forage and concentrates (LAORE, 2014).

In the CRF tables, the weighted average values of parameters reported in the previous box were considered for sheep category.

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 CH_4 conversion rate (CRPA, 2004[c]).

Other livestock categories
A Tier 1 approach, with IPCC default EFs, is used to estimate CH_4 emissions from swine, goats, horses, mules and asses (IPCC, 2006).
In Table 5.7, EFs for all livestock categories (dairy cattle, non-dairy cattle, buffalo, swine, sheep, goats, horses, mules and asses, and rabbits) are presented. In Table 5.8, time series of the number of animals are shown.

Table 5.7 Average CH_4 emission factors for enteric fermentation (kg CH_4 $head^{-1}$ $year^{-1}$)

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	111.1	45.6	74.4	6.9	5.0	18.0	10.0	1.5	1.5	0.08
1995	123.6	47.4	75.8	6.7	5.0	18.0	10.0	1.5	1.5	0.08
2000	124.6	47.0	78.2	6.2	5.0	18.0	10.0	1.5	1.5	0.08
2005	132.9	46.4	84.6	7.1	5.0	18.0	10.0	1.5	1.5	0.08
2010	138.8	45.9	76.7	7.1	5.0	18.0	10.0	1.5	1.5	0.08
2011	138.0	45.6	77.8	7.0	5.0	18.0	10.0	1.5	1.5	0.08
2012	134.9	48.0	77.6	7.2	5.0	18.0	10.0	1.5	1.5	0.08
2013	134.3	47.5	76.3	7.0	5.0	18.0	10.0	1.5	1.5	0.08
2014	138.8	46.9	77.4	6.9	5.0	18.0	10.0	1.5	1.5	0.08
2015	140.5	46.9	77.2	7.0	5.0	18.0	10.0	1.5	1.5	0.08
2016	143.0	47.1	76.7	7.1	5.0	18.0	10.0	1.5	1.5	0.08

Table 5.8 Time series of number of animals from 1990 to 2016 (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
2005	205,093	7,954,167	945,895	278,471	30,254	721,843	8,478,427	20,504,282	188,595,022
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	17,549,225	200,718,160
2012	348,861	7,015,729	891,604	395,913	59,865	621,446	8,040,080	17,465,477	198,767,734
2013	402,659	7,181,828	975,858	393,915	63,166	590,278	7,971,405	16,548,690	194,319,153
2014	369,349	7,166,020	937,029	390,886	67,016	585,714	8,090,378	16,435,598	192,839,707
2015	374,458	7,148,534	961,676	384,767	70,872	582,447	8,092,346	15,903,780	196,386,717
2016	385,121	7,284,874	1,026,263	388,324	74,215	558,065	7,919,865	15,207,274	205,193,988

5.2.3 Uncertainty and time-series consistency

Uncertainty related to CH_4 emissions from enteric fermentation was 20.2% for annual emissions, resulting from the combination of 3% of uncertainty for activity data and 20% for 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 2016, CH_4 emissions from enteric fermentation were 9.4% (561.55 Gg) lower than in 1990 (619.86 Gg). Between 1990 and 2016 cattle livestock has decreased by 23.5% (from 7,752,152 to 5,929,767 heads). Dairy cattle and non-dairy cattle have decreased by 31.0% (from 2,641,755 to 1,821,764) and 19.6% (from 5,110,397 to 4,108,003), respectively. The reduction in number of cattle is the main driver for the reduction in CH_4 emissions, particularly as emissions per head from cattle are more than 10 times greater than those of sheep or goat. In 2016, cattle contribute with 80.8% to total CH_4 emissions from enteric fermentation.
In Table 5.9, emission trends from the enteric fermentation category are shown. Emissions from swine, as reported in the CRF Reporter, are represented by ‘other swine’ and ‘sow’ (12.72 Gg).

Table 5.9 Trend of CH_4 emissions from enteric fermentation (Gg)

Year	Dairy cattle	Non-dairy cattle	Buffalo	Sheep	Goats	Horses	Mules and asses	Sows	Other swine	Rabbits	Total
1990	293.57	233.00	7.03	60.18	6.29	5.18	0.84	0.98	11.63	1.16	**619.86**
1995	256.99	246.22	11.25	71.98	6.86	5.67	0.38	1.03	11.06	1.33	**612.76**
2000	257.36	234.48	15.02	68.96	6.88	5.04	0.33	1.06	11.40	1.39	**601.91**
2005	244.74	204.65	17.36	56.19	4.73	5.01	0.30	1.08	12.72	1.59	**548.37**
2010	242.38	187.46	28.02	55.87	4.91	6.72	0.46	1.08	12.91	1.39	**541.21**
2011	242.13	188.81	27.58	55.75	4.80	6.72	0.51	1.06	12.96	1.36	**541.69**
2012	250.54	186.43	27.06	50.27	4.46	7.13	0.60	0.93	12.06	1.36	**540.82**
2013	250.11	189.39	30.70	50.41	4.88	7.09	0.63	0.89	11.96	1.29	**547.34**
2014	254.13	184.07	28.58	49.61	4.69	7.04	0.67	0.88	12.14	1.28	**543.07**
2015	256.56	185.57	28.90	50.11	4.81	6.93	0.71	0.87	12.14	1.24	**547.82**
2016	260.51	193.31	29.55	51.41	5.13	6.99	0.74	0.84	11.88	1.18	**561.55**

5.2.4 Source-specific QA/QC and verification

Data on cow's milk collection from farms for dairy industry provided by the AGEA[11] were compared to official statistics provided by ISTAT, for the years 2004-2015. Data from AGEA are on average higher by 6% in the years 2004-2007 and 3% in the years 2011-2013. In other years, the differences are negligible, in particular for the years 2014 and 2015.
Differences on sheep's milk collection data are found between FAOSTAT and national statistics. For the years 1990-1995, FAO data are higher on average more than 40%, then the difference decreases. After 2003, FAO data becomes lower than official ISTAT statistics. In the period 2005-2008, FAO data is equal to the total of the milk collected at the farms including the amount used on farms. The milk directly suckled by calves is not considered. In the period 2009-2013, FAO data is only equal to the total of milk collected at the farms. Further investigation will be carried out.
Since the 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). Information related to the 2010 Agricultural census has been analysed and verified. Slight differences in the livestock number (cattle and other swine) are found between conjunctural surveys (used for emissions estimation) and Agricultural census for the year 2010; while for the other categories the differences are more significant[12] (ISTAT, 2012).

5.2.5 Source-specific recalculations

CH_4 emissions have been recalculated because of the update of the methane estimate from enteric fermentation for sheep by applying the Tier 2 methodology. The number of sows for 2015 has been updated.

5.2.6 Source-specific planned improvements

Additional data and information will be collected to improve the estimation of methane emissions from sheep.
Information and administrative data related to number of heads, average weight by livestock category, food rations of livestock for cattle and swine, milk production data will be collected by the Ministry of Economic Development as part of the Decree of Ministry for the Environment, Land and Sea 9 december 2016 *Attuazione della legge 3 maggio n. 79 in materia di ratifica ed esecuzione dell'Emendamento di Doha al*

[11] AGEA is the Agency for Agricultural Payments. The Agency has the task of performing the functions of coordination, monitoring and disbursement of European funds for agriculture - http://www.agea.gov.it/portal/page/portal/AGEAPageGroup/HomeAGEA/home. Data are available online at the link http://www.sian.it/downloadpub/jsp/zfadlx001.jsp (the filename is *Riepilogo per regione di produzione delle consegne mensili non rettificate registrate*).
[12] The number of heads of conjunctural surveys of the sows, sheep, goats, mules and asses, broilers, hens categories is on average 15% higher than the census, whereas for other poultry the difference is 30% and for horses and rabbits is more than double.

Protocollo di Kyoto (GU, 2016) and comparisons and verifications with the data used to estimate emissions will be carried out.

5.3 Manure management (3B)

5.3.1 Source category description

In 2016, CH_4 emissions from manure management were 124.23 Gg, which represents 16.5% of CH_4 emissions for the agriculture sector (18.5% in 1990) and 7.2% of national CH_4 emissions (7.9% in 1990). CH_4 emissions from swine were 54.69 Gg and from cattle were 54.10 Gg. These two sub-categories represented 44.0% and 43.5%, respectively, of total CH_4 manure management emissions.
N_2O direct and indirect emissions, produced during the storage and treatment of manure before it is applied to land, are reported separately. In 2016, N_2O emissions from manure management were 7.12 Gg (of which 4.30 Gg are direct emissions and 2.82 Gg are indirect emissions), which represents 19.3% of total N_2O emissions for the agriculture sector (21.7% in 1990) and 11.8% of national N_2O emissions (10.9% in 1990). In 2016, direct N_2O emissions from this source consist of the solid storage source (2.17 Gg), liquid system (1.93 Gg) and other management systems such as chicken-dung drying process system (0.20 Gg). N_2O emissions of the anaerobic digesters, another management system used in the country, are reported equal to zero in line with the 2006 IPCC Guidelines (IPCC, 2006).
In the framework of the Nitrogen Balance Inter-regional Project, parameters related to the estimation of CH_4 and N_2O emissions, such as average weight, production of slurry and solid manure and the nitrogen excretion rates, have been set.
CH_4 emissions from manure management are key sources at level, following Approach 1 and Approach 2. Direct N_2O emissions from manure management are not key sources, while indirect N_2O emissions from manure management are key sources at level following Approach 2, excluding the LULUCF sector in the analysis.

5.3.2 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 5.3; Table 5.4; Table 5.8).

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, 1993; 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 CH_4 m^{-3} day^{-1}), which is obtained from an equation for slurry and solid manure (Husted, 1994).
Equations are presented below (CRPA, 2006[a]).

For slurry:

$$CH_4 \text{ (g m}^{-3} \text{ day}^{-1}\text{)} = e^{(0.68+0.12) * t \text{ (°C) (average regional monthly temperature)}} \quad \textit{Eq. 5.1}$$

For solid manure:

$$CH_4 \text{ (g m}^{-3} \text{ day}^{-1}\text{)} = e^{(-2.3+0.1) * t \text{ (°C) (monthly storage temperature)}} \quad \textit{Eq. 5.2}$$

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

$$T_{solid\ manure\ storage} = 6{,}7086e^{0.1014t\ (°C)\ (average\ regional\ monthly\ temperature)}$$

For temperatures below 10°C emissions are considered negligible.
The volume of slurry and solid manure produced per livestock category ($m^3\ head^{-1}$) was obtained considering the average production of slurry and solid manure per livestock category per day ($m^3\ head^{-1}\ day^{-1}$) and the days of storage of slurry and solid manure. The volume of slurry and solid manure is based on regional regulations concerning the use of manure. Information about days of storage takes into account the retention time in storage facilities and temporal dynamics of storage and application on land of slurry and manure (CRPA, 1997[a]). On the other hand, the production of solid manure and slurry were estimated assuming a distribution of housing systems in Italy. The abovementioned distribution for dairy cattle has been assessed on the basis of an 1998 CRPA survey carried out in Lombardy, Emilia Romagna and center of Italy and on ISTAT statistics of 2003 (CRPA, 2006[a]; Bonazzi *et al*., 2005; APAT, 2004[a]; APAT, 2004[b]) for the period 1990-2005; starting from 2010 a new distribution of housing systems has been assumed on the basis of the results of the 2010 Agricultural Census. Between 2005 and 2010 a gradual transition to the updated distribution of housing systems has been assumed for the intermediate years, taking in account the gradual penetration of systems to ensure animal welfare. For non-dairy cattle and buffalo categories data on distribution of housing systems derive from national studies and expert judgment (CRPA, 2006[a]).
On the basis of the *methane emission rates* and the volume of slurry and solid manure produced, methane emissions were calculated.
The calculation of volatile solid (VS) production is based on the average production of slurry and solid manure and the factors proposed by Husted: 47 g VS/kg (slurry) and 142 g VS/kg (solid manure) (Husted, 1994; CRPA, 2006[a]).
In order to correlate CH_4 emission production and volatile solid (VS) production, a *specific conversion factor* was estimated as the ratio between methane emissions and VS production. Later, these *specific conversion factor* are used for the simplified methodology (*Method 2*). The *specific conversion factor* values for slurry and solid manure are 15.32 g CH_4/kg VS and 4.80 g CH_4/kg VS, respectively.

Method 2: National basis
A simplified methodology (*Method 2*) for estimating methane EFs from manure management was used for the whole time series. Slurry and solid manure EFs (kg $CH_4\ head^{-1}\ year^{-1}$) were calculated with Equations 5.3 and 5.4, respectively. These equations include the *specific conversion factor*, estimated on a regional basis. The production of volatile solids (kg $head^{-1}day^{-1}$) was estimated with the slurry and solid manure production, and factors proposed by Husted (Husted, 1994; CRPA, 2006[a]): 47g VS/kg (slurry) and 142 g VS/kg (solid manure).
The daily VS excreted, estimated for slurry and solid manure, are summed and used for calculating the methane producing potential (Bo).
In Table 5.10, EF estimations are shown.

$$EF_{slurry} = 15.32\ g\ CH_4/kg\ VS \bullet VS\ production_{slurry}\ (kg\ VS\ head^{-1}\ day^{-1}) \bullet 365\ days \quad \textit{Eq. 5.3}$$

$$EF_{manure} = 4.80\ g\ CH_4/kg\ VS \bullet VS\ production_{solid\ manure}\ (kg\ VS\ head^{-1}\ day^{-1}) \bullet 365\ days \quad \textit{Eq. 5.4}$$

Table 5.10 Methane manure management EFs for cattle and buffalo in 2016 (kg $CH_4\ head^{-1}\ yr^{-1}$)

Livestock category	Slurry (kg $CH_4\ head^{-1}\ yr^{-1}$)	Solid manure (kg $CH_4\ head^{-1}\ yr^{-1}$)	CH_4 manure management EF (kg $CH_4\ head^{-1}\ yr^{-1}$)
Calf	6.22	0.00	**6.22**
Male cattle	5.24	3.61	**8.85**
Female cattle	2.71	4.48	**7.19**
Other dairy cattle (*)	4.01	6.65	**10.66**
Dairy cattle	7.82	9.04	**16.86**
Cow buffalo	4.93	10.32	**15.25**
Other buffaloes	3.19	3.24	**6.43**

(*) Suckler cows and cows in late career (average weight 557 kg)

The average production of slurry and solid manure per livestock category per day (m^3 $head^{-1}$ day^{-1}) has been set 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 5.11 the disaggregated manure management EFs for cattle and buffalo are shown. In Table 5.14 the average EFs of main categories (dairy, non-dairy, buffalo and swine) are reported.

Table 5.11 Methane manure management EFs for cattle and buffalo (kg CH_4 $head^{-1}$ yr^{-1})

Year	Calf	Male cattle	Female cattle	Other dairy cattle (*)	Dairy cattle	Cow buffalo	Other buffaloes
	(kg CH_4 $head^{-1}$ yr^{-1})						
1990	6.22	8.11	6.69	10.66	15.04	15.25	6.48
1995	6.22	8.56	6.69	10.66	15.04	15.25	6.46
2000	6.22	8.27	6.78	10.66	15.04	15.25	6.45
2005	6.22	8.61	6.93	10.66	15.04	15.25	6.43
2010	6.22	8.81	7.01	10.66	16.86	15.25	6.43
2011	6.22	8.80	6.93	10.66	16.86	15.25	6.43
2012	6.22	9.08	7.11	10.66	16.86	15.25	6.43
2013	6.22	8.96	7.19	10.66	16.86	15.25	6.43
2014	6.22	8.90	7.17	10.66	16.86	15.25	6.43
2015	6.22	8.91	7.15	10.66	16.86	15.25	6.43
2016	6.22	8.85	7.19	10.66	16.86	15.25	6.43

(*) Suckler cows and cows in late career (average weight 557 kg)

A reduction of CH_4 emissions has been introduced in the manure management category (3B) in order to consider the biogas production. A national census on biogas production/technology can be found in CRPA and CRPA/AIEL (CRPA, 2008[a]; CRPA/AIEL 2008). Biogas production data are collected annually by the National Electric Network (TERNA, several years). Emissions of methane, from biogas at anaerobic digesters fed with animal manure, to be deducted from the total amount of methane from manure management, were calculated using the information and data provided by TERNA and CRPA. For further information on the country-specific methodology used see Annex 7.2.
Reductions of CH_4 emissions related to biogas recovery are assumed for cattle and swine livestock categories and distributed according to the methodology described in Annex 7.2 (see paragraph *CH_4 emissions to be subtracted*). This reduction is evident in the IEF reported in the CRF tables. In 2016, the CRF IEFs, for dairy cattle and non-dairy cattle, were 16.86 kg CH_4 $head^{-1}$ $year^{-1}$ and 7.74 kg CH_4 $head^{-1}$ $year^{-1}$, respectively. IPCC default EFs for cool temperature (and 13°C as average annual temperature) are 27 kg CH_4 $head^{-1}year^{-1}$ and 8 kg CH_4 $head^{-1}year^{-1}$, respectively (IPCC, 2006).
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 CH_4 reductions from biogas recovery. In the following box, the default EFs of the IPCC 2006 Guidelines are also reported.

Livestock category	EF (kg CH_4 $head^{-1}$ yr^{-1})	IEF(*) (kg CH_4 $head^{-1}$ yr^{-1})	IPCC 2006 default EF (kg CH_4 $head^{-1}$ yr^{-1})
Dairy cattle	16.86	14.58	27
Non-dairy cattle	7.74	6.70	8
Buffalo	11.90	11.90	5

(*) IEF as reported in the CRF submission 2017

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 CH_4 producing potential (Bo) is estimated with Equation 10.23 from IPCC (IPCC, 2006, volume 4, chapter 10). 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]). The used average methane conversion factors have been compared with the MCFs assessed on the basis of the FSS 2007 (ISTAT, 2008[a]) and the 2010

Agriculture Census (ISTAT, 2012), resulting in very slight differences. 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 (IPCC, 2006). Differences are mainly attributed to country-specific characteristics.

Livestock category	VS country-specific (*) (kg dm head^{-1} day^{-1})	VS IPCC default (kg dm head^{-1} day^{-1})	Bo country-specific (*) (CH_4 m^3/kg VS)	Bo IPCC default (CH_4 m^3/kg VS)
Dairy cattle	6.56	5.10	0.16	0.24
Non-dairy cattle	2.91	2.60	0.19	0.18
Buffalo	5.12	3.90	0.13	0.10
Swine	0.34	0.31 (**)	0.60	0.45

(*) IEF as reported in the CRF submission 2017; (**) weighted average with the number of heads of sows and other swine categories

Methane emissions (swine)
For the estimation of CH_4 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 storage systems for slurry (tank and lagoons), type of breeding and 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 CH_4/100 kg live weight/day for fattening swine, and 47 normal litre CH_4/100 kg live weight/day for sows including piglets (CRPA, 2006[a]), based on experimental measurements on covered storage systems.
The shares of covered/uncovered storage systems are equal to 4% and 96% (CRPA, 2006[b]), respectively; the CH_4 emission rates used for uncovered storage systems were: 37.6 normal litre CH_4/100 kg live weight/day for fattening swine and 43.1 normal litre CH_4/100 kg live weight/day for sows, including piglets.

The uncovered systems are emitting less than the covered ones since the temperatures are lower. According to the information on the storage systems collected by the 2010 Agriculture Census, the shares of covered/uncovered storage systems are equal to 11% and 89%, respectively; the shares of covered/uncovered storage systems are equal to 25% and 75%, respectively, taking into account the outcomes of the 2013 FSS ISTAT survey.
Characteristics of swine breeding and EFs are shown in Table 5.12; the emission factors reflect the share of covered/uncovered storage systems. The slurry production considered the different swine categories (classified by weight and housing characteristics); the average weight of sows, the production of slurry (t year^{-1} per t live weight) and the volatile solid content in the slurry (g SV/kg slurry w.b.) have been set on the basis of 598 measurements carried out by CRPA (CRPA, 1996; CRPA, 2006[a]).
In 2016, the EF from sow was 22.84 kg CH_4 head^{-1}year^{-1}, and for the other swine category was 9.01 kg CH_4 head^{-1} year^{-1} (average swine EF is 8.46 kg CH_4 head^{-1}year^{-1}). In Table 5.14 the time series of EFs for the swine category (sow and other swine) are shown. The CRF IEF reported is 6.45 kg CH_4 head^{-1} year^{-1}. IPCC 2006 Guidelines default EF is 7 kg CH_4 head^{-1}year^{-1} for market swine and 11 kg CH_4 head^{-1}year^{-1} for breeding swine respectively, for cool temperature and 13°C as average annual temperature (IPCC, 2006). The difference between the EF and the IEF is due to the reduction in CH_4 because of biogas recovery (see Annex 7.2).
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). Methane producing potential (Bo) used Equation 10.23 from the IPCC (IPCC, 2006, volume 4, chapter 10).

Table 5.12 Methane manure management parameters and emission factors for swine in 2016

Livestock category	Average weight (kg)	Breed live weight (t)	Methane emission rate reduction (Nl CH_4/100 kg live weight)	Emission factor (kg CH_4 head^{-1} yr^{-1})
Other swine	**89**	**582,337**	**14,036**	**9.01**
20-50 kg	35	56,082	14,036	3.54
50-80 kg	65	78,727	14,036	6.58
80-110 kg	95	137,899	14,036	9.62

Livestock category	Average weight (kg)	Breed live weight (t)	Methane emission rate reduction (Nl CH_4/100 kg live weight)	Emission factor (kg CH_4 $head^{-1}$ yr^{-1})
110 kg and more	135	303,894	14,036	13.67
Boar	200	5,735	14,036	20.25
Sows	**172.1**	**109,793**	**16,090**	**22.84**
Piglets	10	13,750	16,090	1.16
Sows	172.1	96,043	16,090	19.98
			Total	**8.46**

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 N_2O emissions.

Other livestock categories
Methane EFs used for calculating the other livestock categories are those included in the 2006 IPCC Guidelines. Since the yearly average temperature in Italy is 13°C, EFs are characteristic of the "cold" climatic region (IPCC, 2006). Considering that some Italian provinces have an average temperature higher than 15°C (temperate), a CRPA study (CRPA, 1997[a]), carried out at national level, assessed specific EFs, to be used in the estimation process of this category, for each animal category, on the basis of the IPCC default values, taking into account the territorial livestock distribution (at NUTS2 level).
In Table 5.13 the distribution of animals in temperate zone is shown.

In Table A.7.2 in the Annex, percentages of animals in temperate zone based on data from the FSS 2005, provided by ISTAT, and the average temperature at provincial level are shown. In order to verify the used animal distribution, the 2010 Agriculture Census (ISTAT, 2012) has been used to infer the percentages of animals in temperate zone. Comparing the assessed percentage with the used distribution slight differences have to be noted, except for other swine, other equines and hens categories (decrease of 30%, 30% and an increase by 27%, respectively); a higher deviation is resulting for the other poultry and broilers categories.

Table 5.13 Distribution of animals in temperate zone

Animals in temperate zone based on data from the FSS 2005 (ISTAT)	Total	N animals	% animals	Based on temperature non weighted by % animals	
				N animals	% animals
Non-dairy cattle	4,409,921	552,951	12.54%	285,415	6.47%
Dairy cattle	1,842,004	140,747	7.64%	55,975	3.04%
Buffalo	205,093	83,864	40.89%	121	0.06%
Other swine	8,478,427	208,355	2.46%	76,427	0.90%
Sows	721,843	21,948	3.04%	14,775	2.05%
Sheep	7,954,167	2,046,930	25.73%	1,273,110	16.01%
Goats	945,895	380,826	40.26%	129,030	13.64%
Horses	278,471	38,047	13.66%	16,695	6.00%
Mules and asses	30,254	6,040	19.97%	2,153	7.12%
Broilers	97,532,025	1,560,813	1.60%	1,269,593	1.30%
Layer hens	52,692,584	3,971,390	7.54%	2,534,710	4.81%
Other poultry	38,370,412	567,236	1.48%	555,050	1.45%
Rabbits	20,504,282	1,378,261	6.72%	477,474	2.33%

In Table 5.14, 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 CH_4 $head^{-1}$ $year^{-1}$
- sheep, 0.211 kg CH_4 $head^{-1}$ $year^{-1}$
- goats, 0.156 kg CH_4 $head^{-1}$ $year^{-1}$
- horses, 1.634 kg CH_4 $head^{-1}$ $year^{-1}$
- mules and asses, 0.839 kg CH_4 $head^{-1}$ $year^{-1}$
- layer hens, 0.030 kg CH_4 $head^{-1}$ $year^{-1}$
- broilers, 0.020 kg CH_4 $head^{-1}$ $year^{-1}$
- other poultry, 0.090 kg CH_4 $head^{-1}$ $year^{-1}$
- fur animals, 0.680 kg CH_4 $head^{-1}$ $year^{-1}$

Table 5.14 Average methane EF for manure management (*) **(kg CH^4 $head^{-1}$ $year^{-1}$)**

Year	Dairy cattle	Non-dairy cattle	Buffalo	Sows	Other swine
	(kg CH_4 $head^{-1}$ $year^{-1}$)				
1990	15.04	7.46	12.22	22.14	8.54
1995	15.04	7.81	12.00	21.96	8.52
2000	15.04	7.66	11.77	21.97	8.43
2005	15.04	7.77	12.33	22.30	8.35
2010	16.86	7.74	12.34	22.48	8.41
2011	16.86	7.69	12.32	22.54	8.46
2012	16.86	7.84	11.79	22.31	9.00
2013	16.86	7.81	11.71	22.83	9.03
2014	16.86	7.75	12.12	22.76	8.94
2015	16.86	7.75	11.86	22.78	8.94
2016	16.86	7.74	11.90	22.84	9.01

(*) These are the EFs used for estimating CH_4 emissions from manure management. CH_4 reductions are not included.

Nitrous oxide emissions from manure management

Direct and indirect N_2O emissions, produced during the storage and treatment of manure before it is applied to land, are reported separately, as indicated in the 2006 IPCC Guidelines.

Direct N_2O emissions from manure management

As suggested in the IPCC (IPCC, 2006, volume 4, chapter 10) N_2O emissions were estimated with equation 10.25. Different parameters were used for the estimation: number of livestock species, country-specific nitrogen excretion rates per livestock category, fraction of total annual nitrogen excretion for each livestock category managed in each manure management systems and EFs for manure management systems (IPCC, 2006).

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 same EF is used: 0.005 kg N_2O-N/kg N excreted (IPCC, 2006). The chicken-dung drying process system is considered since 1995, since it has become increasingly common (CRPA, 2000; CRPA, 1997[b]). N_2O emissions of the anaerobic digesters, another management system used in the country, are reported as zero in line with the 2006 IPCC Guidelines (IPCC, 2006).

When estimating emissions from manure management, the amount related to manure excreted while grazing is subtracted and reported in 'Agricultural soils' under soil emissions - urine and dung deposited by grazing animals (see Table 5.15). 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 5.15, nitrogen excretion rates used for the estimation of N_2O are shown. In 2016, the nitrogen excretion rate for swine is 12.36 kg $head^{-1}$ yr^{-1}. This last parameter is a weighted average: sow (28.43 kg $head^{-1}$ yr^{-1}) and other swine (13.59 kg $head^{-1}$ yr^{-1}).

Table 5.15 Average weight and nitrogen excretion rates in 2016

Livestock category	Average weight (kg)	N excreted housing (kg N head^{-1} yr^{-1})	N excreted grazing (kg N head^{-1} yr^{-1})	Total nitrogen excreted (kg N head^{-1} yr^{-1})
Non-dairy cattle	381.6	49.90	1.43	**51.33**
Dairy cattle	602.7	110.20	5.80	**116.00**
Buffalo	512.0	89.51	2.67	**92.18**
Other swine	89.0	13.59	-	**13.59**
Sows	172.1	28.43	-	**28.43**
Sheep	47.0	1.62	14.58	**16.20**
Goats	45.1	1.62	14.58	**16.20**
Horses	550.0	20.00	30.00	**50.00**
Mules and asses	300.0	20.00	30.00	**50.00**
Poultry	1.7	0.50	-	**0.50**
Rabbits	1.6	1.02	-	**1.02**
Fur animals	1.0	4.10	-	**4.10**

Following the results of the Nitrogen Balance Inter-regional Project, country-specific annual nitrogen excretion rates have been set. 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 rates[13] and net nitrogen arriving to the field[14] 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 5.16, 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 in Table 5.15.
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 5.3.6. As regards non-dairy cattle, buffalo and swine categories, the average values of nitrogen excretion rates are calculated on the basis of the weight of the annual number of animal subcategories and fluctuate over the years. For the 'Less than 1 year' subcategory of the non-dairy cattle category, an average value of nitrogen excreted was calculated based on the weight of the number of animals of the subcategories (calf, fattening male cattle, fattening heifer and heifer for replacement). As regards the sows' category, an average weighted nitrogen excretion rate is calculated taking in account the nitrogen excretion from piglets (swine less than 20 kg).

Table 5.16 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	116.00	50.00	94.32	13.13	28.10
1995	116.00	49.86	92.84	13.10	27.86
2000	116.00	50.08	91.20	12.96	27.87
2005	116.00	49.76	95.28	12.84	28.30
2010	116.00	49.83	95.33	12.85	28.36
2011	116.00	49.46	95.17	12.92	28.44
2012	116.00	51.62	91.41	13.74	28.13
2013	116.00	51.37	90.88	13.62	28.42
2014	116.00	50.99	93.79	13.48	28.34
2015	116.00	50.97	91.89	13.48	28.36
2016	116.00	51.33	92.18	13.59	28.43

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

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 are set on the basis of Italian breeding characteristics, taking into account the 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]). Fractions of total annual nitrogen excretion for dairy cattle category managed in solid manure and liquid/slurry systems have been updated taking into account the distribution of housing systems resulting from the 2010 Agricultural Census.

Indirect N_2O emissions from manure management

N_2O emissions result from volatile nitrogen losses occurring primarily in the forms of ammonia and NO_x and from nitrogen leaching and run-off.
N_2O emissions due to atmospheric deposition of NH_3 and NO_x have been estimated following the IPCC Tier 2 approach (Equation 10.26 and 10.27 of the 2006 IPCC Guidelines, volume 4, chapter 10). Parameters used are: total N excreted by livestock (kg $head^{-1}yr^{-1}$), the fraction of total annual nitrogen excretion for each livestock category managed in each manure management systems, $Frac_{GasMS}$ emission factor, which is the percentage of managed manure nitrogen that volatilises as NH_3 and NO_x in the manure management systems (see Table 5.17) and emission factor 0.01 kg N_2O-N per kg NH_3-N and NO_x-N emitted (IPCC, 2006). The $Frac_{GasMS}$ emission factor is equal to the ratio between the amount of NH_3-N and NO_x-N emissions at housing and storage system and the total nitrogen excreted.
NH_3 and NO_x emissions are estimated on the basis of the methodology indicated in the EMEP/EEA Guidebook for transboundary air pollutants. The estimation procedure for NH_3 and NO_x emissions of the manure management category consists in successive subtractions from the quantification of nitrogen excreted annually for each livestock category. This quantity can be divided in two different fluxes, depending on whether animals are inside (housing, storage and manure application) or outside the stable (grazing). More in detail, part of the nitrogen excreted in housing volatilizes during the settle of manure in the local farming and it is calculated with the relevant emission factor in housing for the different livestock; this amount is therefore subtracted from the total nitrogen excreted to derive the amount of nitrogen for storage. During storage another fraction of nitrogen is lost (calculated with the relevant emission factor for storage), and is therefore subtracted to obtain the amount of nitrogen available for the agronomic spreading. Losses occurring during the spreading are finally calculated with the specific emission factor for spreading. For the nitrogen excreted in the pasture, losses due to volatilization, calculated with the relevant emission factor for grazing by livestock, only occur at this stage. Ammonia and NO_x emissions coming from housing and storage by each livestock category are then summed and divided by the total nitrogen excreted for each year (CRPA, 2006[a]). Ammonia emissions related to the housing and storage by cattle, swine and laying hens categories have been updated based on the basis of ISTAT statistics such as 2010 Agricultural Census and 2013 Farm Structure Survey related to the distribution of housing and storage systems. In relation to the ammonia emissions from storage, NH_3 emissions from digesters biogas facilities (in particular due to different phases of the process: during storage of feedstock on the premises of the biogas facility, during the liquid–solid separation of the digestate, during storage of the digestate) have been estimated taking into account the amount of excreted nitrogen feeding anaerobic digesters and the Tier 1 emission factor derived by the EMEP/EEA Guidebook (EMEP/EEA, 2016). NH_3 emissions from digesters biogas facilities have been subtracted from manure management category (only for cattle and swine categories) and allocated in the anaerobic digestion at biogas facilities (5B2 of the waste sector in the NFR classification under UNECE/LRTAP Convention). The percentage of nitrogen lost through N-NH_3 emissions from anaerobic digesters was subtracted from the percentage of nitrogen left after emissions during housing and storage, reducing the amount of nitrogen used at the spreading. The amount of nitrogen used at the spreading also includes the digestate.
In the 2017 submission, in response to the UNFCCC review process, N_2O emissions due to nitrogen leaching and run-off have been estimated.

For estimating of N_2O emissions due to nitrogen leaching and run-off the IPCC Tier 2 approach was followed (Equation 10.28 of the 2006 IPCC Guidelines, volume 4, chapter 10). Parameters used are: total N

excreted by livestock (kg head^{-1}yr^{-1}), the fraction of total annual nitrogen excretion for each livestock category managed in each manure management systems, $Frac_{leachMS}$ emission factor, which is the percent of managed manure nitrogen losses due to leaching and runoff during solid and liquid storage of manure (see Table 5.17) and emission factor 0.0075 kg N_2O-N per kg N leaching/runoff (IPCC, 2006).
The national legislation (as well as the regional ones) requires that the storage of liquid manure is in containers with waterproof bottom. The solid storage should have the concrete or similar materials on the bottom and the leachate collection system. Near the field, the manure heaps are allowed for limited time aimed at spreading (CRPA, 2016[b]). On the basis of this information, $Frac_{leachMS}$ emission factor is assumed equal to 1% (the lower bound of the typical range, reported in 2006 IPCC Guidelines).

Table 5.17 Parameters used for the estimation of N_2O indirect emissions

Year	N excreted (t N)	$Frac_{GasMS}$ (%)	N volatilised as NH_3 and NO_x (t N)	N excreted housing minus N volatilised (t N)	$Frac_{LeachMS}$ (%)	N leached from manure management (t N)
1990	959,115	23.18	222,368	558,569	1.0	5,586
1995	939,010	21.92	205,832	528,414	1.0	5,284
2000	936,263	21.19	198,361	527,803	1.0	5,278
2005	842,736	21.85	184,174	502,794	1.0	5,028
2010	837,562	21.88	183,279	495,775	1.0	4,958
2011	840,434	21.50	180,726	500,747	1.0	5,007
2012	827,558	21.55	178,356	502,875	1.0	5,029
2013	833,685	21.02	175,245	508,222	1.0	5,082
2014	822,670	20.94	172,252	501,289	1.0	5,013
2015	824,467	20.97	172,873	502,488	1.0	5,025
2016	839,653	20.94	175,834	511,287	1.0	5,113

5.3.3 Uncertainty and time-series consistency

Uncertainty of CH_4 and N_2O emissions from manure management has been estimated equal to 20.6%, as a combination of 5% and 20% for activity data and emission factors, respectively. Uncertainty of indirect N_2O emissions from manure management has been estimated equal to 50.2%, as a combination of 5% and 50% 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 CH_4 and N_2O 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 2016, CH_4 emissions from manure management were 21.1% (124.23 Gg CH_4) lower than in 1990 (157.38 Gg CH_4). From 1990 to 2016, dairy and non-dairy cattle livestock population decreased by 31.0% and 19.6%, respectively, while swine increased by 2.2% (in particular, sows decrease by 14.3% and other swine increase by 3.9%).
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 CH_4 emissions contribute with 43.5% (in 1990 with 49.5%) to total CH_4 manure management emissions and swine with 44.0% (43.3% in 1990).

In Table 5.18, CH_4 emission trends from manure management are shown. These emissions considered the reduction of CH_4 because of biogas recovery.

Table 5.18 Trend in CH_4 emissions from manure management (Gg)

Year	Dairy cattle	Non-dairy cattle	Buffalo	Sows	Other swine	Sheep	Goats	Horses	Mules and asses	Poultry	Rabbits	Fur animals	Total
1990	39.74	38.13	1.15	14.41	53.78	1.90	0.20	0.47	0.07	6.10	1.19	0.22	**157.38**
1995	31.14	40.35	1.78	15.04	50.20	2.32	0.22	0.52	0.03	6.84	1.37	0.15	**149.96**
2000	30.97	38.09	2.26	15.48	51.35	2.38	0.22	0.46	0.03	6.48	1.43	0.16	**149.31**
2005	27.13	33.55	2.53	15.56	54.61	1.69	0.15	0.46	0.02	6.98	1.64	0.14	**144.47**
2010	28.48	30.59	4.51	15.15	54.35	1.66	0.15	0.61	0.04	7.07	1.44	0.09	**144.13**
2011	27.60	29.74	4.37	14.07	51.47	1.67	0.15	0.61	0.04	7.08	1.40	0.11	**138.32**
2012	29.13	28.35	4.11	12.14	52.37	1.48	0.14	0.65	0.05	7.01	1.40	0.11	**136.94**
2013	27.46	27.26	4.72	10.46	45.94	1.51	0.15	0.64	0.05	6.81	1.32	0.12	**126.45**
2014	26.50	26.16	4.48	9.96	44.91	1.51	0.15	0.64	0.06	6.74	1.31	0.12	**122.53**
2015	26.62	26.54	4.44	10.06	45.57	1.51	0.15	0.63	0.06	6.84	1.27	0.12	**123.81**
2016	26.56	27.54	4.58	9.67	45.01	1.54	0.16	0.63	0.06	7.14	1.22	0.11	**124.23**

In Table 5.19, N_2O emissions from liquid systems, solid storage and 'other' sources are shown.

Table 5.19 Trend in N_2O emissions from manure management (Gg)

Year	Direct emissions			Indirect emissions	Total
	Liquid system	Solid storage	Other		
			(Gg)		
1990	2.98	3.16	0.00	3.56	**9.70**
1995	2.72	2.99	0.02	3.30	**9.03**
2000	2.58	2.96	0.14	3.18	**8.86**
2005	2.34	2.66	0.24	2.95	**8.20**
2010	2.42	2.38	0.26	2.94	**8.00**
2011	2.26	2.29	0.27	2.90	**7.72**
2012	2.25	2.32	0.21	2.86	**7.65**
2013	1.98	2.18	0.19	2.81	**7.16**
2014	1.87	2.09	0.18	2.77	**6.92**
2015	1.91	2.12	0.19	2.78	**6.99**
2016	1.93	2.17	0.20	2.82	**7.12**

In 2016, N_2O emissions from manure management were 26.6% (7.12 Gg N_2O) lower than in 1990 (9.70 Gg N_2O). The major contribution of direct emissions is given by the 'solid storage system' with 50.6% (in 1990 with 51.5%). In 2016, indirect N_2O emissions from manure management account for 39.6% of total N_2O emissions from manure management and were 20.7% (2.82 Gg N_2O) lower than in 1990 (3.56 Gg N_2O).

5.3.4 Source-specific QA/QC and verification

A survey on the digesters was conducted by the CRPA in 2016. The outcomes of the survey, which should be available in the course of 2018, will be used to verify the accuracy of the estimates.

MCFs have been assessed on the basis of the data of the FSS 2007 (ISTAT, 2008[a]) and the 2010 Agriculture Census (ISTAT, 2012) to verify the average methane conversion factors used in the estimation process, resulting in very slight differences. Further verification has been carried out to evaluate the animal distribution used in the estimation process; the 2010 Agriculture Census (ISTAT, 2012) has been used to infer the percentages of animals in temperate zone, resulting in slight differences, except for other swine, other equines and hens categories (decrease of 30%, 30% and an increase by 27%, respectively); an higher deviation is resulting for the other poultry and broilers categories.
For verification purposes, the $Frac_{GasMS}$ parameter have been also estimated as a fraction of nitrogen recovered and stored that is emitted as $N\_NH_3\text{-}NO_x$. This value is equal to 0.285, for 1990, and to 0.256 in 2016.

5.3.5 Source-specific recalculations

CH_4 emissions have been recalculated because of the update of the methane emission factors from storage of the dairy cattle and swine categories. On the basis of the 2010 General Agricultural Census data on housing distribution for dairy cattle category, the production of manure both liquid/slurry and solid has been updated, involving a change in the methane emission factors. Based on the 2010 General Agricultural Census and the 2013 Farm Structure Survey data on the manure storage systems, the emission factors of CH_4 for swine category have been updated. The number of sows has been update for the year 2015.
N_2O emissions have been recalculated because of the update of NH_3 and NO_x emissions from housing and storage that involves the update of $Frac_{GasMS,}$ leading to a reduction in indirect N_2O emissions from manure management. On the basis of the results of the 2010 General Agricultural Census and 2013 Farm Structure Survey data on the manure management systems, the emission factors of NH_3 from housing (dairy cattle and laying hens from 2006) and storage (cattle, swine and laying hens from 2006) have been updated. NO_x emissions from storage have been updated according to the Tier 2 methodology reported in the last version of the EMEP/EEA Guidebook (EMEP/EEA, 2016). NH_3 emissions from digesters biogas facilities have been estimated and subtracted from manure management category (cattle and swine) and allocated in the anaerobic digestion at biogas facilities (5B2 of the waste sector in the NFR classification under UNECE/LRTAP Convention).
Based on the update of housing systems of dairy cattle, the distribution of nitrogen excreted between liquid/slurry and solid were also updated and this leads to an increase in N_2O direct emissions from manure management as the amount of nitrogen stored in digesters decreases according to the methodology described in the Annex 7.2.

5.3.6 Source-specific planned improvements

In Table 5.20, future improvements in agreement with the QA/QC plan are presented.

Table 5.20 Improvements for manure management category according to the QA/QC plan

Category/sub category	Parameter	Year of submission 2018	Year of submission 2019	Activities
Dairy cattle	N excretion		√	Further efforts on theoretical assessment of N excretion data will be done based on N balance methodology (Gruber and Poesch, 2006).
Livestock categories	Average temperature		√	The average annual temperatures used in the assessment of the manure management CH_4 emission factors will be verified on the basis of the available information (i.e. updated data from SCIA[15]).

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. Two possible reasons explain the absence of correlation: a) an 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). 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-

[15] SCIA is the national system for the collection, elaboration and dissemination of climatological data, by ISPRA, in the framework of the national environmental information system, in collaboration with the relevant institutions: http://www.scia.isprambiente.it/scia_eng.asp

environmental indicator group coordinated by the Ministry of Agriculture is working to determine gross nitrogen balances; the revision of N coefficients will be considered accordingly.
Improvements will be related to the availability of new information, on emission factors, activity data as well as parameters necessary to carry out the estimates; specifically, a study on the best available technologies used in agriculture practices to reduce emissions are under investigation.

Parameters used for this submission are shown in Table 5.21.

Table 5.21 Parameters used for the different livestock categories (2016)

Livestock category			Average weight (kg)	N excretion (kg N head^{-1} yr^{-1})
DAIRY CATTLE			602.7	116.0
NON- DAIRY CATTLE			381.6 (**)	51.33 (**)
Less than 1 year (*)			205.9 (**)	24.27 (**)
From 1 year - less than 2 years				
	Male	for reproduction	557.0	66.8
		for slaughter	557.0	66.8
	Female	for breeding	405.0	67.6
		for slaughter	444.0	53.3
From 2 years and more				
	Male	for reproduction	700.0	84.0
		for slaughter and work	700.0	84.0
	Female	Breeding heifer	540.0	90.2
		Slaughter heifer	540.0	64.8
		Other dairy cattle (***)	557.0	54.1
BUFFALO			512.0 (**)	92.18 (**)
	Cow buffalo		630.0	116.0
	Other buffaloes		319.5	53.4
OTHER SWINE			89.0 (**)	13.59 (**)
Weight less than 20 kg			10.0	
From 20 kg weight and under 50 kg			35.0	5.3
From 50 kg and more				
		Boar	200.0	30.5
		For slaughter		
		from 50 to 80 kg	65.0	9.9
		from 80 to 110 kg	95.0	14.5
		from 110 kg and more	135.0	20.6
SOWS			172.1	28.43 (**)
SHEEP	Sheep		51.1	16.2
	Other sheep		20.8	16.2
GOATS	Goats		53.8	16.2
	Other goats		14.9	16.2
EQUINE	Horses		550.0	50.0
	Mules and asses		300.0	50.0
POULTRY	Broilers		1.2	0.36
	Layer hens		1.8	0.66
	Other poultry		3.3	0.83
RABBITS	Female rabbits		4.0	2.5
	Other rabbits		1.3	0.8
FUR ANIMALS			1.0	4.1

(*) 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.
(***) Suckler cows and cows in late career.

5.4 Rice cultivation (3C)

5.4.1 Source category description

For the rice cultivation category, only CH_4 emissions are estimated, other GHGs do not occur; N_2O from fertilisation during cultivation was estimated and reported in "Agricultural soils" under direct soil emissions - synthetic fertilizers. Methane emissions from rice cultivation have been identified as a key source at level assessment with Approach 1. In 2016, CH_4 emissions from rice cultivation were 68.4 Gg, which represent 9.1% of CH_4 emissions for the agriculture sector (8.8% in 1990) and 4.0% for national CH_4 emissions (3.9% in 1990).
In Italy, CH_4 emissions from rice cultivation are estimated only for an irrigated regime, other categories suggested by IPCC (rainfed, deep water and "other") are not present. Methane emissions, reported in the CRF tables, represent two water regimes: single aeration (26.4 Gg) and multiple aeration (42.0 Gg).
In response to 2004 and 2005 UNFCCC review processes (UNFCCC, 2005; UNFCCC, 2004) and in consultation with an expert in CH_4 emissions and rice cultivation (Wassmann, 2005), a detailed methodology was developed. 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 contacted[16].
In 2015 submission, the cultivation period (days) for some rice varieties and the daily emission factor for continuously flooded fields without organic amendments for multiple aeration regime have been updated.

5.4.2 Methodological issues

For the estimation of CH_4 emissions from rice cultivation a detailed methodology was implemented following the IPCC guidelines (IPCC, 2006, volume 4, chapter 5). Country-specific circumstances have been considered. Parameters such as an adjusted integrated emission factor (kg CH_4 $m^{-2}day^{-1}$), cultivation period of rice (days) and annual harvested area (ha) cultivated under specific conditions are considered. Information of the cultivated surface is collected 100% from rice farmers. Every year, timely data collection is ensured by the National Rice Institute (ENR, several years [b]). Activity data information is shown in the following box.

Parameters used for the calculation of CH_4 emissions from rice cultivation

Parameters	Reference
Cultivated surface with "dry-seeded" technique (%)	ENR, several years [a]
Cultivated surface – national (ha)	ISTAT, several years [a],[b],[j]; ENR, several years [b]
Cultivated surface by rice varieties (ha)	ENR, several years [b]
Cultivation period of rice varieties (days)	ENR, 2011; ENR, 2014 [a],[b]; ENSE, 1999; ENSE, 2004; ENR, 2013
Methane emission factor (kg CH_4 m^{-2} d^{-1})	Leip *et al*., 2002; Schutz *et al*., 1989[a], [b]; Meijide *et al*., 2011
Crop production (t yr^{-1})	ISTAT, several years [a],[b],[j]
Yield (t ha^{-1})	Estimations based on cultivated surface and crop production data
Straw incorporation (%)	Expert judgement (Tinarelli, 2005; Lupotto *et al*., 2005)
Agronomic practices (%)	ISTAT, 2006[b]; Tinarelli, 2005; Lupotto *et al*., 2005; Zavattaro et. al, 2004; Baldoni & Giardini, 1989; Tinarelli, 1973; 1986
Scaling factors (SFw, SFp, SFo)	IPCC, 2006; Yan *et al.*, 2005

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 5.22, water regimes descriptions for the most common agronomic practices in Italy are presented. Water regime trends have been estimated in collaboration with expert judgement expertise (Tinarelli, 2005; Lupotto *et al*., 2005) and available statistics (ENR, several years [b]).

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

(*) the first fertilization (2/3) during the initial part of the rice cultivation, generally on July there is a second period for the fertilization (1/3), normally there is no aeration during the second fertilization period. Aeration periods have mostly have 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, the 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 is 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 CH_4 daily EF (kg CH_4 m^{-2} d^{-1}) was done. Different scientific publications related to the CH_4 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 CH_4 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 CH_4 emissions 24-31% lower than fields planted with cultivar Roma. Marik *et al*. have published detailed information on agronomic practices (fertilized fields) related to measurements of CH_4 emission factor for years 1998 and 1999; values are similar to those presented in previous publications (Schutz et al., 1989[a], [b]; Holzapfel-Pschorn & Seiler, 1986). Leip *et al*. have published specific CH_4 EF for the so called dry-seeded with delay flooding, as shown in Table 5.23. 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 CH_4 emissions for the rice cultivation category considers an irrigated regime, which includes intermittently flooded with single aeration and multiple aeration regimes. The CH_4 emission factor is adjusted with the following parameters: a daily integrated emission factor for continuously flooded fields without organic fertilizers, a scaling factor to account for the differences in water regime in the rice growing season (*SFw*), a scaling factor to account for the differences in water regime in the preseason status (*SFp*) and a scaling factor which varies for both types and amount of amendment applied (*SFo*). Scaling factor parameters have been updated according to literature (Yan *et al*., 2005) and the IPCC 2006 Guidelines (IPCC, 2006, volume 4, chapter 5).

In 2014, the cultivation period (days) for some rice varieties (ENR, 2014 [a],[b]; ENSE, 1999; ENSE, 2004; ENR, 2013) has been updated. Despite the upload of the vegetation period of some varieties, the estimate of the average value for water regime does not change the previous values.

The Joint Research Centre Institute for Environment and Sustainability - Climate Change Unit, in charge of measuring rice paddy fields in Italy, has been contacted to obtain data related to measurements carried out in the latest years. On the basis of the documentation received, the daily emission factor for continuously flooded fields without organic amendments for multiple aeration regime from 2009 (Meijide et al., 2011) has been updated. The emission factor is based on experimental measurements carried out in 2009 in an area in the Po Valley, in Northern Italy, where rice cultivation is most widespread. The value is slightly lower than the previous one.

Assumptions of agronomic practices and parameters used for CH_4 emission estimations are shown in Table 5.22 and Table 5.23, respectively.

Total CH_4 emissions for rice cultivation in 2016 were 68.40 Gg.

Table 5.23 Parameters used for estimating CH_4 emissions from rice cultivation in 2016

Rice cultivation water regimes: Intermittently flooded	**Single aeration**	**Multiple aeration**	**Multiple aeration**
Type of seeding	Dry-seeded	Wet-seeded (*classic*)	Wet-seeded (*red rice control*)
Surface (ha)	106,250	57,548	70,337
Daily EF (g CH_4 m^{-2} d^{-1})	0.20	0.27	0.27
SF_w	0.60	0.52	0.52
SF_p	0.68	0.68	0.68
SF_o	2.2	2.2	2.2
Adjusted daily EF (g CH_4 m^{-2} d^{-1})	0.18	0.21	0.21
Days of cultivation (days)	139	157	157
Seasonal EF (g CH_4 m^{-2} yr^{-1})	24.89	32.80	32.80
Methane emissions (Gg)	**26.45**	**18.88**	**23.07**

5.4.3 Uncertainty and time-series consistency

Uncertainty of emissions from rice cultivation has been estimated equal to 11.2% as a combination of 5% and 10% for activity data and emissions factor, respectively.
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 2016, CH_4 emissions from rice cultivation were 8.9% (68.40 Gg CH_4) lower than in 1990 (75.06 Gg CH_4). In Italy, the driving force of CH_4 emissions from rice cultivation is the harvest area and the percentage of single aerated surface (lower CH_4 emission factor). From 1990-2016, the harvest area has increased by 8.7%, from 215,442 ha $year^{-1}$ (1990) to 234,134 ha $year^{-1}$ (2016). The percentage of single aerated surface has increased from 1.0% (1990) to 45.4% (2016). In Table 5.24, CH_4 emissions from rice cultivation and harvested area are shown.

Table 5.24 Harvest area and CH_4 emissions from the rice cultivation sector

Year	Harvested area ($10^9 m^2\ yr^{-1}$)	CH_4 emissions (Gg)
1990	2.15	75.06
1995	2.39	79.56
2000	2.20	66.26
2005	2.24	70.09
2010	2.48	72.89
2011	2.47	72.22
2012	2.35	71.57
2013	2.16	66.45
2014	2.20	64.54
2015	2.27	66.73
2016	2.34	68.40

5.4.4 Source-specific QA/QC and verification

Systematic quality control activities have been carried out in order to ensure completeness and consistency in time series and correctness in the sum of sub-categories. 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. The quality of the Italian rice emission inventory was verified with the Denitrification Decomposition model (DNDC). 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).
In particular, the applied methodology has been presented and discussed during several national workshop and expert meeting, collecting findings and comments to be incorporated in the estimation process. All the agriculture categories have been embedded in the overall QA/QC-system of the Italian GHG inventory. In November 2014, the CH_4 emission factors used for the rice cultivation category in the Italian emissions inventory were presented at the 9th Expert Meeting on Data for the IPCC Emission Factor Database (EFDB) and the values were entered into the database.

5.4.5 Source-specific recalculations

CH_4 emissions have been recalculated because of the update of the rice production in 2015.

5.4.6 Source-specific planned improvements

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 2016 they represented 93% (ENR, several years [b]; Confalonieri and Bocchi, 2005).

5.5 Agriculture soils (3D)

5.5.1 Source category description

In 2016, N_2O emissions from managed soils were 29.72 Gg, representing 80.6% of N_2O emissions for the agriculture sector (78.2% in 1990) and 49.3% for national N_2O emissions (39.3% in 1990). N_2O emissions from this source consist of direct emissions from managed soils (23.99 Gg) and indirect emissions from managed soils (5.73 Gg).
Direct and indirect N_2O emissions from managed soils are key sources at level assessment, both with Approach 1 and Approach 2. Direct N_2O emissions from managed soils are key sources at trend assessment, both with Approach 1 and Approach 2 including the LULUCF sector while excluding the LULUCF sector in the analysis direct N_2O emissions from managed soils are key sources at trend assessment with Approach 2.
For direct emissions from managed soils the following sources are estimated: inorganic nitrogen fertilizers; organic nitrogen fertilizers, which include animal manure applied to soils, sewage sludge applied to soils, other organic fertilizers applied to soils (as compost and other organic amendments used as fertiliser); urine and dung deposited by grazing animals; crop residues; cultivation of organic soils (i.e. histosols). Mineralised nitrogen resulting from loss of soil organic C stocks in mineral soils through land-use change or management practices (F_{SOM}) has been assumed as not occurring; agricultural practices have been assessed to be not subject to changes, resulting in no losses nor gains of carbon.
For indirect emissions from managed soils, 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 "Urine and dung deposited by grazing animals" (see Table 5.25).
CH_4 emissions from managed soils have not been estimated as in the IPCC Guidelines the methodology is not available.

Table 5.25 N_2O emissions from managed soils (Gg)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Direct N_2O emissions from managed soils	**27.95**	**28.94**	**28.78**	**27.17**	**22.60**	**23.94**	**25.18**	**23.38**	**23.05**	**22.90**	**23.99**
Inorganic N fertilizers	11.90	12.53	12.35	12.25	7.80	8.11	10.74	8.59	7.94	8.14	8.91
Organic N fertilizers	9.34	8.91	9.03	8.59	8.74	9.77	9.00	9.13	9.27	9.05	9.18
a. Animal manure applied to soils	*9.02*	*8.52*	*8.50*	*8.06*	*7.90*	*7.97*	*8.00*	*8.06*	*7.94*	*7.96*	*8.11*
b. Sewage sludge applied to soils	*0.08*	*0.13*	*0.17*	*0.14*	*0.16*	*0.17*	*0.20*	*0.13*	*0.13*	*0.14*	*0.14*
c. Other organic fertilizers applied to soils	*0.24*	*0.26*	*0.35*	*0.39*	*0.68*	*1.62*	*0.80*	*0.94*	*1.20*	*0.95*	*0.94*
Urine and dung deposited by grazing animals	3.13	3.51	3.60	2.71	2.75	2.76	2.57	2.64	2.61	2.61	2.67
Crop residues	3.25	3.67	3.48	3.30	2.99	2.98	2.54	2.70	2.92	2.77	2.91
Cultivation of organic soils	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Indirect N_2O emissions from managed soils	**6.93**	**7.01**	**6.91**	**6.47**	**5.43**	**5.69**	**6.09**	**5.56**	**5.42**	**5.41**	**5.73**
Atmospheric deposition	2.70	2.61	2.55	2.35	2.01	2.07	2.28	2.03	1.94	1.95	2.10
Nitrogen leaching and run-off	4.23	4.39	4.36	4.12	3.41	3.62	3.81	3.53	3.48	3.46	3.63

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 ensured. The nitrogen balance, from the CLRTAP emission inventory, feeds the UNFCCC inventory, specifically for the estimation of: $Frac_{GasMS}$ parameter, used for calculating managed manure nitrogen available for application to managed soils (Equation 10.34 of 2006 IPCC Guidelines, volume 4, chapter 10) and to assess F_{AM}; $Frac_{GASM}$ and $Frac_{GASF}$ parameters, used for calculating indirect N_2O emissions from atmospheric deposition of

nitrogen volatilised from managed soils (Equation 11.9 of 2006 IPCC Guidelines). Direct and indirect N_2O emissions from the use of sewage sludge in agricultural soils have been estimated and reported.

5.5.2 Methodological issues

Methodologies used for estimating N_2O emissions from "Agricultural soils" follow the IPCC approach (Tier1). Emission factors suggested by the IPCC (IPCC, 2006, volume 4, chapter 11) 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, several years [a], [b], [i]
Nitrogen content (%)	ISTAT, several years [a], [b], [i]
N excretion rates (kg head^{-1} yr^{-1})	CRPA, 2006[a]; GU, 2006; Xiccato *et al*., 2005
Cultivated surface (ha yr^{-1})	ISTAT, several years [a], [b], [j]
Annual crop production (t yr^{-1})	ISTAT, several years [a], [b], [j]
Residue/crop product ratio by crop type	CESTAAT, 1988
Crop residue production (t dry matter ha^{-1}yr^{-1})	CRPA/CNR, 1992
Dry matter content by crop type	CRPA/CNR, 1992
Protein content in dry matter by crop type	CESTAAT, 1988
Livestock data	ISTAT, several years [a], [b], [g]

The estimation of direct N_2O emissions from managed soils has been carried out in line with the IPCC guidelines (IPCC, 2006), taking into account country-specific peculiarities; N_2O-N emissions are estimated from the amount of: inorganic nitrogen fertilizers (F_{SN}); organic nitrogen fertilizers (F_{ON}), which include animal manure applied to soils (F_{AM}), sewage sludge applied to soils (F_{SEW}), other organic fertilizers applied to soils (as compost and other organic amendments used as fertiliser, F_{COMP} and F_{OOA} respectively); urine and dung deposited by grazing animals (F_{PRP}); crop residues (F_{CR}); cultivation of histosols (F_{OS}). Then default IPCC emission factors (IPCC, 2006, volume 4, chapter 11) are applied. Afterwards, N_2O-N emissions are converted to N_2O emissions, multiplying by the ratio of molecular weights (44/28). Urine and dung deposited by grazing animals emissions are estimated according to the methodology described in section 5.3.2 for manure management.
Direct N_2O emissions from N inputs to managed soils include also emissions related to the application of fertilizers to the short rotation forest crops, according the 2006 IPCC Guidelines (IPCC, 2006, par. 11.2.1.3, vol. 4, chapter 11) and coherently with the KP Supplement (IPCC, 2014, par. 2.4.4.2).
Indirect emissions are estimated as suggested by the IPCC (IPCC, 2006).

Direct N_2O emissions from managed soils

Applied synthetic fertilizers (F_{SN})
The total use of synthetic fertilizers (expressed in t N year^{-1}) is estimated for each type of fertilizer (see Table 5.26). Data on synthetic fertilizers are from ISTAT as reported in paragraph 5.1.3, 5.1.4 and 5.5.2. N-N_2O emissions from synthetic fertilizers are obtained multiplying F_{SN} by the emission factor, 0.01 kg N-N_2O/kg N (IPCC, 2006). 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 5.33. In 2016, the total use of synthetic fertilizers was 567,211 t N (see Table 5.26).

Table 5.26 Total use of synthetic fertilizer in 2016 (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	97,023	18.6%	18,064
Calcium cyanamide	14,256	19.7%	2,803
Nitrates (*)	310,685	25.7%	79,753
Urea	718,843	44.7%	321,594

Type of fertilizers	Fertilizers distributed (t yr^{-1})	Nitrogen content (%)	Nitrogen content of synthetic fertilizers (t N yr^{-1})
Other nitric nitrogen	90,960	31.0%	1,513
Other ammoniacal nitrogen	-	-	8,423
Other amidic nitrogen	-	-	18,246
Phosphate nitrogen	242,891	13.7%	33,240
Potassium nitrogen	71,996	18.6%	13,361
NPK nitrogen	397,241	12.5%	49,829
Organic mineral	197,195	10.3%	20,385
Total	**2,141,090**		**567,211**

(*) includes ammonium nitrate < 27% and ammonium nitrate > 27% and calcium nitrate

The time series of applied synthetic fertilisers is shown in Table 5.27. A strong decrease is observed in the year from 2009 to 2011 as result from the official statistics provided by the National Institute of Statistics (ISTAT), due to the economic crisis in particular for the amount of urea applied to soils. In 2012, a recovery from the sharp decline was recorded.

Table 5.27 Trend of annual amount of synthetic fertiliser N applied to soils (t N yr^{-1})

Year	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
F_{SN} (t N)	757,509	797,500	785,593	779,846	496,637	515,966	683,566	546,542	505,126	517,854	567,211

Applied organic N fertilisers (F_{ON})

The amount of organic N inputs applied to soils other than by grazing animals is calculated using Equation 11.3 of the 2006 IPCC Guidelines. This includes applied animal manure (F_{AM}), sewage sludge applied to soil (F_{SEW}) and other organic amendments (F_{OOA}), which also includes compost applied to soils (F_{COMP}).

Table 5.28 Trend of applied organic N fertilisers (t N yr^{-1})

Year	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
F_{AM} (t N)	574,243	541,883	541,019	513,217	502,916	507,082	509,095	512,932	505,366	506,770	515,830
F_{SEW} (t N)	5,071	8,137	10,954	8,874	10,040	11,119	12,864	8,142	8,046	8,611	8,817
F_{OOA} (t N)	15,193	16,791	22,571	24,505	43,342	103,400	50,934	59,886	76,218	60,763	59,607

Animal manure N applied to soil (F_{AM})

The annual amount of animal manure N applied to soils is calculated using Equation 11.4 of the 2006 IPCC Guidelines (IPCC 2006, vol. 4, chapter 11). The amount of managed manure nitrogen available for soil application is calculated using Equation 10.34 (IPCC 2006, vol. 4, chapter 10). The amount of managed manure nitrogen in manure management systems is estimated as reported in paragraph 5.3.2 "Direct N_2O emissions from manure management" and country-specific nitrogen excretion rates (CRPA, 2006[a]; GU, 2006; Xiccato *et al*., 2005) are used. $Frac_{LossMS}$ parameter of the Equation 10.34 is equal to the managed manure nitrogen that volatilises as NH_3 and NO_x in the manure management systems (i.e. the $Frac_{GasMS}$ emission factor) and the nitrogen losses from leaching and run-off at housing and storage sistems. A description of the country-specific $Frac_{GasMS}$ parameter and the nitrogen leaching and run-off is reported in paragraph 5.3.2 "Indirect N_2O emissions from manure management". The amount of nitrogen from bedding materials is considered and default IPCC values are used (IPCC 2006, vol. 4, chapter 10). The values are only applied for solid storage manure management (as reported in the 2006 IPCC Guidelines). $Frac_{FEED}$, $Frac_{FUEL}$ and $Frac_{CNST}$ parameters of the Equation 11.4 are assumed equal to zero.

The F_{AM} (t N yr^{-1}) value is estimated by summing the F_{AM} for each livestock category; then emissions are calculated with emission factor 0.01 kg N-N_2O/kg N (IPCC, 2006). In 2016, F_{AM} parameter was 515,830 t N.

Sewage sludge applied to soils (F_{SEW})

Direct and indirect N_2O emissions from the application of sewage sludge to agricultural soils were calculated using the Tier 1 methodology described in the IPCC (IPCC, 2006). 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, 2014). 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 0.01 kg N-N_2O/kg N (IPCC, 2006).

Other organic amendments applied to soils (F_{OOA}) (*including compost N applied to soils* (F_{COMP}))
As regards the other organic fertilisers applied to soil category, the use of other organic N fertilisers, including compost and organic amendments, and N content are provided by ISTAT (as reported in the paragraph 5.1.3, 5.1.4 and 5.5.2). Data are available from 1998; for the previous years, data were reconstructed based on the trend of the available data. A peak of the amount of compost applied to soil is observed for 2011. A verification was requested to ISTAT which confirmed the value.

Urine and dung from grazing animals (F_{PRP})
The annual amount of N deposited on pasture is calculated using Equation 11.5 (IPCC 2006, vol. 4, chapter 11). As mentioned in section 5.3.2, when estimating N_2O emissions from manure management, the amount related to manure excreted while grazing is subtracted and reported in "Agricultural soils" under urine and dung from grazing animals. In Table 5.14, nitrogen excretion rates (kg head^{-1} yr^{-1}) used for estimations are shown. N_2O emissions are estimated with the total nitrogen excreted from grazing (include all livestock categories), number of animals, an EF for cattle (dairy, non-dairy and buffalo) of 0.02 kg N_2O-N/kg N excreted and an EF for sheep and other animals (goats, horses and mules and asses) of 0.01 kg N_2O-N/kg N excreted (IPCC, 2006).

Table 5.29 Trend of annual amount of urine and dung N deposited by grazing animals on pasture (t N yr^{-1})

Year	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
F_{PRP} (t N)	178,178	204,765	210,099	155,768	158,508	158,960	146,327	150,218	149,129	149,107	152,532

Crop residue N, including N-fixing crops and forage, returned to soils (F_{CR})
For the estimation of nitrogen input from crop residues, 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, percentage of the residue fixed 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 (CESTAAT, 1988; CRPA/CNR, 1992; ENEA, 1994). Data on annual crop production and cultivated surface are from ISTAT as reported in paragraph 5.1.3, 5.1.4 and 5.5.2.
The nitrogen content of crop residues from cereals, legumes, tubers and roots, legumes forages and other forages (t N yr^{-1}) is 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 (IPCC, 1997; CRPA, 1997[b])), and the nitrogen content for each crop type. The nitrogen content is obtained converting protein content in dry matter (CESTAAT, 1988; Borgioli, 1981), dividing by factor 6.25 (100 g of protein/16 g of nitrogen). The contribution of the below-ground nitrogen to the total input of nitrogen from crop residues has been considered, in line with the 2006 IPCC Guidelines, by using the the IPCC default values of ratio of belowground residues to above-ground biomass and N content of below-ground residues. The amount of nitrogen of crop residues from perennial grasses is calculated by using the Equation 11.6 (IPCC 2006, vol. 4, chapter 11). The values used for other forages are the same used for the cultivation alfalfa.
The F_{CR} parameter is obtained by adding the nitrogen content of cultivars crop residues. In 2016, F_{CR} parameter was 185,076 t N (see Table 5.30). Emissions are calculated with emission factor 0.01 kg N-N_2O/kg N (IPCC, 2006).
Following the 2013 review's finding, detailed information related to the cultivated surfaces, crops production, residues production and parameters used for emissions estimates, for each type of crop, are shown in the Annex 7 (Tables A.7.4-9).

Table 5.30 Trend of annual amount of N in crop residues (t N yr^{-1})

Year	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
F_{CR} (t N)	207,122	233,831	221,621	209,831	189,991	189,820	161,745	172,108	185,518	176,417	185,076

Area of drained/managed organic soils (F_{OS})
In Italy, the area of organic soils cultivated annually (histosols) is estimated to be 25,480 hectares for the whole time series (FAOSTAT database[17]). This value is multiplied by 8 kg N-N_2O ha^{-1} yr^{-1}, as suggested by IPCC (IPCC, 2006).
The data are consistent with figures used for estimation in the LULUCF sector. Additional information may be found in paragraph *6.3.4 Methodological issues* of the LULUCF sector.

Indirect N_2O emissions from managed soils
For indirect emissions from agricultural soils the following parameters are estimated:

- Atmospheric deposition
- Nitrogen leaching and run-off

For estimating of N_2O emissions due to atmospheric deposition of NH_3 and NO_x the IPCC tier 1 approach was followed (Equation 11.9 of the 2006 IPCC Guidelines). Parameters used are: total use of synthetic fertilizer F_{SN} (t N yr^{-1}), $Frac_{GASF}$ emission factor, total amount of organic N inputs applied to soils F_{ON} (t N yr^{-1}), total amount of urine and dung N deposited by grazing animals F_{PRP} (t N yr^{-1}), $Frac_{GASM}$ emission factor and the emission factor 0.01 kg N_2O-N per kg NH_3-N and NO_x-N emitted (IPCC, 2006).
$Frac_{GASF}$ parameter is estimated for the whole time series, following the IPCC definition, where the total N-NH_3 and N-NO_x emissions from fertilizers are divided by the total nitrogen content of fertilizers (see table 5.31). NH_3 EFs from the use of synthetic fertilizers for temperate climate and normal pH factors (reported in the EMEP/EEA Guidebook (EMEP/EEA, 2016)) according to the IPCC climate zones classification and the definition available in the 2002 EMEP/CORINAIR Guidebook for which Italy is defined with large areas of acidic soils (soil pH below 7.0) and with some calcareous soils (or managed with soil pH above 7.0), have been updated. NO_x emission factor for synthetic N-fertilizer (reported in the EMEP/EEA Guidebook (EMEP/EEA, 2016)) was also updated. $Frac_{GASM}$ is the fraction of applied organic N fertiliser materials (F_{ON}) and of urine and dung N deposited by grazing animals (F_{PRP}) that volatilises as NH_3 and NO_x.
$Frac_{GASM}$ is then composed of the following fractions:

- Fraction of livestock N excretion that volatilizes as NH_3 and NO_x during spreading and grazing animals - $Frac_{GASM}$ indirect. This fraction is equal to the ratio between the amount of NH_3-N and NO_x-N emissions and the total nitrogen excreted (see table 5.31);
- Fraction of N from other organic N fertilizers applied (sewage sludge, other organic amendments applied to soils including compost) that volatilizes as NH_3 and NO_x. The volatilization factor for N-NH_3 and NO_x-N emissions is 7.8% for other organic N fertilizers and 11.9% for sewage sludge applied, as reported in table 5.31.

As regards $Frac_{GASM}$ indirect, on the basis of ISTAT statistics on spreading systems such as 2010 Agricultural Census and 2013 Farm Structure Survey, an update of ammonia emission factors from land spreading for cattle, swine, laying hens and broilers categories have been assessed. NO_x emission factors (during spreading) were also updated on the basis of the nitrogen mass-flow approach (Tier 2 method of the EMEP/EEA Guidebook (EMEP/EEA, 2016)). NH_3 and NO_x emission factors from other organic N fertilizers applied (sewage sludge, other organic amendments applied to soils including compost) were also updated based on the EMEP/EEA Guidebook (EMEP/EEA, 2016).
The estimation of N_2O emissions due to nitrogen leaching and run-off has followed the IPCC Tier 1 approach (Equation 11.10 of the 2006 IPCC Guidelines). Parameters used are: total use of synthetic fertilizer F_{SN} (t N yr^{-1}), total amount of organic N inputs applied to soils F_{ON} (t N yr^{-1}), total amount of urine and dung N deposited by grazing animals F_{PRP} (t N yr^{-1}), total amount of N in crop residues (above- and below-ground), including N-fixing crops and from forage F_{CR} (t N yr^{-1}), $Frac_{LEACH-(H)}$ emission factor 0.21 kg N/kg

[17] http://faostat3.fao.org/faostat-gateway/go/to/download/G1/GV/E

nitrogen of fertilizer or manure (see table 5.31) and the emission factor 0.0075 kg N_2O-N per kg nitrogen leaching/run-off (IPCC, 2006). As mentioned before, the $Frac_{LEACH-(H)}$ IPCC default value was compared with the country-specific $Frac_{LEACH-(H)}$ parameter (ADBPO, 2001; ADBPO, 1994).
The estimate of N lost through leaching and run-off includes the losses of N due to leaching from managed soils. As requested in 2016 UNFCCC review process, a review of the $Frac_{LEACH-(H)}$ parameter was done. On the basis of monthly average climatic summaries (period 1986-2015) georeferenced data (30 km grid) of precipitation and evapotranspiration, referring to the rainy period (October-December) and to the entire national territory provided by the Research Centre for Agriculture and Environments CREA-AA (CREA, 2017), and data on soil water-holding capacity elaborated by the Research Centre for Agriculture and Environments CREA-AA Florence office (Costantini E. A. C., L'Abate G., 2004; L'Abate G., Costantini E. A. C., 2005; L'Abate G., Costantini E. A. C., 2016) and available online, the criteria indicated in the Table 11.3 of the 2006 IPCC Guidelines have been investigated. According to the 2006 IPCC Guidelines, the leached nitrogen has to be estimated only in those areas where there is a water surplus or where irrigation is employed. The water surplus is calculated by subtracting, from the precipitations, the water evaporated by evapotranspiration and the amount of water that can retain the soil (that is the soil water holding capacity). This estimate was made at the level of mesh centers 30x30 km and then a weighted average at the provincial level was calculated. At this point the UAA was considered at the provincial level and the sum of the UAA of the provinces interested in the phenomenon of water surplus was calculated. The analysis shows that the water surplus occurs on 68.9% of the national agricultural area. The areas not interested by this phenomenon are generally localized in Puglia, Sicily and Sardinia and Lombardy, Veneto and Piedmont (resulting in a total of 53% and 29% of the area affected by the water deficit, respectively). For the agricultural areas affected by the water surplus, the $Frac_{LEACH-(H)}$ is assumed equal to 0.3 kg N/kg N applied to soils or deposited by grazing animals, while a value equal to zero is assumed for the agricultural areas affected by the water deficit. The weighted average value of $Frac_{LEACH-(H)}$ relative to the entire national agricultural area will be equal 20.7% of nitrogen applied to soils or deposited by grazing animals. Data on precipitation and evapotranspiration have been also used for the definition of wet and dry areas for the estimation of methane from landfills (see chapter waste, 7.2.2 methodological issues paragraph).

Table 5.31 Parameters used for the estimation of indirect N_2O emissions from managed soils

	Atmospheric deposition					N leaching and run-off	
Year	**$Frac_{GASF}$ (1) (%)**	**$Frac_{GASM}$ indirect (2) (%)**	**Fraction of N from other organic N fertilizers applied (%) (3)**	**Fraction of N from from sewage sludge applied (%)(4)**	**N volatilised from managed soils (t N)**	**$Frac_{LEACH-(H)}$ (5) (kg N/kg N)**	**N lost through leaching and run-off (t N)**
1990	8.88	10.71	7.8	11.9	171,775	0.21	359,088
1995	8.82	9.98	7.8	11.9	166,347	0.21	372,645
2000	8.90	9.53	7.8	11.9	162,246	0.21	370,361
2005	8.78	9.27	7.8	11.9	149,502	0.21	349,729
2010	9.23	9.27	7.8	11.9	128,069	0.21	289,664
2011	9.20	8.91	7.8	11.9	131,763	0.21	307,215
2012	9.93	8.65	7.8	11.9	144,916	0.21	323,374
2013	10.00	8.24	7.8	11.9	128,968	0.21	299,666
2014	9.71	8.20	7.8	11.9	123,432	0.21	295,445
2015	9.76	8.20	7.8	11.9	123,930	0.21	293,403
2016	10.42	8.20	7.8	11.9	133,662	0.21	307,778

Note: (1) the fraction is multiplied by F_{SN} (see Table 5.27); (2) the fraction is multiplied by total N excreted (see Table 5.17); (3) the fraction is multiplied by F_{OOA} (see Table 5.28); (4) the fraction is multiplied by F_{SEW} (see Table 5.28); (5) the fraction is multiplied by F_{SN}, F_{SEW}, F_{OOA}, F_{AM} and by F_{CR} (see Table 5.30).

5.5.3 Uncertainty and time-series consistency

Uncertainty for N_2O direct and indirect emissions from managed soils has been estimated to be 53.9%, as combination of 20% and 50% 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 5.32, time series of N_2O emissions from managed soils are reported.

Table 5.32 Nitrous oxide emission trends from managed soils (Gg)

Year	Direct emissions from managed soils	Indirect emissions from managed soils	Total
		Gg	
1990	27.95	6.93	34.89
1995	28.94	7.01	35.95
2000	28.78	6.91	35.69
2005	27.17	6.47	33.64
2010	22.60	5.43	28.03
2011	23.94	5.69	29.63
2012	25.18	6.09	31.27
2013	23.38	5.56	28.94
2014	23.05	5.42	28.48
2015	22.90	5.41	28.30
2016	23.99	5.73	29.72

In 2016, N_2O emissions from managed soils were 14.8% (29.72 Gg N_2O) lower than in 1990 (34.89 Gg N_2O). Major contributions were given by direct emissions (23.99 Gg), that come mainly (70.9%) from inorganic N fertilizers (8.91 Gg) and animal manure applied to soils (8.11 Gg) (see Table 5.25). Indirect emissions (5.73 Gg) are mainly (46.1%) due to N_2O emissions from nitrogen leaching and run-off from inorganic N fertilizers (1.38 Gg) and animal manure applied to soils (1.26 Gg) (see Table 5.25). 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. 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).

5.5.4 Source-specific QA/QC and verification

Synthetic fertilizers and nitrogen content are compared with the international FAO agriculture database statistics (FAO, several years). In Table 5.33, 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. A join meeting, held in July 2011 with the FAO experts in charge of the fertiliser database, ISPRA verified that there are two FAO databases for fertilisers. In Table 5.33 the two databases are presented.

Table 5.33 Total annual N content in fertilizer applied from 1990 to 2016

Year	National data (t N)	FAO database (Nitrous fertilizer consumption, t N)	FAO new database (Nitrous fertilizer consumption, t N)
1990	757,509	878,960	-
1995	797,500	875,000	-
2000	785,593	828,000	-
2005	779,846		800,697
2010	496,637		498,605

Year	National data (t N)	FAO database (Nitrous fertilizer consumption, t N)	FAO new database (Nitrous fertilizer consumption, t N)
2011	515,966		516,543
2012	683,566		591,000
2013	546,542		600,600(*)
2014	505,126		574,016(*)
2015	517,854		571,490(*)
2016	567,211		Not available

(*) Provisional official data or manual estimation

Data on national sales of synthetic nitrogen fertilizers (by type of fertilizers) as provided by *Assofertilizzanti – Federchimica*[18] (personal communication) for the period 2012-2016 have been compared to official statistics provided by ISTAT. Differences were mainly found for the amount of simple mineral nitrogen fertilizers, where data from *Assofertilizzanti* are higher by 20%, on average, for the years 2013-2016. This could be due to a possible double counting of some product which could be considered as a single product and as a compound with other fertilizers. Further investigations will be conducted.
In 2015, data on crop residues and, in particular, on the relationship between crop residues and product were compared with studies and research provided by the Agricultural Research Council (CRA)[19]. However, these studies were conducted in different countries from Italy, so despite the differences, the values used in the inventory, based on national studies, have not been changed.
Following the suggestion of the CRA experts, in the estimation of N_2O emissions from crop residues, the total amount of residues has been considered, without deducting the fraction removed for purposes such as feed, bedding and construction. Therefore, the data were revised using the fixed residues/removable residues ratio for each crop considered (ENEA, 1994), also used to estimate the emissions from category 3F (see paragraph 5.6.2).
Concerning compost data, from waste sector only data on compost production are available. Official statistics provided by ISTAT on compost used in agriculture sector (considered as the green and mixed amendments) are compared to data on compost from waste sector. For the year 2015, the amount of compost used is 58.1% of the compost production only from plants that treat a selected waste.
In 2017 submission, in response to the UNFCCC review process, the cross check of crop residues with the calculations of the amount of organic bedding materials added to animal manure available for application to soils has been done. The estimated amount of nitrogen in bedding materials is equal to 66% of the nitrogen contained in straw removed from wheat and barley crops, for the year 2015.
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).
At the end of 2016, in response to the UNFCCC review process, experts on land use and wheater climate were contacted to investigate on the $Frac_{LEACH-(H)}$ fulfilment to criteria set out in the 2006 IPCC Guidelines.

5.5.5 Source-specific recalculations

N_2O emissions have been recalculated according to the update of the average value of $Frac_{LEACH-(H)}$ for the entire national territory based on a country specific methodology.
The update of NH_3 and NO_x emissions from manure spreading and from sewage sludge and other organic fertilisers applied to soil involves the update of $Frac_{GASM}$; the update of NH_3 and NO_x emissions from synthetic nitrogen fertilizers involves the update of $Frac_{GASF}$.
The amount of animal manure N applied to soil is affected by the update of NH_3 and NO_x emissions from housing and storage. In addition, the part of nitrogen lost through N-NH_3 emissions from digesters biogas facilities was subtracted to the percentage of nitrogen left housing and storage by reducing the amount of nitrogen to spread.

18 Federchimica is the National Association of the Chemical Industry and Assofertilizzanti represents the production companies of the fertilizer industry.
19 CRA is a national research organization which operates under the supervision of the Ministry of Agriculture, with general scientific competence within the fields of agriculture, agro-industry, food, fishery and forestry.

The amount of nitrogen supplied by bedding decreases as a result of the new distribution of nitrogen excreted between liquid and solid type of dairy cows, following the update of housing sistems made on the basis of the 2010 Agricultural Census.
Updating data on sewage N applied for the period 2013-2016.
The number of sows has been update for the year 2015.

5.5.6 Source-specific planned improvements

In Table 5.34, planned improvements for this category are presented.

Table 5.34 Improvements for the agricultural soils category

Category/sub category	Parameter	Year of submission 2019	Activities
Activity data	Land spreading	√	Figures on land spreading collected in the framework of the 2016 Farm Structure Survey will be considered for the next annual submission.

A specific research on land spreading practices, (CRPA, 2009) will be analysed, and considered in the next submissions.
Improvements will be related to the availability of new information, on emission factors, activity data as well as parameters necessary to carry out the estimates; specifically, a study on the best available technologies used in agriculture practices and the elaboration of data from the 2016 farm structure survey are under investigation.

5.6 Field burning of agriculture residues (3F)

5.6.1 Source category description

Methane and nitrous oxide emissions from field burning agriculture residues have not been identified as a key source.
In 2016, CH_4 emissions from this source were 0.67 Gg, representing 0.09% of emissions for the agriculture sector. N_2O emissions were 0.014 Gg, representing 0.04% of emissions for the agriculture sector.

5.6.2 Methodological issues

The estimation of emissions from field burning of agriculture residues has been carried out on the basis of the IPCC methodology, using different parameters, such as the amount of residues produced, the amount of dry residues, the total biomass burned, and the total carbon and nitrogen released as reported in the following box.

Data used for estimating field burning of agriculture residues emission

Data	Reference
Annual crop production	ISTAT, several years [a], [b], [j]
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	IPCC, 1997; CRPA, 1997[b]; ANPA-ONR, 2001; CESTAAT, 1988
Fraction of residues oxidized during burning	IPCC, 2006
Fraction of carbon of dry matter of residues	IPCC, 1997
Raw protein in residues (dry matter fraction)	CESTAAT, 1988; Borgioli, 1981
IPCC default emission rates (CH_4, N_2O)	IPCC, 1997

Activity data (annual crop production of cereals) used for estimating burning of agriculture residues are reported in the Table 5.35.
The same methodology is used to estimate emissions from open burning of agriculture residues (burnt off-site). Emissions from fixed residues (stubble), burnt on open fields, are reported in this category (3F) while emissions from removable residues burnt off-site, are reported under the waste sector (waste incineration - 5C category).

Table 5.35 Time series of activity data (tons) used for 3F estimations

Year	Wheat	Barley	Maize	Oats	Rye	Rice	Sorghum
			Agricultural production (tons)				
1990	8,108,500	1,702,500	5,863,900	298,400	20,800	1,290,700	114,200
1995	7,946,081	1,387,069	8,454,164	301,322	19,780	1,320,851	214,802
2000	7,427,660	1,261,560	10,139,639	317,926	10,292	1,245,555	215,200
2005	7,717,129	1,214,054	10,427,930	429,153	7,876	1,444,818	184,915
2010	6,849,858	944,257	8,495,946	288,880	13,926	1,574,320	275,572
2011	6,641,807	950,934	9,752,373	297,079	14,381	1,560,128	299,862
2012	7,654,248	940,234	7,888,668	292,357	16,083	1,601,478	157,808
2013	7,312,025	875,553	7,899,617	246,916	14,306	1,433,111	316,919
2014	7,141,926	848,681	9,250,045	241,138	11,529	1,415,906	368,782
2015	7,394,495	955,131	7,073,897	261,366	13,183	1,505,804	294,218
2016	8,037,872	988,285	6,839,499	260,798	13,170	1,587,346	313,788

The methodology for estimating emissions refers to fixed residues burnt. The same steps are followed to calculate emissions from removable residues burnt off-site reported in 5C. Parameters taken into consideration are the following:

a) Amount of “fixed” residues (t), estimated with annual crop production, removable residues/product ratio, and “fixed” residue/removable residues ratio.
b) Amount of dry residues in “fixed” residue (t dry matter), calculated with amount of fixed residues and fraction of dry matter.
c) 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.
d) 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.
e) C-CH_4 from stubble burning (t C-CH_4), calculated with the amount of carbon from stubble burning release in air and default emissions rate for C-CH_4, equal to 0.005 (IPCC, 1997).

Data related to the removable residues/product ratio, the “fixed” residue/removable residues ratio, the fraction of dry matter, the fraction of carbon of dry matter of residues are available for each type of cereals.
Fraction of the field where “fixed” residues are burned is 10% (IPCC, 1997; CRPA, 1997[b]) for all crops except for rice, for which the fraction varies as a function of the change in annual percentage of the reincorporated rice straw into the soil (see *straw incorporation* in the methodological issues in rice cultivation (3C) paragraph).
CH_4 emissions from on field burning of agriculture residues (0.67 Gg CH_4 in 2016) have been estimated multiplying the C-CH_4 value (0.500 Gg C-CH_4) by the ratio of molecular weights (16/12).
In Table 5.36, parameters used for estimating of CH_4 emissions from on field burning of agriculture residues are shown.

Table 5.36 Parameters used for the estimation of CH_4 emissions from agriculture residues in 2016

Crops	Annual crop harvest 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	8,038	1,387	1,183	115	50	251
Rye	13	2	2	0	0	0

Crops	Annual crop harvest 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 C-CH_4 from stubble burning (t 1000 C)	Amount of C-CH_4 from stubble burning (t C-CH_4)
Barley	988	198	169	17	6	28
Oats	261	46	39	4	1	7
Rice	1,587	266	199	120	40	198
Maize	6,839	684	285	0	0	0
Sorghum	314	110	91	9	3	15
Total	**18,041**	**2,692**	**1,969**	**265**	**100**	**500**

For estimating N_2O emissions, the same amount of "fixed" dry residue oxidized described above were used; further parameters are:

a) 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.
b) N-N_2O from stubble burning (t N-N_2O), calculated with the amount of nitrogen from stubble burning release in air and the default emissions rate for N- N_2O, equal to 0.007 (IPCC, 1997).

Data related to the raw protein content from residues (dry matter fraction) is available for each type of cereals.
N_2O emissions from on field burning of agriculture residues (0.014 Gg N_2O in 2016) are estimated by multiplying the N-N_2O value (0.009 Gg N) by the ratio of molecular weights (44/28).

In Table 5.37 the parameters for the estimation of N_2O emissions from field burning of agriculture residues are shown.

Table 5.37 Parameters used for the estimation of nitrous oxide from agriculture residues in 2016

Crops	Amount of "fixed" dry residues oxidized (t 1000 dry matter)	Raw protein content from residues (dry matter fraction)	Fraction of nitrogen from the dry matter of residues	Amount of nitrogen from stubble burning (t 1000 N)	N-N_2O from stubble burning (t N-N_2O)
Wheat	115	0.030	0.005	0.497	3.48
Rye	0	0.036	0.006	0.001	0.01
Barley	17	0.037	0.006	0.090	0.63
Oats	4	0.040	0.006	0.023	0.16
Rice	120	0.041	0.007	0.628	4.40
Maize	0	0.057	0.007	0.000	0.00
Sorghum	9	0.037	0.006	0.049	0.34
Total	**265**			**1.288**	**9.01**

5.6.3 Uncertainty and time-series consistency

Uncertainties for CH_4 and N_2O emissions from field burning of agriculture residues are estimated to be 58.3% as a result of 30% and 50% for activity data and emission factor, respectively.
In 2016, CH_4 emissions from field burning of agriculture residues were 0.67 Gg emissions of CH_4 and 0.014 Gg emissions of N_2O emissions (see Table 5.38). Variation in emissions trend is related to cereal production trends. In particular, in the period 1998-2003, the biomass available from wheat and barley decreases compared to the first half of the ninety years due to the sharp drop in production as a consequence of unfavourable weather conditions.

Table 5.38 CH_4 and N_2O emission trends from field burning of agriculture residues (Gg)

Year	CH_4 (Gg)	N_2O (Gg)
1990	0.601	0.012
1995	0.593	0.012
2000	0.591	0.012
2005	0.636	0.013

Year	CH_4 (Gg)	N_2O (Gg)
2010	0.612	0.013
2011	0.604	0.013
2012	0.643	0.014
2013	0.607	0.013
2014	0.599	0.013
2015	0.624	0.013
2016	0.667	0.014

5.6.4 Source-specific QA/QC and verification

Activity data of this category were calculated on the basis of various parameters, and in particular the fraction of carbon and nitrogen of dry matter of residues, whose values are differentiated by crops. IPCC emission factors used (IPCC, 1997) are the ratios for carbon compounds (i.e. C-CH_4), that are mass of carbon compound released (in units of C) relative to mass of total carbon released from burning (in units of C); those for the nitrogen compounds (i.e. N-N_2O) are expressed as the ratios of mass of nitrogen compounds relative to the total mass of nitrogen released from the fuel (IPCC, 1997). The comparison with the 2006 IPCC emission factors has been done. The implied emission factors are consistent with those of the 2006 IPCC Guidelines.
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 has been carried out by ISTAT, in the framework of FSS in 2003. The information, provided by ISTAT, related to the regional practises of field burning (cereals) has confirmed the abovementioned assumption (ISTAT, 2007[c]).

5.6.5 Source-specific recalculations

Updating data on rice production for the year 2015 involves a slight decrease in CH_4 and N_2O emissions.

5.6.6 Source-specific planned improvements

No specific improvements are planned.

5.7 Liming (3G)

5.7.1 Source category description

CO_2 emissions from application of carbonate containing lime and dolomite to agricultural soils have been estimated. In 2017 submission, in response to the UNFCCC review process, CO_2 emissions from application of carbonate containing lime and dolomite are estimated separately. In 2016, CO_2 emissions from liming were 12.2 Gg, which represents 2.3% of CO_2 emissions of the agriculture sector (0.3% in 1990) and 0.0035% of national CO_2 emissions (0.0003% in 1990). CO_2 emissions from liming have not been identified as a key source.

5.7.2 Methodological issues

Tier 1 approach, assuming that the total amount of carbonate containing lime and dolomite is applied annually to soil, has been followed. The 2006 IPCC Guidelines equation 11.12 has been used to estimate CO_2 emissions. National statistics report an aggregate annual amount of lime and dolomite, without disaggregation between calcic limestone and dolomite (ISTAT, several years [i]; ISTAT, several years [f]). Data on the disaggregation between limestone and dolomite used in agriculture are provided by the largest lime producer in the country (UNICALCE, 2016). These values are equal to 55% and 45%, respectively. Therefore the average emission factor weighed is equal to 0.1245 t C/t limestone-dolomite (=0.12*0.55+0.13*0.45).

Data on agricultural lime application have been estimated for the period 1990-1997, since these data have not been made available for that period. Data were estimated on the basis of the ratio of the amount of limestone or dolomite applied for the year 1998 and the area planted to crops, woody and permanent forage.

5.7.3 Uncertainty and time-series consistency

Uncertainty for CO_2 emissions from additions of carbonate limes to soils has been estimated to be 22.4%, as combination of 10% and 20% for activity data and emission factor, respectively.
In 2016, CO_2 emissions from liming (12.2 Gg CO_2) were ten times higher than in 1990 (1.36 Gg CO_2). An increasing trend is observed from 2002, both for limestone and dolomite application, as resulting from the official statistics published by the National Institute of Statistics (ISTAT).

In Table 5.39 activity data, emission factor and CO_2 emission trend from liming are shown.

Table 5.39 CO_2 emissions from lime application

Year	Amount of limestone and dolomite (Mg)	EF (t C (t limestone and dolomite)$^{-1}$)	C emissions (Gg)	CO_2 emissions (Gg)
1990	2,969	0.1245	0.370	1.36
1995	3,045	0.1245	0.379	1.39
2000	4,050	0.1245	0.504	1.85
2005	31,451	0.1245	3.916	14.36
2010	40,115	0.1245	4.994	18.31
2011	55,675	0.1245	6.932	25.42
2012	34,792	0.1245	4.332	15.88
2013	30,934	0.1245	3.851	14.12
2014	26,222	0.1245	3.265	11.97
2015	29,583	0.1245	3.683	13.50
2016	26,732	0.1245	3.328	12.20

5.7.4 Source-specific QA/QC and verification

Systematic quality control activities have been carried out in order to ensure completeness and consistency in time series and correctness in the estimation of emissions.

5.7.5 Source-specific recalculations

Updating activity data and emission factors for all years involves a slight increase in CO_2 emissions.

5.7.6 Source-specific planned improvements

No specific improvements are planned.

5.8 Urea application (3H)

5.8.1 Source category description

CO_2 emissions from application of urea to agricultural soils have been estimated. In 2016, CO_2 emissions from urea application were 527.2 Gg, which represents 97.7% of CO_2 emissions of the agriculture sector (99.7% in 1990) and 0.15% of national CO_2 emissions (0.11% in 1990). CO_2 emissions from urea application have not been identified as a key source.

5.8.2 Methodological issues

Tier 1 approach, assuming that the total amount of urea is applied annually to soil, has been followed; an overall emission factor of 0.20 t C (t urea)$^{-1}$ has been used to estimate CO_2 emissions. The 2006 IPCC Guidelines equation 11.13 has been used to estimate CO_2 emissions. The source of the activity data are national statistics (ISTAT, several years [i]).

5.8.3 Uncertainty and time-series consistency

Uncertainty for CO_2 emissions from urea application to soils has been estimated to be 22.4%, as combination of 10% and 20% for activity data and emission factor, respectively.
In 2016, CO_2 emissions from urea application were 13.4% (527.2 Gg CO_2) higher than in 1990 (464.8 Gg CO_2).
In Table 5.40 activity data, emission factor and CO_2 emission trend from urea application are shown. A strong decrease is observed in the years from 2009 to 2011 due to the economic crisis in particular for the amount of urea applied to soils. In 2012, a recovery from the sharp decline was recorded as result from the official statistics provided by the National Institute of Statistics (ISTAT).

Table 5.40 CO_2 emissions from urea application

Year	Amount of urea (Mg)	EF (t C (tonnes of urea)$^{-1}$)	C emissions (Gg)	CO_2 emissions (Gg)
1990	633,873	0.20	126.8	464.8
1995	698,251	0.20	139.7	512.1
2000	716,412	0.20	143.3	525.4
2005	691,255	0.20	138.3	506.9
2010	456,951	0.20	91.4	335.1
2011	478,306	0.20	95.7	350.8
2012	751,235	0.20	150.2	550.9
2013	614,208	0.20	122.8	450.4
2014	560,449	0.20	112.1	411.0
2015	579,444	0.20	115.9	424.9
2016	718,843	0.20	143.8	527.2

5.8.4 Source-specific QA/QC and verification

Systematic quality control activities have been carried out in order to ensure completeness and consistency in time series and correctness in the estimation of emissions. Activity data are the same used in the agriculture soils (3D) category.

5.8.5 Source-specific recalculations

No specific recalculations are observed.

5.8.6 Source-specific planned improvements

No specific improvements are planned.

6 LAND USE, LAND USE CHANGE AND FORESTRY [CRF sector 4]

6.1 Sector overview

CO_2 emissions and removals occur as a result of changes in land-use and forestry. The sector is responsible for 29.9 Mt of CO_2 eq. removals from the atmosphere in 2016.
The 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC Guidelines) have 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; for category 4A (Forest Land) estimates were supplied by a growth model, applied to national forestry inventory data, with country specific emission factors.
CO_2 emissions from forest fires have been considered in the calculation of the net carbon stocks reported in 4A.
Greenhouse gas removals and emissions in the main categories of the LULUCF sector in 2016 are shown in Figure 6.1.

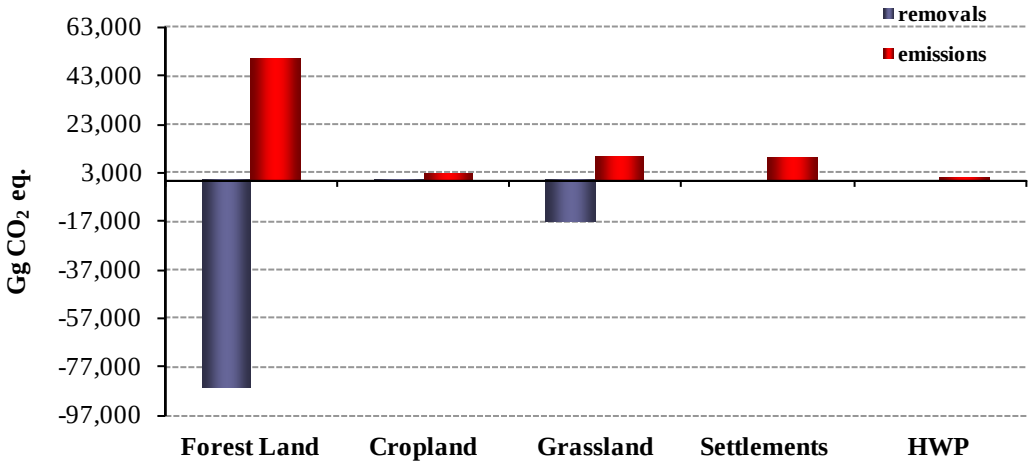


Figure 6.1 Greenhouse gas removals and emissions in LULUCF sector in 2016 [Gg CO_2 eq.]

In Table 6.1 emissions and removals time series is reported.

Table 6.1 Trend in greenhouse gas emissions from the LULUCF sector in the period 1990-2016

GHG Gas Source and Sink Categories	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CO_2	**-5,349**	**-22,748**	**-17,266**	**-28,482**	**-29,263**	**-7,731**	**-25,325**	**-26,749**	**-31,639**	**-26,292**	**-19,735**	**-33,679**	**-34,355**	**-36,173**	**-31,078**
A. Forest Land	-17,635	-30,769	-25,434	-33,797	-33,466	-18,149	-30,005	-32,659	-35,709	-31,796	-27,736	-36,627	-37,821	-39,224	-36,081
B. Cropland	2,172	1,785	2,014	1,429	1,219	1,253	1,221	1,313	1,305	2,401	2,356	2,318	2,206	2,157	2,460
C. Grassland	3,993	-1,237	131	-2,881	-3,575	2,628	-3,116	-2,460	-4,488	-4,461	-2,145	-7,219	-6,521	-6,791	-6,644
D. Wetlands	NE,NO	5	8	8	8	8	8	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NO,NE	NO,NE
E. Settlements	6,640	8,272	6,491	7,290	7,300	7,303	7,341	7,377	7,380	7,386	7,390	7,397	7,405	7,418	9,014
F. Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. HWP	-520	-804	-476	-531	-749	-775	-775	-320	-128	178	400	453	375	267	172
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CH_4	**59.33**	**13.85**	**37.31**	**14.37**	**11.77**	**73.37**	**19.77**	**23.85**	**14.28**	**22.80**	**48.46**	**7.60**	**13.74**	**11.63**	**15.84**
A. Forest Land	31.67	6.56	21.12	7.39	5.75	41.30	8.30	9.36	4.69	9.13	24.97	4.77	7.18	7.59	11.13
B. Cropland	0.22	0.06	0.13	0.06	0.05	0.25	0.08	0.09	0.05	0.10	0.19	0.31	0.03	0.10	0.08
C. Grassland	27.44	7.22	16.06	6.93	5.97	31.82	11.40	14.41	9.54	13.56	23.30	2.52	6.52	3.94	4.63
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. HWP															
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N_2O	**2.76**	**2.78**	**2.28**	**2.06**	**2.03**	**2.86**	**2.21**	**2.31**	**2.15**	**2.26**	**2.55**	**1.87**	**1.97**	**1.87**	**2.54**
A. Forest Land	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
B. Cropland	0.16	0.25	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.08	0.06	0.05	0.02	0.00	0.09
C. Grassland	0.86	0.23	0.50	0.22	0.19	1.00	0.36	0.45	0.30	0.43	0.73	0.08	0.21	0.12	0.15
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	1.70	2.25	1.65	1.72	1.72	1.72	1.73	1.74	1.74	1.74	1.74	1.74	1.74	1.74	2.27
F. Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. HWP															
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
LULUCF (*Gg CO_2 equivalent*)	**-3,043**	**-21,574**	**-15,655**	**-27,509**	**-28,364**	**-5,045**	**-24,172**	**-25,464**	**-30,640**	**-25,049**	**-17,763**	**-32,930**	**-33,425**	**-35,326**	**-29,927**

CO_2 emissions and removals in LULUCF sector, in the period 1990-2016, are shown in Figure 6.2.

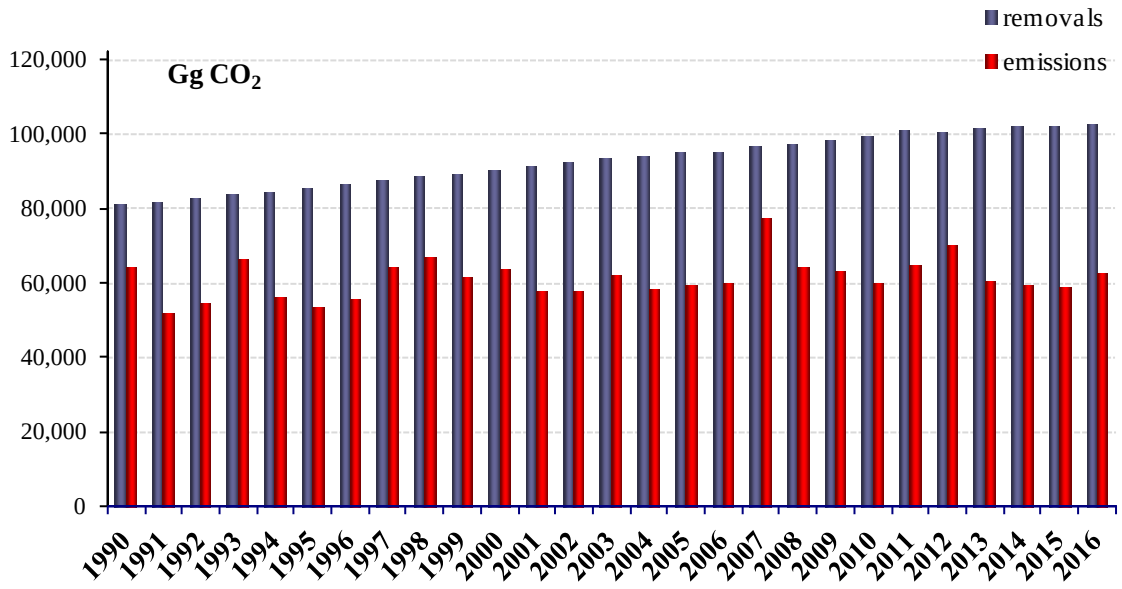


Figure 6.2 CO_2 removals and emissions in LULUCF sector in the period 1990-2016 [Gg CO_2]

The outcome of the key category analysis for 2016, according to level and/or trend assessment (*IPCC Approach 1 and Approach 2*), is listed in Table 6.2. CO_2 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. CO_2 emissions and removals from grassland remaining grassland have resulted key category in trend assessment and key category with Approach 2 concerning level assessment. CO_2 emissions and removals from land converted to cropland, CO_2 emissions and removals from HWP and CH_4 emissions and removals from grassland remaining grassland have been identified as a key category with Approach 2 concerning trend assessment; N_2O emissions from Land converted to Settlements have been identified as key category with approach 2 concerning level assessment.

Table 6.2 Key categories identification in the LULUCF sector

	gas	*categories*	2016
4.A.1	CO_2	Forest land remaining forest land	key (L, T)
4.A.2	CO_2	Land converted to forest land	key (L, T)
4.B.1	CO_2	Cropland remaining cropland	key (L, T2)
4.B.2	CO_2	Land converted to cropland	key (L2)
4.C.1	CO_2	Grassland remaining Grassland	key (L2, T)
4.C.1	CH_4	Grassland remaining Grassland	key (T2)
4.C.2	CO_2	Land converted to Grassland	key (L, T)
4.E.2	CO_2	Land converted to Settlements	key (L, T)
4.G	CO_2	HWP	key (T)
4(III)	N_2O	Land converted to Settlements	key (L2)
4(V).A1	CH_4	Forest land remaining forest land	Non-key
4(V).A1	N_2O	Forest land remaining forest land	Non-key
4.B.2	CH_4, N_2O	Land converted to cropland	Non-key
4.C.1	N_2O	Grassland remaining Grassland	Non-key
4.D	CO_2	Wetlands	Non-key
4.E.1	CO_2	Settlements remaining Settlements	Non-key

An updated methodology to assess land uses and land use changes has been used, on the basis of the IUTI[20] data, related to 1990, 2000 and 2008. An additional assessment of land use and land use changes has been carried out in 2012, through the survey in the framework of the III NFI, on an IUTI's subgrid (i.e. 301300 points, covering the entire country). Time series related to the areas to be included into the different IPCC categories have been assembled using IUTI data, and the data assessed by the national forest inventories (1985, 2005, 2012) (i.e. National Forest Service, Ministry of Agricultural, Food and Forestry Policies (MIPAAF), Forest Monitoring and Planning Research Unit (CRA-MPF)).
Due to the technical characteristics of the IUTI assessment (i.e. classification of orthophotos for 1990, 2000, 2008 and 2012), it was technically impossible to have a clear distinction among some subcategories in *cropland* and *grassland* categories (i.e. annual pastures versus grazing land). Therefore, it has been decided to aggregate the *cropland* and *grassland* categories, as detected by IUTI, and then disaggregate them into the different subcategories, using as proxies the national statistics (ISTAT, [b], [c]) related to annual crops and perennial woody crops. 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.
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; new cropland area can only come from grassland area, as new grassland area can only come from cropland area. Concerning settlements, initial land use may be forest land, cropland, grassland or other land (see Table 6.29, 6.31 and 6.32); in addition, a conservative approach was applied, assuming that the total deforested area is converted into settlements. Land transition to wetlands is from cropland and grassland categories. 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)).
On the basis of the land uses classification, the land use matrices, for each year of the period 1990–2016, have been assembled for the categories forest land, croplands, grasslands, wetlands and settlements.
In order to determine the lands converted to other land uses 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.
Italy uses 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
- Land converted to Cropland
- Land converted to Grassland
- Land converted to Settlements
- Land converted to Wetlands

KP-LULUCF

- Art. 3.3 - Afforestation/Reforestation
- Art. 3.3 – Deforestation

The relevant equations of 2006 IPCC Guidelines (vol. 4, chapter 2, eq. 2.15, 2.16, 2.24, 2.25) 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 CO_2 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

[20] Detailed information on IUTI is reported in Annex 10

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 6.3, the land use matrices for each year of the period 1990–2016 are reported.

Table 6.3 Land use change matrices for the years 1990-2016

		1990						total 1989
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1989	Forest	**7,511**				0.72		*7,512*
	Grassland	78.68	**8,891**	0.00	0.00	1.73		*8,971*
	Cropland		0	**10,841**	0.00	25		*10,866*
	Wetland				**510**			*510*
	Settlements					**1,616**		*1,616*
	Other Land					0.00	**658**	*658*
	total 1990	*7,590*	*8,891*	*10,841*	*510*	*1,644*	*658*	30,134
	Land converted	78.7	0.0	0.0	0.0	27.6	0.0	

		1991						total 1990
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1990	Forest	**7,589**				0.72		*7,590*
	Grassland	78.68	**8,768**	16.77	0.47	26.70		*8,891*
	Cropland		0	**10,841**	0.00	0		*10,841*
	Wetland				**510**			*510*
	Settlements					**1,644**		*1,644*
	Other Land					0.18	**658**	*658*
	total 1991	*7,668*	*8,768*	*10,857*	*511*	*1,672*	*658*	30,134
	Land converted	78.7	0.0	16.8	0.5	27.6	0.0	

		1992						total 1991
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1991	Forest	**7,667**				0.72		*7,668*
	Grassland	78.68	**8,646**	16.77	0.47	26.70		*8,768*
	Cropland		0	**10,857**	0.00	0		*10,857*
	Wetland				**511**			*511*
	Settlements					**1,672**		*1,672*
	Other Land					0.18	**658**	*658*
	total 1992	*7,746*	*8,646*	*10,874*	*511*	*1,699*	*658*	30,134
	Land converted	78.7	0.0	16.8	0.5	27.6	0.0	

		1993						total 1992
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1992	Forest	**7,745**				0.72		*7,746*
	Grassland	78.68	**8,523**	16.77	0.47	26.70		*8,646*
	Cropland		0	**10,874**	0.00	0		*10,874*
	Wetland				**511**			*511*
	Settlements					**1,699**		*1,699*
	Other Land					0.18	**658**	*658*
	total 1993	*7,824*	*8,523*	*10,891*	*511*	*1,727*	*658*	30,134
	Land converted	78.7	0.0	16.8	0.5	27.6	0.0	

		1994						total 1993
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1993	Forest	**7,823**				0.72		*7,824*
	Grassland	78.68	**8,400**	16.77	0.47	26.70		*8,523*
	Cropland		0	**10,891**	0.00	0		*10,891*
	Wetland				**511**			*511*
	Settlements					**1,727**		*1,727*
	Other Land					0.18	**658**	*658*
	total 1994	*7,902*	*8,400*	*10,908*	*512*	*1,754*	*658*	30,134
	Land converted	78.7	0.0	16.8	0.5	27.6	0.0	

		1995						total 1994
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1994	Forest	**7,901**				0.72		*7,902*
	Grassland	78.68	**8,278**	16.77	0.47	26.70		*8,400*
	Cropland		0	**10,908**	0.00	0		*10,908*
	Wetland				**512**			*512*
	Settlements					**1,754**		*1,754*
	Other Land					0.18	**657**	*658*
	total 1995	*7,980*	*8,278*	*10,924*	*512*	*1,782*	*657*	30,134
	Land converted	78.7	0.0	16.8	0.5	27.6	0.0	

		1996						total 1995
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1995	Forest	**7,979**				0.72		*7,980*
	Grassland	78.68	**8,199**	0	0.00	0.00		*8,278*
	Cropland		60.32	**10,837**	0.47	26.70		*10,924*
	Wetland				**512**			*512*
	Settlements					**1,782**		*1,782*
	Other Land					0.18	**657**	*657*
	total 1996	*8,058*	*8,259*	*10,837*	*513*	*1,810*	*657*	30,134
	Land converted	78.7	60.3	0.0	0.5	27.6	0.0	

20 years matrix		1990						total 1971
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1971	Forest	**6,901**				14.4		*6,916*
	Grassland	689	**8,566**	136	0.00	33		*9,423*
	Cropland		325	**10,704**	0.00	174		*11,203*
	Wetland				**510**			*510*
	Settlements					**1,423**		*1,423*
	Other Land					0.00	**658**	*658*
	Total 1990	*7,589.8*	*8,890.9*	*10,840.5*	*510.1*	*1,644.0*	*658.3*	30,134
	Land converted to:	688.5	325.0	136.1	0.0	220.8	0.0	

20 years matrix		1991						total 1972
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1972	Forest	**6,932**				14.4		*6,947*
	Grassland	736	**8,450**	153	0.47	59		*9,398*
	Cropland		318	**10,704**	0.00	169		*11,192*
	Wetland				**510**			*510*
	Settlements					**1,429**		*1,429*
	Other Land					0.18	**658**	*658*
	Total 1991	*7,668*	*8,768*	*10,857*	*511*	*1,672*	*658*	30,134
	Land converted to:	736	318	153	0	243	0	

20 years matrix		1992						total 1973
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1973	Forest	**6,963**				14.4		*6,978*
	Grassland	782	**8,334**	170	0.95	86		*9,373*
	Cropland		312	**10,704**	0.00	164		*11,181*
	Wetland				**510**			*510*
	Settlements					**1,434**		*1,434*
	Other Land					0.36	**658**	*658*
	Total 1992	*7,746*	*8,646*	*10,874*	*511*	*1,699*	*658*	30,134
	Land converted to:	782	312	170	1	265	0	

20 years matrix		1993						total 1974
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1974	Forest	**6,994**				14.4		*7,009*
	Grassland	829	**8,218**	186	1.42	113		*9,348*
	Cropland		305	**10,704**	0.00	159		*11,169*
	Wetland				**510**			*510*
	Settlements					**1,440**		*1,440*
	Other Land					0.54	**658**	*658*
	Total 1993	*7,824*	*8,523*	*10,891*	*511*	*1,727*	*658*	30,134
	Land converted to:	829	305	186	1	287	0	

20 years matrix		1994						total 1975
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1975	Forest	**7,025**				14.4		*7,040*
	Grassland	876	**8,101**	203	1.89	139		*9,322*
	Cropland		299	**10,704**	0.00	155		*11,158*
	Wetland				**510**			*510*
	Settlements					**1,445**		*1,445*
	Other Land					0.72	**658**	*658*
	Total 1994	*7,902*	*8,400*	*10,908*	*512*	*1,754*	*658*	30,134
	Land converted to:	876	299	203	2	309	0	

20 years matrix		1995						total 1976
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1976	Forest	**7,056**				14.4		*7,071*
	Grassland	923	**7,985**	220	2.37	166		*9,297*
	Cropland		292	**10,704**	0.00	150		*11,147*
	Wetland				**510**			*510*
	Settlements					**1,451**		*1,451*
	Other Land					0.90	**657**	*658*
	Total 1995	*7,980*	*8,278*	*10,924*	*512*	*1,782*	*657*	30,134
	Land converted to:	923	292	220	2	331	0	

20 years matrix		1996						total 1977
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1977	Forest	**7,068**				14.4		*7,083*
	Grassland	989	**7,907**	193	2.37	161		*9,252*
	Cropland		353	**10,644**	0.47	176		*11,174*
	Wetland				**510**			*510*
	Settlements					**1,456**		*1,456*
	Other Land					1.08	**657**	*658*
	Total 1996	*8,058*	*8,259*	*10,837*	*513*	*1,810*	*657*	30,134
	Land converted to:	989	353	193	3	353	0	

1996	1997						total 1996
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**8,057**				0.72		*8,058*
Grassland	78.68	**8,181**	0	0.00	0.00		*8,259*
Cropland		60.32	**10,749**	0.47	26.70		*10,837*
Wetland				**513**			*513*
Settlements					**1,810**		*1,810*
Other Land					0.18	**657**	*657*
total 1996	*8,136*	*8,241*	*10,749*	*513*	*1,837*	*657*	30,134
Land converted	78.7	60.3	0.0	0.5	27.6	0.0	

1978	20 years matrix	1997						total 1978
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
	Forest	**7,080**				14.4		*7,095*
	Grassland	1,055	**7,828**	166	2.37	157		*9,207*
	Cropland		413	**10,584**	0.95	203		*11,201*
	Wetland				**510**			*510*
	Settlements					**1,462**		*1,462*
	Other Land					1.26	**657**	*658*
	Total 1997	*8,136*	*8,241*	*10,749*	*513*	*1,837*	*657*	30,134
	Land converted to:	1,055	413	166	3	375	0	

1997	1998						total 1997
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**8,135**				0.72		*8,136*
Grassland	78.68	**8,162**	0	0.00	0.00		*8,241*
Cropland		60.32	**10,662**	0.47	26.70		*10,749*
Wetland				**513**			*513*
Settlements					**1,837**		*1,837*
Other Land					0.18	**657**	*657*
total 1998	*8,213*	*8,223*	*10,662*	*514*	*1,865*	*657*	30,134
Land converted	78.7	60.3	0.0	0.5	27.6	0.0	

1979	20 years matrix	1998						total 1979
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
	Forest	**7,093**				14.4		*7,107*
	Grassland	1,121	**7,749**	138	2.37	152		*9,163*
	Cropland		473	**10,524**	1	230		*11,228*
	Wetland				**510**			*510*
	Settlements					**1,467**		*1,467*
	Other Land					1.44	**657**	*658*
	Total 1998	*8,213*	*8,223*	*10,662*	*514*	*1,865*	*657*	30,134
	Land converted to:	1,121	473	138	4	398	0	

1998	1999						total 1998
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**8,213**				0.72		*8,213*
Grassland	78.68	**8,144**	0	0.00	0.00		*8,223*
Cropland		60.32	**10,574**	0.47	26.70		*10,662*
Wetland				**514**			*514*
Settlements					**1,865**		*1,865*
Other Land					0.18	**657**	*657*
total 1999	*8,291*	*8,204*	*10,574*	*514*	*1,892*	*657*	30,134
Land converted	78.7	60.3	0.0	0.5	27.6	0.0	

1980	20 years matrix	1999						total 1980
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
	Forest	**7,105**				14.4		*7,119*
	Grassland	1,187	**7,671**	111	2.37	147		*9,118*
	Cropland		534	**10,463**	1.89	257		*11,256*
	Wetland				**510**			*510*
	Settlements					**1,473**		*1,473*
	Other Land					1.62	**657**	*658*
	Total 1999	*8,291*	*8,204*	*10,574*	*514*	*1,892*	*657*	30,134
	Land converted to:	1,187	534	111	4	420	0	

1999	2000						total 1999
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**8,291**				0.72		*8,291*
Grassland	78.68	**8,126**	0	0.00	0.00		*8,204*
Cropland		60.32	**10,487**	0.47	26.70		*10,574*
Wetland				**514**			*514*
Settlements					**1,892**		*1,892*
Other Land					0.18	**656**	*657*
total 2000	*8,369*	*8,186*	*10,487*	*515*	*1,920*	*656*	30,134
Land converted	78.7	60.3	0.0	0.5	27.6	0.0	

1981	20 years matrix	2000						total 1981
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
	Forest	**7,117**				14.4		*7,131*
	Grassland	1,252	**7,592**	84	2.37	142		*9,073*
	Cropland		594	**10,403**	2.37	283		*11,283*
	Wetland				**510**			*510*
	Settlements					**1,478**		*1,478*
	Other Land					1.80	**656**	*658*
	Total 2000	*8,369*	*8,186*	*10,487*	*515*	*1,920*	*656*	30,134
	Land converted to:	1,252	594	84	5	442	0	

2000	2001						total 2000
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**8,369**				0.72		*8,369*
Grassland	78.68	**8,107**	0	0.00	0.00		*8,186*
Cropland		94.48	**10,365**	0.47	26.70		*10,487*
Wetland				**515**			*515*
Settlements					**1,920**		*1,920*
Other Land					0.18	**656**	*656*
total 2001	*8,447*	*8,202*	*10,365*	*515*	*1,948*	*656*	30,134
Land converted	78.7	94.5	0.0	0.5	27.6	0.0	

1982	20 years matrix	2001						total 1982
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
	Forest	**7,131**				14.4		*7,145*
	Grassland	1,317	**7,572**	84	2.37	142		*9,117*
	Cropland		630	**10,281**	2.84	305		*11,219*
	Wetland				**510**			*510*
	Settlements					**1,484**		*1,484*
	Other Land					1.98	**656**	*658*
	Total 2001	*8,447*	*8,202*	*10,365*	*515*	*1,948*	*656*	30,134
	Land converted to:	1,317	630	84	5	464	0	

2001	2002						total 2001
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**8,447**				0.72		*8,447*
Grassland	78.68	**8,123**	0	0.00	0.00		*8,202*
Cropland		94.48	**10,244**	0.47	26.70		*10,365*
Wetland				**515**			*515*
Settlements					**1,948**		*1,948*
Other Land					0.18	**656**	*656*
total 2002	*8,525*	*8,218*	*10,244*	*516*	*1,975*	*656*	30,134
Land converted	78.7	94.5	0.0	0.5	27.6	0.0	

1983	20 years matrix	2002						total 1983
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
	Forest	**7,144**				14.4		*7,159*
	Grassland	1,381	**7,552**	84	2.37	142		*9,161*
	Cropland		666	**10,160**	3.32	327		*11,156*
	Wetland				**510**			*510*
	Settlements					**1,489**		*1,489*
	Other Land					2.17	**656**	*658*
	Total 2002	*8,525*	*8,218*	*10,244*	*516*	*1,975*	*656*	30,134
	Land converted to:	1,381	666	84	6	486	0	

2002	2003						total 2002
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**8,525**				0.72		*8,525*
Grassland	78.68	**8,139**	0	0.00	0.00		*8,218*
Cropland		94.48	**10,122**	0.47	26.70		*10,244*
Wetland				**516**			*516*
Settlements					**1,975**		*1,975*
Other Land					0.18	**656**	*656*
total 2003	*8,603*	*8,233*	*10,122*	*516*	*2,003*	*656*	30,134
Land converted	78.7	94.5	0.0	0.5	27.6	0.0	

1984	20 years matrix	2003						total 1984
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
	Forest	**7,158**				14.4		*7,173*
	Grassland	1,445	**7,531**	84	2.37	142		*9,205*
	Cropland		702	**10,038**	3.79	349		*11,093*
	Wetland				**510**			*510*
	Settlements					**1,495**		*1,495*
	Other Land					2.35	**656**	*658*
	Total 2003	*8,603*	*8,233*	*10,122*	*516*	*2,003*	*656*	30,134
	Land converted to:	1,445	702	84	6	508	0	

2003	2004						total 2003
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**8,603**				0.72		*8,603*
Grassland	78.68	**8,155**	0	0.00	0.00		*8,233*
Cropland		94.48	**10,000**	0.47	26.70		*10,122*
Wetland				**516**			*516*
Settlements					**2,003**		*2,003*
Other Land					0.18	**656**	*656*
total 2004	*8,681*	*8,249*	*10,000*	*517*	*2,030*	*656*	30,134
Land converted	78.7	94.5	0.0	0.5	27.6	0.0	

1985	20 years matrix	2004						total 1985
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
	Forest	**7,172**				14.4		*7,186*
	Grassland	1,509	**7,511**	84	2.37	142		*9,249*
	Cropland		738	**9,916**	4.26	371		*11,030*
	Wetland				**510**			*510*
	Settlements					**1,500**		*1,500*
	Other Land					2.53	**656**	*658*
	Total 2004	*8,681*	*8,249*	*10,000*	*517*	*2,030*	*656*	30,134
	Land converted to:	1,509	738	84	7	530	0	

2004	2005						total 2004
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**8,678**				3.69		*8,681*
Grassland	81.65	**8,168**	0	0.00	0.00		*8,249*
Cropland		97.46	**9,879**	0.47	23.73		*10,000*
Wetland				**517**			*517*
Settlements					**2,030**		*2,030*
Other Land					0.18	**656**	*656*
total 2005	*8,759*	*8,265*	*9,879*	*517*	*2,058*	*656*	30,134
Land converted	81.7	97.5	0.0	0.5	27.6	0.0	

20 years matrix	2005						total 1986
1986	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**7,183**				17.4		*7,200*
Grassland	1,577	**7,488**	84	2.37	142		*9,293*
Cropland		777	**9,795**	4.74	390		*10,966*
Wetland				**510**			*510*
Settlements					**1,506**		*1,506*
Other Land					2.71	**656**	*658*
Total 2005	*8,759*	*8,265*	*9,879*	*517*	*2,058*	*656*	30,134
Land converted to:	1,577	777	84	7	552	0	

2005	2006						total 2005
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**8,756**				3.69		*8,759*
Grassland	58.31	**8,207**	0	0.00	0.00		*8,265*
Cropland		84.89	**9,769**	0.47	23.73		*9,879*
Wetland				**517**			*517*
Settlements					**2,058**		*2,058*
Other Land					0.18	**655**	*656*
total 2006	*8,814*	*8,292*	*9,769*	*518*	*2,086*	*655*	30,134
Land converted	58.3	84.9	0.0	0.5	27.6	0.0	

20 years matrix	2006						total 1987
1987	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**7,258**				20.4		*7,278*
Grassland	1,556	**7,430**	84	2.37	140		*9,213*
Cropland		862	**9,686**	5.21	388		*10,941*
Wetland				**510**			*510*
Settlements					**1,534**		*1,534*
Other Land					2.89	**655**	*658*
Total 2006	*8,814*	*8,292*	*9,769*	*518*	*2,086*	*655*	30,134
Land converted to:	1,556	862	84	8	552	0	

2006	2007						total 2006
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**8,810**				3.69		*8,814*
Grassland	58.31	**8,233**	0	0.00	0.00		*8,292*
Cropland		84.89	**9,660**	0.47	23.73		*9,769*
Wetland				**518**			*518*
Settlements					**2,086**		*2,086*
Other Land					0.18	**655**	*655*
total 2007	*8,868*	*8,318*	*9,660*	*518*	*2,113*	*655*	30,134
Land converted	58.3	84.9	0.0	0.5	27.6	0.0	

20 years matrix	2007						total 1988
1988	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**7,333**				23.4		*7,356*
Grassland	1,536	**7,371**	84	2.37	139		*9,132*
Cropland		947	**9,577**	5.68	387		*10,916*
Wetland				**510**			*510*
Settlements					**1,561**		*1,561*
Other Land					3.07	**655**	*658*
Total 2007	*8,868*	*8,318*	*9,660*	*518*	*2,113*	*655*	30,134
Land converted to:	1,536	947	84	8	552	0	

2007	2008						total 2007
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**8,865**				3.69		*8,868*
Grassland	58.31	**8,260**	0	0.00	0.00		*8,318*
Cropland		84.89	**9,551**	0.47	23.73		*9,660*
Wetland				**518**			*518*
Settlements					**2,113**		*2,113*
Other Land					0.18	**655**	*655*
total 2008	*8,923*	*8,345*	*9,551*	*519*	*2,141*	*655*	30,134
Land converted	58.3	84.9	0.0	0.5	27.6	0.0	

20 years matrix	2008						total 1989
1989	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**7,408**				26.3		*7,434*
Grassland	1,516	**7,313**	84	2.37	137		*9,052*
Cropland		1,032	**9,467**	6.16	386		*10,891*
Wetland				**510**			*510*
Settlements					**1,589**		*1,589*
Other Land					3.25	**655**	*658*
Total 2008	*8,923*	*8,345*	*9,551*	*519*	*2,141*	*655*	30,134
Land converted to:	1,516	1,032	84	9	552	0	

2008	2009						total 2008
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**8,919**				3.69		*8,923*
Grassland	58.31	**8,286**	0	0.00	0.00		*8,345*
Cropland		172.46	**9,355**	0.00	23.91		*9,551*
Wetland				**519**			*519*
Settlements					**2,141**		*2,141*
Other Land					0.00	**655**	*655*
total 2009	*8,978*	*8,459*	*9,355*	*519*	*2,169*	*655*	30,134
Land converted	58.3	172.5	0.0	0.0	27.6	0.0	

20 years matrix	2009						total 1990
1990	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**7,483**				29.3		*7,512*
Grassland	1,495	**7,255**	84	2.37	135		*8,971*
Cropland		1,204	**9,271**	6.16	384		*10,866*
Wetland				**510**			*510*
Settlements					**1,616**		*1,616*
Other Land					3.25	**655**	*658*
Total 2009	*8,978*	*8,459*	*9,355*	*519*	*2,169*	*655*	30,134
Land converted to:	1,495	1,204	84	9	552	0	

2009	2010						total 2009
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**8,974**				3.69		*8,978*
Grassland	58.31	**8,401**	0	0.00	0.00		*8,459*
Cropland		172.46	**9,159**	0.00	23.91		*9,355*
Wetland				**519**			*519*
Settlements					**2,169**		*2,169*
Other Land					0.00	**655**	*655*
total 2010	*9,032*	*8,573*	*9,159*	*519*	*2,196*	*655*	30,134
Land converted	58.3	172.5	0.0	0.0	27.6	0.0	

20 years matrix	2010						total 1991
1991	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**7,558**				32.3		*7,590*
Grassland	1,475	**7,196**	84	2.37	134		*8,891*
Cropland		1,377	**9,075**	6.16	383		*10,841*
Wetland				**510**			*510*
Settlements					**1,644**		*1,644*
Other Land					3.25	**655**	*658*
Total 2010	*9,032*	*8,573*	*9,159*	*519*	*2,196*	*655*	30,134
Land converted to:	1,475	1,377	84	9	552	0	

2010	2011						total 2010
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**9,029**				3.69		*9,032*
Grassland	58.31	**8,515**	0.00	0.00	0.00		*8,573*
Cropland		38	**9,097**	0.00	24		*9,159*
Wetland				**519**			*519*
Settlements					**2,196**		*2,196*
Other Land					0.00	**655**	*655*
total 2011	*9,087*	*8,553*	*9,097*	*519*	*2,224*	*655*	30,134
Land converted	58.3	38.0	0.0	0.0	27.6	0.0	

20 years matrix	2011						total 1992
1992	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**7,633**				35.3		*7,668*
Grassland	1,454	**7,138**	67	1.89	107		*8,768*
Cropland		1,415	**9,029**	6.2	407		*10,857*
Wetland				**511**			*511*
Settlements					**1,672**		*1,672*
Other Land					3.07	**655**	*658*
Total 2011	*9,087*	*8,553*	*9,097*	*519*	*2,224*	*655*	30,134
Land converted to:	1,454	1,415	67	8	552	0	

2011	2012						total 2011
	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**9,083**				3.69		*9,087*
Grassland	58.31	**8,494**	0.00	0.00	0.00		*8,553*
Cropland		38	**9,035**	0.00	24		*9,097*
Wetland				**519**			*519*
Settlements					**2,224**		*2,224*
Other Land					0.00	**655**	*655*
total 2012	*9,142*	*8,532*	*9,035*	*519*	*2,251*	*655*	30,134
Land converted	58.3	38.0	0.0	0.0	27.6	0.0	

20 years matrix	2012						total 1993
1993	Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
Forest	**7,707**				38.2		*7,746*
Grassland	1,434	**7,080**	50	1.42	80		*8,646*
Cropland		1,453	**8,984**	6.16	431		*10,874*
Wetland				**511**			*511*
Settlements					**1,699**		*1,699*
Other Land					2.89	**655**	*658*
Total 2012	*9,142*	*8,532*	*9,035*	*519*	*2,251*	*655*	30,134
Land converted to:	1,434	1,453	50	8	552	0	

2012	2013 Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	total 2012
Forest	**9,138**				3.69		*9,142*
Grassland	58.31	**8,474**	0.00	0.00	0.00		*8,532*
Cropland		38	**8,973**	0.00	24		*9,035*
Wetland				**519**			*519*
Settlements					**2,251**		*2,251*
Other Land					0.00	**655**	*655*
total 2013	*9,196*	*8,512*	*8,973*	*519*	*2,279*	*655*	30,134
Land converted	58.3	38.0	0.0	0.0	27.6	0.0	

1994	20 years matrix 2013 Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	total 1994
Forest	**7,782**				41.2		*7,824*
Grassland	1,414	**7,021**	34	0.95	53		*8,523*
Cropland		1,491	**8,939**	6.16	455		*10,891*
Wetland				**511**			*511*
Settlements					**1,727**		*1,727*
Other Land					2.71	**655**	*658*
Total 2013	*9,196*	*8,512*	*8,973*	*519*	*2,279*	*655*	30,134
Land converted to:	1,414	1,491	34	7	552	0	

2013	2014 Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	total 2013
Forest	**9,192**				3.69		*9,196*
Grassland	58.31	**8,454**	0.00	0.00	0.00		*8,512*
Cropland		38	**8,911**	0.00	24		*8,973*
Wetland				**519**			*519*
Settlements					**2,279**		*2,279*
Other Land					0.00	**655**	*655*
total 2014	*9,251*	*8,492*	*8,911*	*519*	*2,307*	*655*	30,134
Land converted	58.3	38.0	0.0	0.0	27.6	0.0	

1995	20 years matrix 2014 Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	total 1995
Forest	**7,857**				44.2		*7,902*
Grassland	1,393	**6,963**	17	0.47	27		*8,400*
Cropland		1,529	**8,894**	6.16	479		*10,908*
Wetland				**512**			*512*
Settlements					**1,754**		*1,754*
Other Land					2.53	**655**	*658*
Total 2014	*9,251*	*8,492*	*8,911*	*519*	*2,307*	*655*	30,134
Land converted to:	1,393	1,529	17	7	552	0	

2014	2015 Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	total 2014
Forest	**9,247**				3.69		*9,251*
Grassland	58.31	**8,434**	0.00	0.00	0.00		*8,492*
Cropland		38	**8,849**	0.00	24		*8,911*
Wetland				**519**			*519*
Settlements					**2,307**		*2,307*
Other Land					0.00	**655**	*655*
total 2014	*9,305*	*8,472*	*8,849*	*519*	*2,334*	*655*	30,134
Land converted	58.3	38.0	0.0	0.0	27.6	0.0	

1996	20 years matrix 2015 Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	total 1996
Forest	**7,932**				47.1		*7,980*
Grassland	1,373	**6,905**	0	0.00	0		*8,278*
Cropland		1,567	**8,849**	6.16	503		*10,924*
Wetland				**512**			*512*
Settlements					**1,782**		*1,782*
Other Land					2.35	**655**	*657*
Total 2015	*9,305*	*8,472*	*8,849*	*519*	*2,334*	*655*	30,134
Land converted to:	1,373	1,567	0	6	552	0	

2015	2016 Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	total 2015
Forest	**9,302**				3.69		*9,305*
Grassland	58.31	**8,309**	80.48	0.00	23.91		*8,472*
Cropland		0	**8,849**	0.00	0		*8,849*
Wetland				**519**			*519*
Settlements					**2,334**		*2,334*
Other Land					0.00	**655**	*655*
total 2015	*9,360*	*8,309*	*8,929*	*519*	*2,362*	*655*	30,134
Land converted	58.3	0.0	80.5	0.0	27.6	0.0	

1997	20 years matrix 2016 Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	total 1997
Forest	**8,007**				50.1		*8,058*
Grassland	1,353	**6,802**	80	0.00	24		*8,259*
Cropland		1,507	**8,849**	5.68	476		*10,837*
Wetland				**513**			*513*
Settlements					**1,810**		*1,810*
Other Land					2.17	**655**	*657*
Total 2016	*9,360*	*8,309*	*8,929*	*519*	*2,362*	*655*	30,134
Land converted to:	1,353	1,507	80	6	552	0	

6.2 Forest Land (4A)

6.2.1 Description

Under this category, CO_2 emissions from living biomass, dead organic matter and soils, from forest land remaining forest land and from land converted to forest land have been reported.
Forest land removals share, in 2016, 65.5% of total CO_2 eq. LULUCF emissions and removals; in particular, the living biomass removals represent 95.5%, while the removals from dead organic matter and soils stand for 2.1% and 2.4% of total 2016 forest land CO_2 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).
CO_2 emissions and removals from forest land remaining forest land and from land converted to forest land have been identified as key categories in level and in trend assessment either with Approach 1 and Approach 2. Concerning CH_4 or N_2O emissions, neither forest land nor land converting to forest land have resulted as a key source.

6.2.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The 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 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 shrublands in the grassland category because they do not fulfil national forest definition; in the current submission, following a key finding in the 2013 review process, the plantations, previously classified in the cropland category, have been included in forest.
The forest definition adopted under the Convention and under Kyoto Protocol is the same used by the NFIs[21]. The forest definition included trees which 1) fulfill the criteria based on the required threshold or 2) "have the potential to reach" such required thresholds. In the second case, there is an assessment on future vegetation conditions, so that in principle it is considered forest a land that is expected to reach the thresholds but not a land with severe limitations that do not make it possible to reach the thresholds. In the example, *abandoned land with regenerating forest* is assessed considering the potential to reach the thresholds while shrublands will not and for this reason has been included in grassland category, other wooded land. The assessment of potential tree-height is carried out in the field (phase 2 of the NFI). Transition from shrublands to forest is estimated in terms of the time needed. If the transition is expected in a time span similar to that needed to reach the thresholds by areas under reforestation or temporarly unstoched areas which are expected to regenerate, the area is considered forest otherwise it is considered shrublands and transition is in practice discarded.
For the land use conversion, land use change matrices have been used; as abovementioned, LUC matrices for each year of the period 1990–2016 have been assembled on the basis of the IUTI[22] data, related to 1990, 2000 and 2008 and 2012. Annual figures for areas in transition between different land uses have been

[21] The detailed definition is reported on the website of the NFIs http://www.sian.it/inventarioforestale/jsp/q_features.jsp *(forest definition:* http://www.sian.it/inventarioforestale/jsp/linkmetodo/definizionilink1.jsp*)*
[22] Detailed information on IUTI is reported in Annex 10

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.
Forest land area detected by the National Forest Inventories (NFI) has been used as basis to assess the growth in forest land area. 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 NFI 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 (INFC2005), 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 third national forest inventory (NFI2015), using the same sampling design of the II NFI, has been carried out in 2013, concluding the first phase, interpretation of orthophotos, in October 2013. Even though the NFI2015 has completed only the first phase, the data related to "Forest + other wooded land", resulting by the first phase (photo-interpretation) of NFI2015, have been split in the "Forest" and "other wooded land", region by region, using the ratio "other wooded land"/ "Forest", deduced from previous NFI. The abovementioned data, referring to forest area estimates, have been used in the estimation process.

6.2.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The forest definition adopted by Italy in the framework of the Kyoto Protocol has been used; 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.

6.2.4 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 IPCC 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; 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 have been used to deduce the carbon stock changes in the pools, on the basis of the results of the II National Forestry Inventory and the national forest definition. Details are reported in the following relevant sections.

Carbon pools, ecosystem components in the NFI surveys

Forest carbon pools	Ordinary survey	Supplementary survey
Aboveground biomass	Biomass of trees with DBH≥4.5 cm (trees-AGB)	
	Number or subjects of regeneration and shrubs	Ratio dry on wet weight
Deadwood	Volume of coarse woody debris (CWD)	Basic densities
	Volume of stumps	Basic densities
	Volume of standing dead trees (STD)	Basic densities
	Fine woody debris: still unmeasured (FWD)	Quantity (wet weight) per unit area; dry to wet weight ratio
Litter	--	Quantity per unit area (wet weight); dry to weight ratio
Soil	--	Organic carbon per unit area

The model has been applied at regional scale (NUTS2) because of availability of forest-related statistical data: model input data for the forest area, per region and inventory typologies, were the Italian forest inventories (NFI1985, NFI2005), while the results of the first phase of the NFI2015 were used in forest area assessment.
An independent verification of the model results versus measured data, relating to the year 2005, was carried out and provided validation of the model (Tabacchi et al., 2010), more details are included in paragraph 6.2.6.
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 2016, the following methodology was applied:

1. the initial growing stock volume is the 1985 growing stock data (MAF/ISAFA, 1988);
2. starting from 1985, for each year, the current increment per hectare [m^3 ha^{-1}] is computed with the derivative Richards function[23], for each forest typology by the Italian yield tables collection;
3. starting from 1986, for each year the growing stock per hectare [m^3 ha^{-1}] is computed, from the previous year growing stock volume, with the addition of the calculated increment ("y" value of the derivative Richards) for the current year and subtraction of the losses due to harvest, mortality and fire for the current year. 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

[23] In the followed approach the Richards function is fitted through the data of growing stock [m^3] and increment [m^3 y^{-1}] obtained by the data of the national forestry inventory and yield tables collection.

$$y = a \cdot \left[1 \pm e^{(\beta - kt)}\right]^{-\frac{1}{\nu}}$$ (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.

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

where the general constrain for the parameters are the following:

$a,k>0$ $-1 \leq v \leq \infty$ and $v \neq 0$

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).

v_i is the volume per hectare of growing stock for the current year

V_{i-1} is the total previous year growing stock volume

I_i is the total current increment of growing stock for the current year

H_i is the total amount of harvested growing stock for the current year

F_i is the total amount of burned growing stock for the current year

Mi is the annual rate of mortality

D is the annual rate of drain and grazing for the protective forest

A_i is the total area referred to a specific forest typology for the current year

v_{i-1} is the previous year growing stock volume per hectare

A_{i-1} is the total area referred to a specific forest typology for the previous year

f is the Richards function reported above

The average rate of mortality, the fraction of standing biomass per year, used for the calculation was 0.0116, concerning the evergreen forest, and 0.0117, 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.
Biomass losses from timber harvest, fuel wood collection and harvest from short rotation forests are calculated on the basis of official statistic by ISTAT; total commercial harvested wood, for construction and energy purposes, has been 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])). Nevertheless as data on biomass removed in commercial harvest, particularly concerning fuelwood consumption, have been judged underestimated (APAT - ARPA Lombardia, 2007, UNECE – FAO, Timber Committee, 2008, Corona et al., 2007), the time series has been recalculated, applying a correction factor, on regional basis, to the commercial harvested wood statistical data. The correction factor[24], was inferred with the outcome of a specific survey[25] conducted in the framework of the NFI, carrying out a regional assessment of the harvested biomass; the computed figures have been subtracted, as losses, from growing stock volume, as mentioned above. In Figure 6.3, the time series of harvest, with reference to stand, coppices and plantations, is shown.

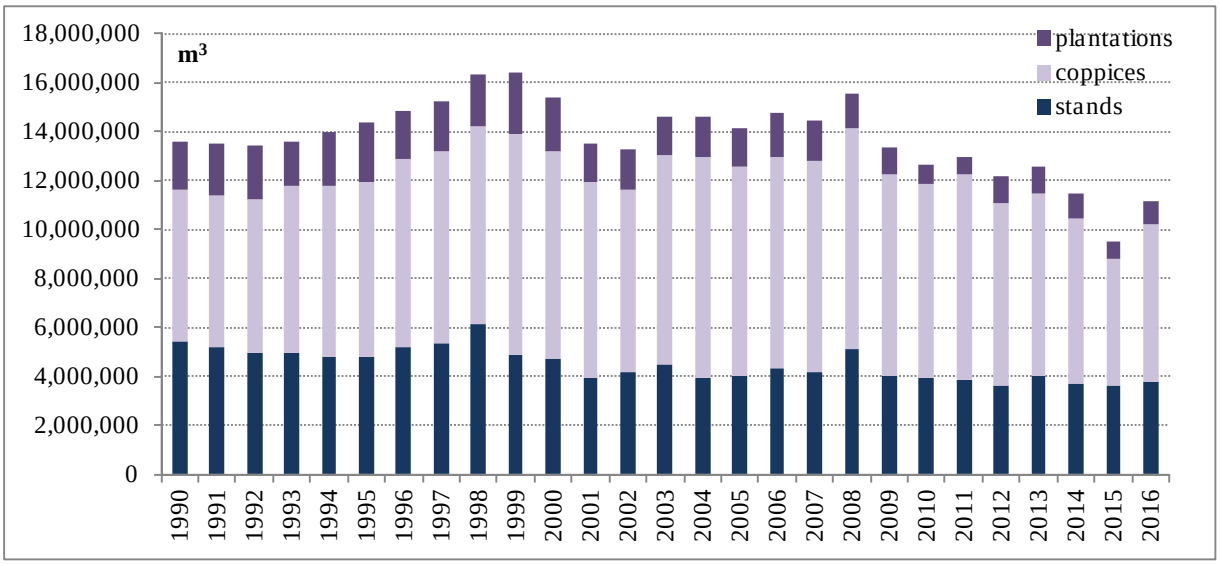


Figure 6.3 Harvest time series

Carbon amount released by forest fires has been included in the overall assessment of carbon stocks change.

[24] 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.
[25] INFC survey on harvested volume: http://www.sian.it/inventarioforestale/caricaDocumento?idAlle=442

In Figure 6.4, losses of carbon due to harvest and forest fires, referred to forest land category and reported as percentage on total aboveground carbon, are shown.

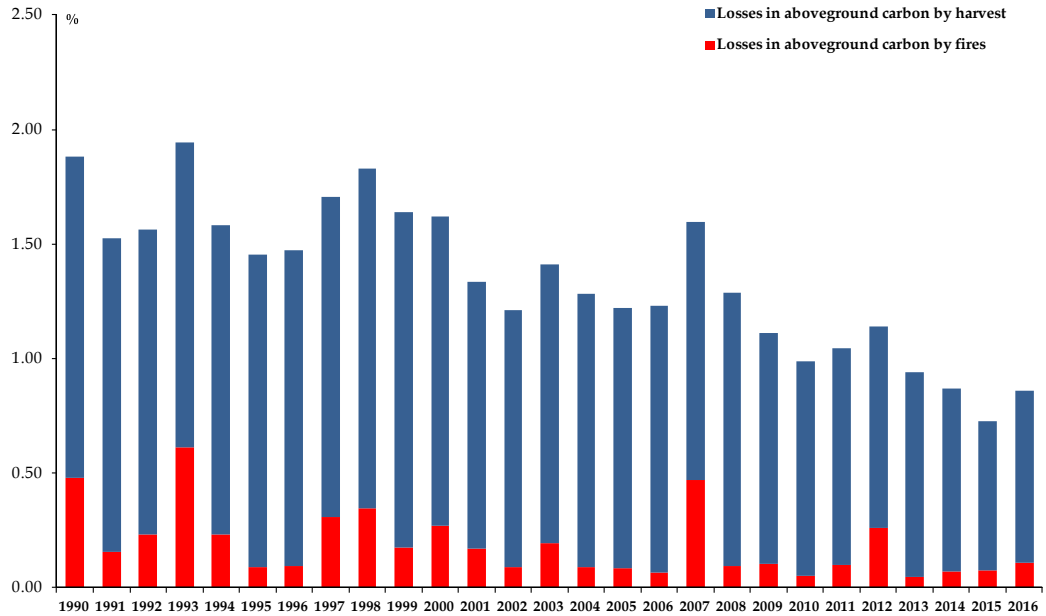


Figure 6.4 Losses by harvest and fires in relation to aboveground carbon

CO_2 emissions due to wildfires in forest land remaining forest land are included in CRF Table 4.A.1, carbon stocks change in living biomass - losses. Non-CO_2 emissions from fires have been estimated and reported in CRF table 4(V); details on the methodology used to estimate emissions are reported in the paragraph 6.12.2.
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 2016. In the following, the default value of carbon fraction of dry matter (0.47 t d.m.) has been applied to obtain carbon amount from biomass.
The net carbon stock change of living biomass has been calculated according to the 2006 IPCC Guidelines (IPCC, 2006), 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.

With regard to the aboveground biomass:

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

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

where:
GS = volume of growing stock (MAF/ISAFA, 1988) [m^3 ha^{-1}]
BEF = Biomass Expansion Factors which expands growing stock volume to volume of aboveground woody biomass (ISAFA, 2004)
WBD = Wood Basic Density for conversions from fresh volume to dry weight (d.m) [t m^{-3}] (Giordano, 1980)
A = forest area occupied by specific typology [ha] (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 [m^3 ha^{-1} y^{-1}] is computed with the derivative Richards function, for every specific forest typology by the Italian yield tables collection;

3. starting from 1986, for each year growing stock per hectare [m^3 ha^{-1}] is computed, from the previous year growing stock volume, adding the calculated increment ("y" value of the derivative Richards) for the current year and subtracting losses due to harvest, mortality and fire for the current year, as described above.
   Re-applying the relation:

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

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

In Table 6.4 biomass expansion factors for the conversions of volume to aboveground tree biomass and wood basic densities are reported.

Table 6.4 Biomass Expansion Factors and Wood Basic Densities

	Inventory typology	**BEF** *aboveground biomass / growing stock*	**WBD** *Dry weigth t/ fresh volume*
Stands	norway spruce	1.29	0.38
	silver fir	1.34	0.38
	larches	1.22	0.56
	mountain pines	1.33	0.47
	mediterranean pines	1.53	0.53
	other conifers	1.37	0.43
	european beech	1.36	0.61
	turkey oak	1.45	0.69
	other oaks	1.42	0.67
	other broadleaves	1.47	0.53
Coppices	european beech	1.36	0.61
	sweet chestnut	1.33	0.49
	hornbeams	1.28	0.66
	other oaks	1.39	0.65
	turkey oak	1.23	0.69
	evergreen oaks	1.45	0.72
	other broadleaves	1.53	0.53
	conifers	1.38	0.43
Plantations	eucalyptuses coppices	1.33	0.54
	other broadleaves coppices	1.45	0.53
	poplars stands	1.24	0.29
	other broadleaves stands	1.53	0.53
	conifers stands	1.41	0.43
	others	1.46	0.48
	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 [m^3 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 database[26]. 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 CANIF[27] (*CArbon and NItrogen cycling in Forest ecosystems*), CARBODATA[28] (*Carbon Balance Estimates and Resource Management - Support with Data from Project Networks Implemented at European Continental Scale*), CARBOINVENT[29] (*Multi-source inventory methods for quantifying carbon stocks and stock changes in European forests*) and COST[30] Action E21- Contribution of forests and forestry to mitigate greenhouse effects.

In Table 6.5 root/shoot ratio and wood basic densities are reported.

Table 6.5 Root/Shoot ratio and Wood Basic Densities

	Inventory typology	**R** *Root/shoot ratio*	**WBD** *Dry weigth t/ fresh volume*
stands	norway spruce	0.29	0.38
	silver fir	0.28	0.38
	Larches	0.29	0.56
	mountain pines	0.36	0.47
	mediterranean pines	0.33	0.53
	other conifers	0.29	0.43
	european beech	0.20	0.61
	turkey oak	0.24	0.69
	other oaks	0.20	0.67
	other broadleaves	0.24	0.53
coppices	european beech	0.20	0.61
	sweet chestnut	0.28	0.49
	Hornbeams	0.26	0.66
	other oaks	0.20	0.65
	turkey oak	0.24	0.69
	evergreen oaks	1.00	0.72
	other broadleaves	0.24	0.53
	Conifers	0.29	0.43
Plantations	eucalyptuses coppices	0.43	0.54
	other broadleaves coppices	0.24	0.53
	poplars stands	0.21	0.29
	other broadleaves stands	0.24	0.53
	conifers stands	0.29	0.43
	others	0.28	0.48
Prot. ectiv	rupicolous forest	0.42	0.52

[26] 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

[27] 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

[28] CARBODATA - Carbon Balance Estimates and Resource Management - Support with Data from Project Networks Implemented at European Continental Scale: http://afoludata.jrc.it/carbodat/proj_desc.html

[29] CARBOINVENT - Multi-source inventory methods for quantifying carbon stocks and stock changes in European forests; http://www.joanneum.at/carboinvent/

[30] 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

riparian forest	0.23	0.41

The dead organic matter carbon pool is defined, in the 2006 IPCC Guidelines (IPCC, 2006), as the sum of the dead wood and the litter.

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

The total amount of carbon for dead organic matter has been obtained from the dead organic matter (d.m.), multiplying by the conversion factor carbon content / dry matter.
The 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 NFI website: http://www.sian.it/inventarioforestale/jsp/dati_carquant_tab.jsp.
The definition of the deadwood pool, coherent with the definition adopted by the NFI, is related to "*All non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, stumps larger than or equal to 10 cm in diameter and standing trees with DBH > 4,5 cm*". Additional explanation on the data and parameters used for deadwood are included in the paper Di Cosmo et al., 2013, and in the NFI website (http://www.sian.it/inventarioforestale/jsp/necromassa.jsp).
In Table 6.6 dead wood coefficients are reported.

Table 6.6 Dead-wood expansion factor

	Inventory typology	**dead wood (dry matter)** *t ha*$^{-1}$
stands	norway spruce	6.360
	silver fir	7.770
	Larches	3.830
	mountain pines	4.385
	mediterranean pines	2.670
	other conifers	4.290
	european beech	3.350
	turkey oak	1.770
	other oaks	1.690
	other broadleaves	3.990
coppices	european beech	3.350
	sweet chestnut	12.990
	Hornbeams	2.730
	other oaks	1.690
	turkey oak	1.770
	evergreen oaks	1.370
	other broadleaves	2.690
	Conifers	4.290
plantations	eucalyptuses coppices	0.670
	other broadleaves coppices	0.670
	poplars stands	0.480
	other broadleaves stands	0.670
	conifers stands	3.040
protective	rupicolous forest	2.730
	riparian forest	4.790

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]

Carbon amount contained in litter pool has been estimated using the values of litter carbon content, per hectare, assessed by the Italian national forest inventory. The values used, aggregated at regional level, may be found on the NFI website: http://www.sian.it/inventarioforestale/jsp/dati_carquant_tab.jsp. The average value of litter organic carbon content, for Italy, is equal to 2.67 t C ha^{-1}.
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. 9.3.1.2.

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. 6.2.4 where forest land remaining forest land is concerned.
Net carbon stock change in dead organic matter and soil has been calculated as well. Italy used 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 2006 IPCC Guidelines (vol. 4, ch. 2, eq. 2.24, 2.25) 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, ERSAF 2008, Del Gardo *et al* 2003, LaMantia *et al* 2007, Benedetti *et al* 2004, Masciandaro and Ceccanti 1999, Xiloyannis 2007). Concerning forest soils, the SOCs reported in Table 6.7 have been used; each SOC reported in the abovementioned table has been used for the years indicated in the first column of Table 6.7. A detailed description of the methodology used in the estimation process of soils pool, and consequently of the SOCs, is provided in par. 9.3.1.2, related to the KP-LULUCF.

Table 6.7 Soil Organic Content (SOC) values for *forest land remaining forest land*

years	**SOC** *t C ha^{-1}*
1985-1994	79.809
1995-1999	80.172
2000-2004	80.575
2005-2009	81.083
2010-2014	81.601
2015	82.011
2016	82.141

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 6.8 carbon stock changes due to conversion to forest land, for the living biomass, dead organic matter and soil pools, have been reported.

Table 6.8 Carbon stock changes in land converting to forest land

	Conversion Area	Carbon stock change in living biomass			Net C stock change in dead organic matter	Net C stock change in mineral soils
	20 years change	***Increase***	***Decrease***	***Net change***		
year	*kha*			*Gg C*		
1990	689	2,160	-1,471	689	31	59
1991	736	2,269	-1,272	996	32	63
1992	782	2,381	-1,402	978	34	67
1993	829	2,494	-1,775	719	36	71
1994	876	2,607	-1,588	1,019	37	75
1995	923	2,721	-1,590	1,131	39	96
1996	989	2,880	-1,672	1,208	41	103
1997	1,055	3,033	-2,058	975	43	110
1998	1,121	3,185	-2,248	937	45	117
1999	1,187	3,346	-2,208	1,138	48	123
2000	1,252	3,505	-2,339	1,165	50	156
2001	1,317	3,651	-2,172	1,479	52	163
2002	1,381	3,800	-2,129	1,670	54	171
2003	1,445	3,947	-2,504	1,443	56	179
2004	1,509	4,094	-2,415	1,679	57	187
2005	1,577	4,246	-2,478	1,768	59	236
2006	1,556	4,197	-2,474	1,722	37	233
2007	1,536	4,125	-3,180	945	37	230
2008	1,516	4,056	-2,566	1,491	36	227
2009	1,495	3,988	-2,397	1,591	35	224
2010	1,475	3,924	-2,226	1,697	35	259
2011	1,454	3,861	-2,374	1,487	34	255
2012	1,434	3,802	-2,550	1,252	33	252
2013	1,414	3,741	-2,135	1,606	33	248
2014	1,393	3,679	-2,055	1,624	32	244
2015	1,373	3,614	-1,950	1,664	31	242
2016	1,353	3,738	-2,180	1,558	32	242

CO_2 emissions due to wildfires in land converting to forest land are included in CRF Table 4.A.2, carbon stocks change in living biomass - losses.
Non CO_2 emissions from fires have been estimated and reported in CRF table 4(V); details on the methodology used to estimate emissions are reported in paragraph 6.12.2.

6.2.5 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 1990–2016, Approach 1 of 2006 IPCC Guidelines (IPCC, 2006) has been followed. Input uncertainties dealing with activity data and emission factors have been assessed on the basis of the country specific information and the values provided in the 2006 IPCC Guidelines (IPCC, 2006).

In Table 6.9, the values of carbon stocks in the reported pools, for the year 1985, and the abovementioned uncertainties are reported.

Table 6.9 Carbon stocks and uncertainties for year 1985 and current increment related uncertainty

Carbon stocks *t CO_2 eq. ha^{-1}*	*Aboveground biomass*	V_{AG}	139.92
	Belowground biomass	V_{BG}	31.6
	Dead wood	V_D	3.3

	Litter	V_L	2.7
Uncertainty	*Growing stock*	E_{NFI}	3.2%
	Current increment (Richards)[31]	E_{NFI}	51.6%
	Harvest	E_H	30%
	Fire	E_F	30%
	Drain and grazing	E_D	30%
	Mortality	E_M	30%
	BEF	E_{BEF1}	30%
	R	E_R	30%
	deadwood	E_{DEF}	4.6%
	Litter	E_L	10%
	Basic Density	E_{BD}	30%
	C Conversion Factor	E_{CF}	2%

The uncertainties related to the carbon pools and the overall uncertainty for 1985 has been computed and shown in Table 6.10.

Table 6.10 Uncertainties for the year 1985

Aboveground biomass	E_{AG}	42.59%
Belowground biomass	E_{BG}	52.10%
Dead wood	E_D	42.84%
Litter	E_L	43.75%
Overall uncertainty	$\mathbf{E_{1985}}$	**34.85%**

The overall uncertainty related to 1985 (the year of the first National Forest Inventory) has been propagated through the years, till 2016, following Approach 1.
The uncertainties related to the carbon pools and the overall uncertainty for 2016 are shown in Table 6.11.

Table 6.11 Uncertainties for the year 2014

Aboveground biomass	E_{AG}	42.64%
Belowground biomass	E_{BG}	52.14%
Dead wood	E_D	42.89%
Litter	E_L	43.80%
Overall uncertainty	**E**	**35.37%**

Following Approach 1 and the abovementioned methodology, the overall uncertainty in the estimates produced by the described model has been quantified; in Table 6.12 the uncertainties of the 1985-2016 period are reported.

Table 6.12 Overall uncertainties 1985 – 2015 (%)

1985	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
34.9	35.0	35.1	35.2	35.2	35.3	35.3	35.3	35.3	35.3	35.4	35.4

The overall uncertainty in the model estimates between 1990 and 2016 has been assessed with the following relation:

$$E_{1990-2016} = \frac{\sqrt{\left(E_{1990} \cdot V_{1990}\right)^2 + \left(E_{2016} \cdot V_{2015}6\right)^2}}{\left|V_{1990} + V_{2016}\right|}$$

[31] 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

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 1990–2016 is equal to 25.1%.
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, deadwood and litter pools, estimated with the described methodology, and the II NFI data (INFC2005) is reported in Table 6.13.

Table 6.13 Comparison between estimated and INFC2005 aboveground carbon stock

	INFC2005	**For-est model**	*differences*	
	t C	*t C*	*t C*	*%*
aboveground	456,857,390	425,240,589	-31,616,801	**-6.92**
deadwood	15,987,541	15,869,766	-117,775	**-0.74**
litter	28,170,660	28,138,039	-32,621	**-0.12**

6.2.6 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 database[32], ISTAT data[33]) 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 6.5 outcome of the comparison is shown.

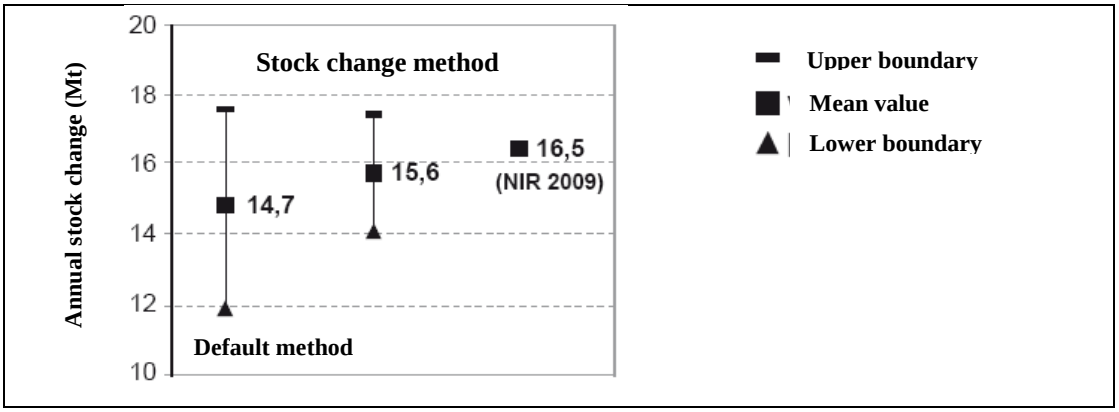


Figure 6.5 Comparison between carbon stock changes, for living biomass pool, by the National Inventory (NIR, 2009) and estimated data on the basis of NFI2005 (II NFI) measurements (modified from Tabacchi et al., 2010)

The II NFI 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 NFI2005 and first forest inventory classification systems, has been planned to be elaborated. In the meanwhile a comparison

[32] FAO, 2015. FAOSTAT, http://faostat3.fao.org/home/E
[33] ISTAT, several years [a], [b], [c]

among NFI2005 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 6.6 the comparison has been reported.

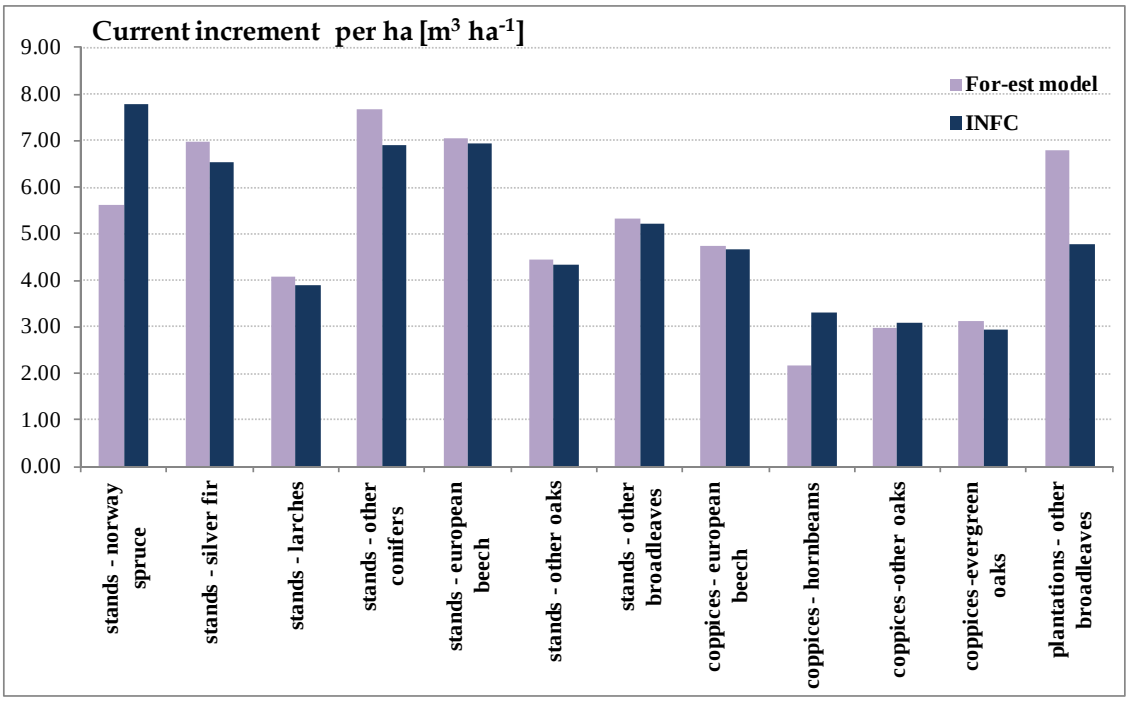


Figure 6.6 Comparison among NFI2005 (INFC) current increment data and For-est model current increment data

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 Piazzi, 2006). Results show a good agreement between the two dataset either in litter and soil. An interregional project, named INEMAR[34], 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 6.7 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 (ARPA Lombardia - Regione Lombardia, 2011 [a, b]).

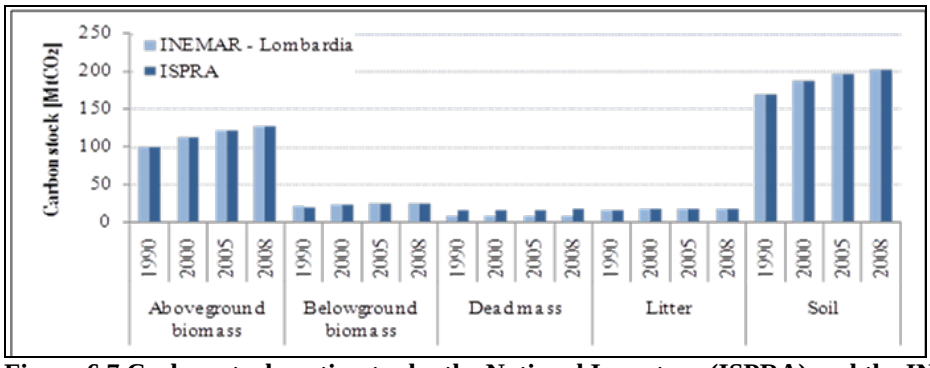


Figure 6.7 Carbon stocks estimates by the National Inventory (ISPRA) and the INEMAR project for Lombardia

In Table 6.14 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.

[34] INEMAR: INventario EMissioni Aria: http://www.ambiente.regione.lombardia.it/inemar/e_inemarhome.htm

Table 6.14 Carbon stocks estimates by the National Inventory (ISPRA) and the INEMAR project for Lombardia

	INEMAR - Lombardia	ISPRA	Differences
	Gg CO_2	*Gg CO_2*	*%*
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.
An additional verification activity has been carried out, comparing the implied carbon stock change per area (IEF), related to the living biomass, with the IEFs reported by other Parties. The 2014 submission has been considered to deduce the different IEFs; in the figure 6.8 the comparison is showed, taking into account the IEFs for both the forest land remaining forest land (FL-FL) and land converting to forest land (L-FL) subcategories, for the living biomass.

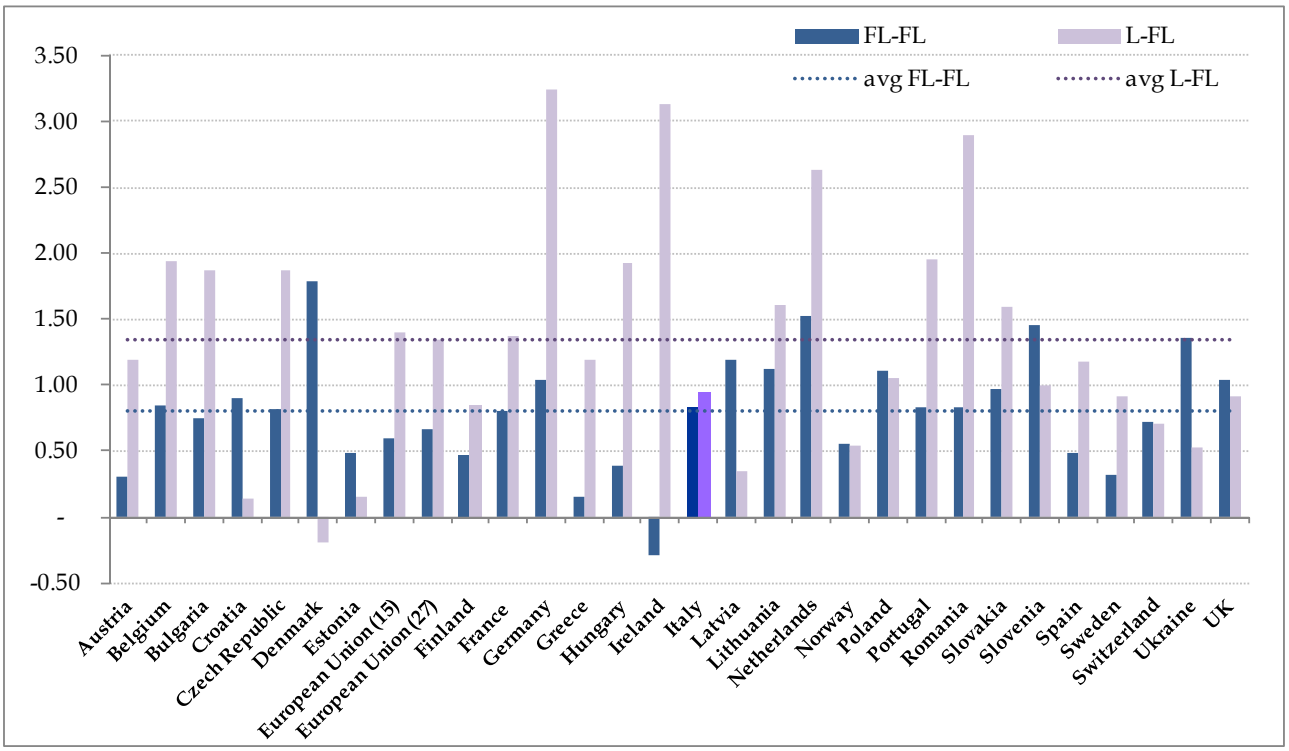


Figure 6.8 Implied carbon stock change per area for the living biomass

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 have been used in the refining estimation process.

6.2.7 Category-specific recalculations

No deviations from the 2016 submission sectoral estimates are resulting for forest land category.

6.2.8 Category-specific planned improvements

The implementation of the III national forest inventory, which has already completed the first phase related to forest area assessment, is increased the robustness of the data sources used in the estimation process. The third NFI, which has the same sampling design of the previous one, is a three-phase inventory. In particular the ongoing field surveys, related to the qualitative and quantitative attributes measurements, planned to provide results in 2019, will allow using the IPCC carbon stock change method to estimate emissions and removals for forest land remaining forest land category. In addition a comparison between the two IPCC methods (carbon stock change versus gains-losses) could be undertaken; the comparison is a valuable verification exercise and is able to highlight any potential outlier which detaches the two estimates.
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, 2014) and includes information on units of lands subject to 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) has been completed, resulting in land use classification, for all national territory, for the years 1990, 2000 and 2008. After a process of validation and verification, the IUTI data has been used in the previous and in the current submission. An update of the for-est model has been done; the II NFI-NFI2005 (CRA-MPF, several years) data related to the litter carbon content, collected in the framework of II NFI surveys, have been implemented in the model and land use and land use changes assessment has been carried out through the use of IUTI results.
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 EUROSTAT[35], 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.
Following the election of Cropland Management and Grazing land Management activities under article 3.4 of the Kyoto Protocol, the Ministry for the Environment, Land and Sea (MATTM) jointly with the Ministry of Agriculture, Food and Forest Policies (MIPAAF) has established a Committee of National experts at institutional and scientific level, aimed to deal with all issues related to reporting and coordination of activities related to LULUCF reporting, included also the needs set out by the Kyoto Protocol.
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.
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.

[35] Eurostat is the statistical office of the European Union: http://epp.eurostat.ec.europa.eu/portal/page/portal/about_eurostat/introduction

6.3 Cropland (4B)

6.3.1 Description

Under this category, CO_2 emissions from living biomass, dead organic matter and soils, from cropland remaining cropland and from land converted in cropland have been reported.
Cropland emissions and removals share 4.6% of total 2016 LULUCF CO_2 eq. emissions and removals; in particular, the living biomass emissions and removals represent 50.4%, while the emissions and removals from soils stand for 49.6% of total cropland CO_2 emissions and removals.
CO_2 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. CO_2 emissions and removals from land converting to cropland have been identified as key category with Approach 2 concerning trend assessment. Concerning N_2O and CH_4 emissions, the category land converting to cropland has not resulted as a key source.

6.3.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

Following 2013 ERT's finding, plantations, previously included into cropland category, have been allocated in forest land category. For the land use conversion, land use change matrices have been used; as abovementioned, LUC matrices for each year of the period 1990–2016 have been assembled on the basis of the IUTI data, related to 1990, 2000 and 2008 and 2012. 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. The IPCC default land use transition period of 20 years has been used, 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.

6.3.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

Cropland areas have been assessed on the basis of IUTI assessment; due to the technical characteristics of the IUTI assessment (i.e. classification of orthophotos for 1990, 2000, 2008 and 2012), it was technically impossible to have a clear distinction among some subcategories in *cropland* and *grassland* categories (i.e. annual pastures versus grazing land). Therefore it has been decided to aggregate the *cropland* and *grassland* categories, as detected by IUTI, and then disaggregate them into the different subcategories, using as proxies the national statistics (ISTAT, [b], [c]) related to annual crops and perennial woody crops. 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.

6.3.4 Methodological issues

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. 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 2006 IPCC Guidelines.

Perennial – woody crops

Concerning woody crops, estimates of carbon stocks changes are applied to aboveground biomass only, according to the 2006 IPCC Guidelines (IPCC, 2006). 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 (JRC[36]) 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 -189 Gg C for 1990, and -272 Gg C for 2016, as far as living biomass pool is concerned. In Table 6.16 change in carbon stock in living biomass are reported.

Table 6.16 Change in carbon stock in living biomass

	Area	**Gains (Area <30yrs)**		**Losses**		**net change in C stock**
year	*Kha*	*kha*	*GgC*	*Kha*	*GgC*	*GgC*
1990	2,698	70	35	-22	-224	-189
1991	2,701	58	29	0	0	29
1992	2,704	49	25	0	0	25
1993	2,707	40	20	0	0	20
1994	2,710	32	16	0	0	16
1995	2,712	23	11	0	0	11
1996	2,691	14	7	-21	-212	-206
1997	2,670	14	7	-21	-213	-206
1998	2,648	14	7	-21	-213	-206
1999	2,627	14	7	-21	-213	-206
2000	2,606	14	7	-21	-213	-206
2001	2,600	14	7	-6	-57	-50
2002	2,594	14	7	-6	-57	-50
2003	2,589	14	7	-6	-57	-50
2004	2,583	14	7	-6	-57	-50
2005	2,577	14	7	-6	-57	-50
2006	2,578	14	7	0	0	7
2007	2,579	14	7	0	0	7
2008	2,579	15	8	0	0	8
2009	2,577	16	8	-2	-25	-17
2010	2,574	16	8	-2	-25	-17
2011	2,540	16	8	-34	-339	-331
2012	2,507	13	7	-34	-339	-333
2013	2,473	10	5	-34	-339	-334
2014	2,439	7	4	-34	-339	-335
2015	2,405	5	2	-34	-339	-337
2016	2,378	2	1	-27	-273	-272

[36] European Commission's Joint Research Centre (JRC) - Institute for Environment and Sustainability (IES): http://ies.jrc.ec.europa.eu/

According to the 2006 IPCC Guidelines (IPCC, 2006), the change in soil C stocks (vol. 4, chapter 2, eq. 2.25) 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 1990-2016 under investigation; therefore, as no management changes can be documented, resulting change in carbon stock has been reported as zero.
CO_2 emissions from cultivated organic soils (CRPA, 1997) in cropland remaining cropland have been estimated, using default emission factor for warm temperate, reported in Table 5.6 of 2006 IPCC Guidelines (vol.4, chapter 5); the IPCC default EF for cultivated organic soils is equal to 10 t C ha^{-1} y^{-1}. The area of organic soils has been updated on the basis of the data reported in the FAOSTAT[37] database; these FAOSTAT assessement have been carried out through the stratification of different global datasets:
- the area covered by organic soils have been defined by extracting the Histosols classes from the *Harmonized World Soil Database*[38];
- the cultivated area has been identified from the global land cover dataset, GLC2000[39], using the three "cropland" classes.

Land converted to Cropland
In accordance with the IPCC methodology, estimates of carbon stock change in living biomass have been provided. Italy uses 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.
N_2O emissions arising from the conversion of land to cropland have been also estimated, and reported in Table 4(III) - Direct nitrous oxide (N_2O) emissions from nitrogen mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils.
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 2016, has been estimated through the construction of the land use change matrices, one for each year. The 2006 IPCC Guidelines equation 2.16 (vol. 4, chapter 2) 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 6.4 of the 2006 IPCC Guidelines (vol. 4, chapter 6) 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 5.9 of the 2006 IPCC Guidelines (vol. 4, chapter 5), 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.
As pointed out in the land use matrices reported above, in Table 6.3, conversion of lands into cropland has taken place only in a few years during the period 1990-2016. C emissions [Gg C] due to change in carbon stocks in living biomass in land converted to cropland are reported in Table 6.17.

Table 6.17 Change in carbon stock in living biomass in land converted to cropland

	Conversion Area		**$\Delta C_{converted\ land}$**
	annual change	*20 years change*	
year	*kha*	*kha*	*Gg C*
1990	0	136	0

[37] FAOSTAT database: http://faostat3.fao.org/faostat-gateway/go/to/download/G1/GV/E
[38] FAO/IIASA/ISRIC/ISSCAS/JRC, 2012. Harmonized World Soil Database (version 1.2). FAO, Rome, Italy and IIASA, Laxenburg, Austria.
[39] EC-JRC. 2003. Global Land Cover 2000 database. Available at http://bioval.jrc.ec.europa.eu/products/glc2000/glc2000.php

	Conversion Area		$\Delta C_{converted\ land}$
	annual change	*20 years change*	
year	*kha*	*kha*	*Gg C*
1991	16.8	153	-12.9
1992	16.8	170	-12.9
1993	16.8	186	-12.9
1994	16.8	203	-12.9
1995	16.8	220	-12.9
1996	0	193	0
1997	0	166	0
1998	0	138	0
1999	0	111	0
2000	0	84	0
2001	0	84	0
2002	0	84	0
2003	0	84	0
2004	0	84	0
2005	0	84	0
2006	0	84	0
2007	0	84	0
2008	0	84	0
2009	0	84	0
2010	0	84	0
2011	0	67	0
2012	0	50	0
2013	0	34	0
2014	0	17	0
2015	0	0	0
2016	80	80	-62

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 t C/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, ERSAF 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 2.25 of the the 2006 IPCC Guidelines (vol. 4, chapter 2). C emissions [Gg C] due to change in carbon stocks in soils in land converted to cropland are reported in Table 6.18.

Table 6.18 Change in carbon stock in soil in land converted to cropland

	Conversion Area		**Carbon stock**
	annual change	*20 years change*	
year	*kha*	*kha*	*Gg C*
1990	0	136.1	-145.6
1991	16.8	152.9	-163.6
1992	16.8	169.7	-181.5
1993	16.8	186.5	-199.5
1994	16.8	203.2	-217.4
1995	16.8	220.0	-235.3
1996	0	192.8	-206.2
1997	0	165.5	-177.1
1998	0	138.3	-147.9
1999	0	111.1	-118.8
2000	0	83.8	-89.7
2001	0	83.8	-89.7
2002	0	83.8	-89.7
2003	0	83.8	-89.7
2004	0	83.8	-89.7
2005	0	83.8	-89.7
2006	0	83.8	-89.7
2007	0	83.8	-89.7
2008	0	83.8	-89.7
2009	0	83.8	-89.7
2010	0	83.8	-89.7
2011	0	67.1	-71.8
2012	0	50.3	-53.8
2013	0	33.5	-35.9
2014	0	16.8	-17.9
2015	0	0.0	0
2016	80	80.5	-86

6.3.5 Uncertainty and time series consistency

Uncertainty estimates for the period 1990–2016 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). Input uncertainties dealing with activity data and emission factors have been assessed on the basis of the information provided in the 2006 IPCC Guidelines (IPCC, 2006).
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.

6.3.6 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 database[40], ISTAT data[41]) 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.

6.3.7 Category-specific recalculations

No deviations from the 2016 submission sectoral estimates are resulting for cropland category.

6.3.8 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.
Following the election of Cropland Management and Grazing land Management activities under article 3.4 of the Kyoto Protocol, the Ministry for the Environment, Land and Sea (MATTM) jointly with the Ministry of Agriculture, Food and Forest Policies (MIPAAF) has established a Committee of National experts at institutional and scientific level, aimed to deal with all issues related to reporting and coordination of activities related to LULUCF reporting, included also the needs set out by the Kyoto Protocol; a focus will be applied to verification activities carried out in the framework of the implementation of EU Decision n. 529/2013[42]. In the same framework, activity data and emission factors will be analyzed (checking availability and quality) and consequently reporting for *Cropland* category will be improved.
In late 2016, the LIFE project "Mediterranean Network for Reporting Emissions and Removals in Cropland and Grazing land Management" MEDINET[43] has started, with the specific goal to create a a solid network among mediterranean institutions involved in the reporting/accounting of emissions and removals at national level, including also universities, research centers and relevant stakeholders, ir order to collect and share data with relevance for reporting croplands and grasslands emissions in Mediterranean conditions, in particular for mineral soil and aboveground biomass of perennial crops.
In addition, in 2013, the joint project "ITALI" (*Integration of Territorial And Land Information*) started its activities; the project, coordinated by the National Institute of Statistics and promoted by EUROSTAT[44], involves ISPRA, the Ministry of Agriculture, Food and Forest Policies, the National Forestry Service and the

[40] FAO, 2005. FAOSTAT, http://faostat3.fao.org/home/E
[41] ISTAT, several years [a], [b], [c]
[42] Decision n. 529/2013/EU of the European Parliament and of the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities**:** http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013D0529
[43] http://www.lifemedinet.com/
[44] Eurostat is the statistical office of the European Union: http://epp.eurostat.ec.europa.eu/portal/page/portal/about_eurostat/introduction

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.

6.4 Grassland (4C)

6.4.1 Description

Under this category, CO_2 emissions from living biomass, dead organic matter and soils, from grassland remaining grassland and from land converted in grassland have been reported.
Grassland category is responsible for 6,644 Gg of CO_2 removals in 2016, sharing 11.9% of absolute CO_2 eq. LULUCF emissions and removals; in particular the living biomass emissions represent 6.8%, while the removals from dead organic matter pool share for 20.5% and removals from soils stand for 72.7% of absolute total grassland CO_2 emissions and removals.
CO_2 emissions and removals from grassland remaining grassland have resulted key category in trend assessment and key category with Approach 2 concerning level assessment; CO_2 emissions and removals from land converted to grassland have resulted key category in level and trend assessment with Approach 1 and Approach 2. CH_4 emissions and removals from grassland remaining grassland have been identified as a key category with Approach 2 concerning trend assessment. Concerning N_2O emissions, the category land converting to grassland has not resulted as a key source.

6.4.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

Consistently 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 1990–2016 have been assembled on the basis of the IUTI data, related to 1990, 2000 and 2008 and 2012. Annual figures for areas in transition between different land uses have been derived by a hierarchy of basic assumptions (informed by expert judgment) 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. Italy uses 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.

6.4.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

Grassland areas have been assessed on the basis of IUTI assessment; due to the technical characteristics of the IUTI assessment (i.e. classification of orthophotos for 1990, 2000, 2008 and 2012), it was technically impossible to have a clear distinction among some subcategories in *cropland* and *grassland* categories (i.e. annual pastures versus grazing land). Therefore it has been decided to aggregate the *cropland* and *grassland* categories, as detected by IUTI, and then disaggregate them into the different subcategories, using as proxies the 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 (CRA-MPF, several years) (NFI1985, NFI2005 and the ongoing NFI2015), through linear interpolations for the periods 1985-2005, 2005-2012 and linear extrapolation for 2012-2016. 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.

6.4.4 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 2006 IPCC Guidelines (IPCC, 2006) no data regarding the dead organic matter pool have been provided, since not enough information is available.
According to the 2006 IPCC Guidelines (IPCC, 2006), the estimation method is based on changes in soil C stocks over a finite period following changes in management that impact soil C (eq. 2.25, vol.4, chapter 2). 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 1990-2016; therefore, as no management changes can be documented, resulting change in carbon stock has been reported as zero.
CO_2 emissions from organic soils in grassland remaining grassland been estimated, using default emission factor for warm temperate, reported in Table 5.6 of 2006 IPCC Guidelines (vol.4, chapter 5); the IPCC default EF for cultivated organic soils is equal to 10 t C ha^{-1} y^{-1}. The area of organic soils has been updated on the basis of the data reported in the FAOSTAT[45] database; these FAOSTAT assessement have been carried out through the stratification of different global datasets:
- the area covered by organic soils have been defined by extracting the Histosols classes from the *Harmonized World Soil Database*[46]
- the grassland area has been identified from the global land cover dataset, GLC2000[47].

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 6.2.4.
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) [m^3 ha-^{1}]
BEF = Biomass Expansion Factors which expands growing stock volume to volume of aboveground woody biomass (ISAFA, 2004)
WBD = Wood Basic Density for conversions from fresh volume to dry weight (d.m.) [t m^{-3}] (Giordano, 1980)
A = area occupied by specific typology [ha] (MAF/ISAFA, 1988)

In Table 6.20 biomass expansion factors for the conversions of volume to aboveground tree biomass and wood basic densities are reported.

[45] FAOSTAT database: http://faostat3.fao.org/faostat-gateway/go/to/download/G1/GV/E
[46] FAO/IIASA/ISRIC/ISSCAS/JRC, 2012. Harmonized World Soil Database (version 1.2). FAO, Rome, Italy and IIASA, Laxenburg, Austria.
[47] EC-JRC. 2003. Global Land Cover 2000 database. Available at http://bioval.jrc.ec.europa.eu/products/glc2000/glc2000.php

Table 6.20 Biomass Expansion Factors and Wood Basic Densities for shrublands

Inventory typology	BEF *aboveground biomass / growing stock*	WBD *Dry weigth 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 [$m^3\,ha^{-1}$]
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 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 database[48]. Further details are reported in par. 6.2.4.
In Table 6.21 Root/shoot ratio for the conversion of growing stock biomass in belowground biomass and wood basic density for shrubland are reported.

Table 6.21 Root/Shoot ratio and Wood Basic Densities for shrubland

Inventory typology	R *Root/shoot ratio*	WBD *Dry weigth 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 NFI website: http://www.sian.it/inventarioforestale/jsp/dati_carquant_tab.jsp.
In Table 6.22 Dead wood coefficients are reported.
The dead wood [t] is computed, as:

$$\text{Dead wood (d.m.)} = DC \cdot A$$

where:
DC = Dead-wood expansion factor (dead/live ratio – dry matter) [$t\,ha^{-1}$]
A = forest area occupied by specific typology [ha]

Table 6.22 Dead-wood expansion factor [live/dead ratio]

Inventory typology	dead wood (dry matter) $t\,ha^{-1}$
Shrublands	1.510

Carbon amount contained in litter pool has been estimated using the values of litter carbon content assessed by the Italian national forest inventory. The values used, aggregated at regional level, may be found on the INFC website: http://www.sian.it/inventarioforestale/jsp/dati_carquant_tab.jsp. The average value of litter organic carbon content, for Italy, is equal to 1.990 t C ha^{-1}.

[48] 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

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 6.23, other wooded land areas and net changes in carbon stock, for the different required pools, are reported, for the period 1990-2016.

Table 6.23 Change in carbon stock in living biomass, dead organic matter and soil organic matter in other wooded land

	Area	**Living biomass**			**Dead organic matter**
		Increase	*Decrease*	*Net Change*	
	kha			*Gg C*	
1990	1,554	2,293	-2,387	-93.70	31.11
1991	1,570	2,328	-2,174	154.29	31.11
1992	1,586	2,366	-2,296	69.88	31.11
1993	1,602	2,412	-2,636	-224.10	31.11
1994	1,618	2,447	-2,315	132.47	31.11
1995	1,634	2,476	-2,119	356.41	31.11
1996	1,650	2,504	-2,149	355.57	31.11
1997	1,665	2,537	-2,321	215.39	31.11
1998	1,681	2,573	-2,483	90.03	31.11
1999	1,697	2,602	-2,266	335.97	31.11
2000	1,713	2,635	-2,421	213.40	31.11
2001	1,729	2,663	-2,314	349.65	31.11
2002	1,745	2,690	-2,274	416.06	31.11
2003	1,760	2,718	-2,364	354.46	31.11
2004	1,776	2,744	-2,317	427.51	31.11
2005	1,792	2,770	-2,319	450.44	31.11
2006	1,804	2,801	-2,317	483.76	25.60
2007	1,815	2,829	-2,836	-6.78	25.60
2008	1,827	2,844	-2,396	448.04	25.60
2009	1,838	2,861	-2,465	395.64	25.60
2010	1,850	2,874	-2,353	520.83	25.60
2011	1,861	2,889	-2,462	427.65	25.60
2012	1,873	2,910	-2,667	242.38	25.60
2013	1,884	2,922	-2,375	546.67	25.60
2014	1,896	2,935	-2,420	515.36	25.60
2015	1,907	2,950	-2,490	460.12	25.60
2016	1,907	2,967	-2,582	384.30	25.60

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 IPCC methodology, estimates of carbon stock change in living biomass have been provided. Concerning soil carbon pool, Italy uses 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 to grassland during each year has been pointed out, from 1990 to 2016, for each initial and final land use, through the use of the land use change matrices, one for each year. The 2006 IPCC Guidelines equation 2.16 (vol. 4, chapter 2) 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 6.4 of the 2006 IPCC Guidelines (vol. 4, chapter 6) 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 5.9 of the 2006 IPCC Guidelines (vol. 4, chapter 5), for annual cropland.
As pointed out above in the land use matrices (see Table 6.3), the conversion of lands into grassland has taken place only in a few years during the period 1990-2016. C emissions [Gg C] due to change in carbon stocks in living biomass in land converted to grassland, are reported in Table 6.24.

Table 6.24 Change in carbon stock in living biomass in land converted to grassland

	Conversion Area		**C_{before}**	**ΔC_{growth}**	**ΔC**
	annual change	*20 years change*			
year	*kha*	*Kha*	*t C ha^{-1}*	*t C ha^{-1}*	*Gg C*
1990	0	325	4.7	2.87	0
1991	0	318	4.7	2.87	0
1992	0	312	4.7	2.87	0
1993	0	305	4.7	2.87	0
1994	0	299	4.7	2.87	0
1995	0	292	4.7	2.87	0
1996	60	353	4.7	2.87	-111
1997	60	413	4.7	2.87	-111
1998	60	473	4.7	2.87	-111
1999	60	534	4.7	2.87	-111
2000	60	594	4.7	2.87	-111
2001	94	630	4.7	2.87	-173
2002	94	666	4.7	2.87	-173
2003	94	702	4.7	2.87	-173
2004	94	738	4.7	2.87	-173
2005	97	777	4.7	2.87	-179
2006	85	862	4.7	2.87	-156
2007	85	947	4.7	2.87	-156
2008	85	1,032	4.7	2.87	-156
2009	172	1,204	4.7	2.87	-316
2010	172	1,377	4.7	2.87	-316
2011	38	1,415	4.7	2.87	-70
2012	38	1,453	4.7	2.87	-70
2013	38	1,491	4.7	2.87	-70
2014	38	1,529	4.7	2.87	-70
2015	38	1,567	4.7	2.87	-70
2016	0	1,507	4.7	2.87	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 [SOC_0] 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^{-1} 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^{-1} (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, ERSAF 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 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 2.25 of the the 2006 IPCC Guidelines (vol. 4, chapter 2). C emissions [Gg C] due to change in carbon stocks in soils in land converted to grassland, are reported in Table 6.25.

Table 6.25 Change in carbon stock in soils

	Conversion Area		**Carbon stock**
year	*annual change*	*20 years change*	
	kha	*kha*	*Gg C*
1990	0	325	348
1991	0	318	341
1992	0	312	334
1993	0	305	327
1994	0	299	320
1995	0	292	313
1996	60	353	377
1997	60	413	442
1998	60	473	506
1999	60	534	571
2000	60	594	635
2001	94	630	674
2002	94	666	712
2003	94	702	751
2004	94	738	789
2005	97	777	831
2006	85	862	922
2007	85	947	1,013
2008	85	1,032	1,104
2009	172	1,204	1,288
2010	172	1,377	1,473
2011	38	1,415	1,513
2012	38	1,453	1,554
2013	38	1,491	1,595
2014	38	1,529	1,635
2015	38	1,567	1,635
2016	0	1,507	1,635

6.4.5 *Uncertainty and time series consistency*

Uncertainty estimates for the period 1990–2015 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). Input uncertainties dealing with activity data and emission factors have been assessed on the basis of the information provided in the 2006 IPCC Guidelines (IPCC, 2006).
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.

6.4.6 *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 database[49], ISTAT data[50]) 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 meetings, 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.

6.4.7 *Category-specific recalculations*

The comparison with the 2016 submission sectoral estimates results in a slight deviation (an average[51] decrease of 0.1% for the grassland category), due to the activity data updating and errors' correction.

6.4.8 *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.
Following the election of Cropland Management and Grazing land Management activities under article 3.4 of the Kyoto Protocol, the Ministry for the Environment, Land and Sea (MATTM) jointly with the Ministry of Agriculture, Food and Forest Policies (MIPAAF) has established a Committee of National experts at institutional and scientific level, aimed to deal with all issues related to reporting and coordination of activities related to LULUCF reporting, included also the needs set out by the Kyoto Protocol; a focus will be applied to verification activities carried out in the framework of the implementation of EU Decision n. 529/2013[52]. In the same framework, activity data and emission factors will be analyzed (checking availability and quality) and consequently reporting for *grassland* category will be improved.

[49] FAO, 2005. FAOSTAT, http://faostat3.fao.org/home/E
[50] ISTAT, several years [a], [b], [c]
[51] Average value on the period 1990-2014
[52] Decision n. 529/2013/EU of the European Parliament and of the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities**:** http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013D0529

In late 2016, the LIFE project "Mediterranean Network for Reporting Emissions and Removals in Cropland and Grazing land Management" MEDINET has started, with the specific goal to create a a solid network among mediterranean institutions involved in the reporting/accounting of emissions and removals at national level, including also universities, research centers and relevant stakeholders, ir order to collect and share data with relevance for reporting croplands and grasslands emissions in Mediterranean conditions, in particular for mineral soil and aboveground biomass of perennial crops.
In 2013, the joint project "ITALI" (*Integration of Territorial And Land Information*) started its activities; the project, coordinated by the National Institute of Statistics and promoted by EUROSTAT[53], 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.

6.5 Wetlands (4D)

6.5.1 Description

Under this category, activity data from wetlands remaining wetlands are reported. Neither wetlands remaining wetlands nor land converting to wetlands have resulted as a key category.

6.5.2 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 1990–2016 have been assembled on the basis of the IUTI data, related to 1990, 2000, 2008 and 2012, through linear interpolations for the periods 1990-2005, 2005-2012 and linear extrapolation for 2012-2016. 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 land converted to wetland, during the period 1990-2016, cropland and grassland categories have been converted into wetlands area.

6.5.3 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). CO_2 emissions related to land converted to Wetlands, addressing the 2014 review's recommendation. Reservoirs or water bodies regulated by human activities have not been considered.

6.5.4 Methodological issues

CO_2, emissions from flooded lands have been supplied. According to the 2006 IPCC guidelines eq 7.10 (vol. 4, chapter 7) the biomass stock after flooding is zero. The biomass in land immediately before conversion to flooded land have been estimated on the basis of the default values reported in the 2006 IPCC guidelines:
GL (B_{before}): the value reported in table 6.4 (vol 4, chapter 6) for warm temperate dry, equal to 6.1 t d.m. ha^{-1} has been used; CL (B_{before}): the value reported in par. 6.3.1.2 (vol 4, chapter 6) for cropland containing annual crops, equal to 10 t d.m. ha^{-1} has been used.

[53] Eurostat is the statistical office of the European Union: http://epp.eurostat.ec.europa.eu/portal/page/portal/about_eurostat/introduction

In Table 6.26 C stocks [Gg C] related to change in carbon stocks in living biomass in cropland converted to wetlands are reported.

Table 6.26 Change in carbon stocks in living biomass in cropland converted to wetlands

	annual change	**20 yrs change**	**B after**	**B before**	**ΔC *converted***
	kha	*kha*	*t d.m. ha-1*	*t d.m. ha-1*	*GgC*
1990	0	0	0	10	0
1991	0	0	0	10	0
1992	0	0	0	10	0
1993	0	0	0	10	0
1994	0	0	0	10	0
1995	0	0	0	10	0
1996	0.47	0.47	0	10	-2.23
1997	0.47	0.95	0	10	-2.23
1998	0.47	1.42	0	10	-2.23
1999	0.47	1.89	0	10	-2.23
2000	0.47	2.37	0	10	-2.23
2001	0.47	2.84	0	10	-2.23
2002	0.47	3.32	0	10	-2.23
2003	0.47	3.79	0	10	-2.23
2004	0.47	4.26	0	10	-2.23
2005	0.47	4.74	0	10	-2.23
2006	0.47	5.21	0	10	-2.23
2007	0.47	5.68	0	10	-2.23
2008	0.47	6.16	0	10	-2.23
2009	0	6.16	0	10	0
2010	0	6.16	0	10	0
2011	0	6.16	0	10	0
2012	0	6.16	0	10	0
2013	0	6.16	0	10	0
2014	0	6.16	0	10	0
2015	0	6.16	0	10	0
2016	0	5.68	0	10	0

In Table 6.27 C stocks [Gg C] related to change in carbon stocks in living biomass in grassland converted to wetlands are reported.

Table 6.27 Change in carbon stocks in living biomass in grassland converted to wetlands

	annual change	**20 yrs change**	**B after**	**B before**	**ΔC *converted***
	kha	*kha*	*t d.m. ha-1*	*t d.m. ha-1*	*GgC*
1990	0	0	0	6.1	0
1991	0.47	0.47	0	6.1	-1.36
1992	0.47	0.95	0	6.1	-1.36
1993	0.47	1.42	0	6.1	-1.36
1994	0.47	1.89	0	6.1	-1.36
1995	0.47	2.37	0	6.1	-1.36
1996	0	2.37	0	6.1	0
1997	0	2.37	0	6.1	0
1998	0	2.37	0	6.1	0

	annual change	20 yrs change	B after	B before	ΔC *converted*
	kha	*kha*	*t d.m. ha-1*	*t d.m. ha-1*	*GgC*
1999	0	2.37	0	6.1	0
2000	0	2.37	0	6.1	0
2001	0	2.37	0	6.1	0
2002	0	2.37	0	6.1	0
2003	*0*	*2.37*	*0*	*6.1*	*0*
2004	0	2.37	0	6.1	0
2005	0	2.37	0	6.1	0
2006	0	2.37	0	6.1	0
2007	0	2.37	0	6.1	0
2008	0	2.37	0	6.1	0
2009	0	2.37	0	6.1	0
2010	0	2.37	0	6.1	0
2011	0	1.89	0	6.1	0
2012	0	1.42	0	6.1	0
2013	0	0.95	0	6.1	0
2014	0	0.47	0	6.1	0
2015	0	0.00	0	6.1	0
2016	0	0.00	0	6.1	0

6.5.5 Uncertainty and time series consistency

Uncertainty estimates for the period 1990–2016 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). Input uncertainties dealing with activity data and emission factors have been assessed on the basis of the information provided in the 2006 IPCC Guidelines (IPCC, 2006).

6.5.6 Category-specific recalculations

No deviations result from the 2017 submission.

6.5.7 Category-specific planned improvements

Improvements will concern the development of an higher tier country-specific method based on models, measurements and associated parameters.

6.6 Settlements (4E)

6.6.1 Description

Under this category, activity data from settlements and from land converted to settlements are reported; CO_2 emissions, from living biomass and soil, from land converted in settlements have been also reported. In 2016, settlements emissions share 15.9% of absolute CO_2 eq. LULUCF emissions and removals.
CO_2 emissions and removals from land converting to settlements have resulted as key category, concerning level and trend analysis, either by Approach 1 and Approach 2.

6.6.2 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 1990–2016 have been assembled on the basis of the IUTI data, related to 1990, 2000, 2008 and 2012, through linear interpolations for the periods 1990-2005, 2005-2012 and linear extrapolation for 2012-2016. 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. The average area of land undergoing a transition from non-settlements to settlements during each year, from 1990 to 2016, 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.

6.6.3 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.

6.6.4 Methodological issues

Settlements remaining Settlements
CO_2 estimates related to carbon stocks changes for settlements remaining settlements haven't been submitted, following the 2006 IPCC Tier 1 approach which assume no change in carbon stocks in living biomass, considering that changes in biomass carbon stocks due to growth in biomass are fully offset by decreases in carbon stocks due to removals from both living and from dead biomass. Furthermore Tier 1 approach assumes that the dead wood, litter and soils stocks are at equilibrium, and so there is no need to estimate the carbon stock changes for these pools.

Land converted to Settlements
The 2006 IPCC Guidelines equations 2.15 and 2.16 in Chapter 2, vol. 4 (IPCC, 2006) have 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 CO_2 emissions are assumed to happen 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 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 6.3, conversions from forest land, grassland and cropland and other land categories to settlements have occurred in the 1990-2016 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 6.2.4 and 9.3.1.2, concerning soils pool.

Concerning forest soils, the SOCs reported in the table 6.28 have been used; the time range reported in the first column of the abovementioned table provides the time references for the SOCs' use. A detailed description of the methodology used in the estimation process of soils pool, and consequently of the SOCs, is provided in par. 9.3.1.2, related to the KP-LULUCF.

Table 6.28 Soil Organic Content (SOC) values for *forest land remaining forest land*

	SOC
years	*t C ha^{-1}*
1985-1994	79.809
1995-1999	80.172
2000-2004	80.575
2005-2009	81.083
2010-2014	81.601
2015	82.011
2016	82.141

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, ERSAF 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, ERSAF 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 6.29 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 6.29 Change in carbon stocks in forest land converted to settlements

		Forest land to settlements			***Total Carbon stock***
Year	*Conversion Area*	*Living biomass*	*Dead organic matter*	*Soils*	
	kha	*Gg C*	*Gg C*	*Gg C*	*Gg C*
1990	0.72	-32.09	-3.07	-57.64	-92.79
1991	0.72	-32.38	-3.06	-57.64	-93.09
1992	0.72	-32.64	-3.06	-57.64	-93.34
1993	0.72	-32.66	-3.06	-57.64	-93.36
1994	0.72	-32.91	-3.06	-57.64	-93.61
1995	0.72	-33.24	-3.06	-57.90	-94.20
1996	0.72	-33.55	-3.05	-57.90	-94.51
1997	0.72	-33.70	-3.05	-57.90	-94.66
1998	0.72	-33.81	-3.05	-57.90	-94.76
1999	0.72	-34.02	-3.05	-57.90	-94.98
2000	0.72	-34.21	-3.05	-58.19	-95.45
2001	0.72	-34.51	-3.05	-58.19	-95.75
2002	0.72	-34.89	-3.04	-58.19	-96.12
2003	0.72	-35.13	-3.04	-58.19	-96.37
2004	0.72	-35.46	-3.04	-58.19	-96.69
2005	3.69	-183.12	-15.55	-299.56	-498.24
2006	3.69	-185.27	-15.54	-299.56	-500.37
2007	3.69	-185.77	-15.53	-299.56	-500.86
2008	3.69	-187.54	-15.51	-299.56	-502.62
2009	3.69	-189.52	-15.50	-299.56	-504.58
2010	3.69	-191.80	-15.49	-301.48	-508.77
2011	3.69	-193.66	-15.48	-301.48	-510.62
2012	3.69	-195.06	-15.46	-301.48	-512.00
2013	3.69	-197.36	-15.45	-301.48	-514.29
2014	3.69	-199.73	-15.44	-301.48	-516.65
2015	3.69	-202.19	-15.42	-302.99	-520.60
2016	3.69	-204.30	-15.41	-302.99	-522.71

Concerning grassland converted to settlements, change in carbon stocks has been computed for living biomass, addressing a 2014 review report's recommendation, and for the soil pool. The carbon stocks in living biomass immediately following conversion from grassland to settlements has been set to 6.1 t d.m ha^{-1}, equivalent to 2.867 t C ha^{-1} (IPCC, 2006, table 6.4, vol. 4, chapter 6).
For what concerns cropland in transition to settlements, carbon stocks have been estimated, for each year and for crops type (annual or perennial), using as default coefficients the factors shown in the following Table 6.30 (IPCC, 2006, table 8.4, vol. 4, chapter 8).

Table 6.30 Stock change factors for cropland

	Biomass carbon stock *t C ha^{-1}*
Annual cropland	4.7
Perennial woody cropland	10

In Table 6.31 C stocks [Gg C] related to change in carbon stocks in living biomass in cropland and grassland converted to settlements are reported.

Table 6.31 Change in carbon stocks in living biomass in cropland and grassland converted to settlements

	cropland to settlements		**grassland to settlements**	
Year	*Conversion Area kha*	*Carbon stock Gg C*	*Conversion Area kha*	*Carbon stock Gg C*
1990	25.15	-152	1.73	-5
1991	0	0	26.70	-77
1992	0	0	26.70	-77
1993	0	0	26.70	-77
1994	0	0	26.70	-77
1995	0	0	26.70	-77
1996	26.70	-161	0	0
1997	26.70	-161	0	0
1998	26.70	-161	0	0
1999	26.70	-161	0	0
2000	26.70	-161	0	0
2001	26.70	-161	0	0
2002	26.70	-162	0	0
2003	26.70	-162	0	0
2004	26.70	-162	0	0
2005	23.73	-145	0	0
2006	23.73	-145	0	0
2007	23.73	-145	0	0
2008	23.73	-146	0	0
2009	23.91	-148	0	0
2010	23.91	-148	0	0
2011	23.91	-148	0	0
2012	23.91	-148	0	0
2013	23.91	-147	0	0
2014	23.91	-147	0	0
2015	23.91	-147	0	0
2016	0	0	24	-69

Changes in soil carbon stocks from land converting to settlements have been also estimated.
In Table 6.32 soil C stocks [Gg C] of cropland and grassland converted to settlements are reported.

Table 6.32 Change in carbon stocks in soil in cropland and grassland converted to settlements

	Cropland to settlements		grassland to settlements	
Year	*Conversion Area kha*	*Carbon stock Gg C*	*Conversion Area kha*	*Carbon stock Gg C*
1990	25.15	-1,426	1.73	-135
1991	0	0	26.70	-2,085
1992	0	0	26.70	-2,085
1993	0	0	26.70	-2,085
1994	0	0	26.70	-2,085
1995	0	0	26.70	-2,085
1996	26.70	-1,514	0	0
1997	26.70	-1,514	0	0
1998	26.70	-1,514	0	0
1999	26.70	-1,514	0	0
2000	26.70	-1,514	0	0
2001	26.70	-1,514	0	0
2002	26.70	-1,514	0	0
2003	26.70	-1,514	0	0
2004	26.70	-1,514	0	0
2005	23.73	-1,345	0	0
2006	23.73	-1,345	0	0
2007	23.73	-1,345	0	0
2008	23.73	-1,354	0	0
2009	23.91	-1,360	0	0
2010	23.91	-1,356	0	0
2011	23.91	-1,356	0	0
2012	23.91	-1,356	0	0
2013	23.91	-1,356	0	0
2014	23.91	-1,356	0	0
2015	23.91	-1,356	0	0
2016	0	0	24	-1,867

Concerning other land converted to settlements, change in carbon stocks has been not estimated, in line with the 2006 IPCC Guidelines (IPCC, 2006) as no change in carbon stocks in the other land has been assumed.

6.6.5 Uncertainty and time series consistency

Uncertainty estimates for the period 1990–2016 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). Input uncertainties dealing with activity data and emission factors have been assessed on the basis of the information provided in the 2006 IPCC Guidelines (IPCC, 2006).
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.

6.6.6 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 database[54], ISTAT data[55]) has been made. Data entries have been checked several

[54] FAO, 2015. FAOSTAT, http://faostat3.fao.org/home/E
[55] ISTAT, several years [a], [b], [c]

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.

6.6.7 Category-specific recalculations

No deviations result by the comparison with 2016 submission.

6.6.8 Category -specific planned improvements

Urban tree formations will be probed for information, in order to estimate carbon stocks. In addition, in 2013, the joint project "ITALI" (*Integration of Territorial And Land Information*) started its activities; the project, coordinated by the National Institute of Statistics and promoted by EUROSTAT[56], 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.

6.7 Other Land (4F)

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

6.8 Direct N_2O emissions from N inputs to managed soils (4(I))

N_2O emissions from N inputs to managed soils of cropland and grassland are reported in the agriculture sector; therefore only N inputs to managed soils in forest land should be included in this table. By including the short rotation forests under forest land category (and consequently under the art. 3.3 and 3.4 activities under Kyoto Protocol), we have to take into account the amount of fertiliser applied to these lands; nevertheless, in Italy, data related to the amount of applied fertilisers are deduced by the national fertiliser sales statistics that include also the fertilisers used for short rotation forest crops. All the related emissions are reported in the Agriculture sector, following the 2006 IPCC Guidelines (IPCC, 2006, par. 11.2.1.3, vol. 4, chapter 11) and coherently with the KP Supplement (IPCC, 2014, par. 2.4.4.2).

6.9 Emissions and removals from drainage and rewetting and other management of organic and mineral soils (4(II))

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

[56] Eurostat is the statistical office of the European Union: http://epp.eurostat.ec.europa.eu/portal/page/portal/about_eurostat/introduction

6.10 N_2O emissions from N mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils

6.10.1 Description

Under this category, N_2O emissions from N mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils are reported, according to the 2006 IPCC Guidelines (IPCC, 2006). N_2O emissions from Land converted to Settlements have been identified as key category with approach 2 concerning level assessment.

6.10.2 Methodological issues

N_2O emissions from land use conversions are derived from mineralization of soil organic matter resulting from conversion of land to cropland. The average area of land undergoing a transition from non-cropland to cropland during each year, from 1990 to 2016, 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 2006 IPCC Guidelines eq. 11.1 and 11.8 (vol. 4, chapter 11) have been used to estimate the emissions of N_2O from mineral soils, resulting N mineralization/immobilization associated with loss/gain of soil organic matter 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 2006 IPCC default values, 15 and 0.01 kg N_2O-N/kg N for the C/N ratio and for calculating N_2O emissions from N in the soil respectively, N_2O emissions have been estimated.

In Table 6.33 and Table 6.34 N_2O emissions resulting from the disturbance associated with land-use conversion to cropland and associated with land-use conversion to settlements are reported, respectively.

Table 6.33 N_2O emissions from land-use conversion to cropland

	Conversion Area		**Carbon stock**	**F_{SOM}**	**$N_2O_{net\text{-}min}$ -N**	**N_2O emissions**
	annual change	*20 yrs change*				
year	*kha*	*kha*	*Gg C*	*kt N*	*kt N_2O-N*	*Gg N_2O*
1990	0.0	136.15	145.64	9.71	0.097	0.153
1991	16.77	152.92	163.57	10.90	0.109	0.171
1992	16.77	169.69	181.51	12.10	0.121	0.190
1993	16.77	186.46	199.45	13.30	0.133	0.209
1994	16.77	203.23	217.39	14.49	0.145	0.228
1995	16.77	220.00	235.33	15.69	0.157	0.247
1996	0.0	192.77	206.20	13.75	0.137	0.216
1997	0.0	165.54	177.07	11.80	0.118	0.186
1998	0.0	138.31	147.94	9.86	0.099	0.155
1999	0.0	111.08	118.82	7.92	0.079	0.124
2000	0.0	83.85	89.69	5.98	0.060	0.094
2001	0.0	83.85	89.69	5.98	0.060	0.094
2002	0.0	83.85	89.69	5.98	0.060	0.094
2003	0.0	83.85	89.69	5.98	0.060	0.094
2004	0.0	83.85	89.69	5.98	0.060	0.094
2005	0.0	83.85	89.69	5.98	0.060	0.094
2006	0.0	83.85	89.69	5.98	0.060	0.094
2007	0.0	83.85	89.69	5.98	0.060	0.094
2008	0.0	83.85	89.69	5.98	0.060	0.094

2009	0.0	83.85	89.69	5.98	0.060	0.094
2010	0.0	83.85	89.69	5.98	0.060	0.094
2011	0.0	67.08	71.75	4.78	0.048	0.075
2012	0.0	50.31	53.81	3.59	0.036	0.056
2013	0.0	33.54	35.88	2.39	0.024	0.038
2014	0.0	16.77	17.94	1.20	0.012	0.019
2015	0.0	0.0	0.0	0.0	0.000	0.000
2016	80.48	80.48	86.08	5.74	0.057	0.090

Table 6.34 N_2O emissions from land-use conversion to settlements

	Conversion Area		**Carbon stock**	**F_{SOM}**	**$N_2O_{net\text{-}min}$ -N**	**N_2O emissions**
	annual change	*20 yrs change*				
year	*kha*	*kha*	*Gg C*	*kt N*	*kt N_2O-N*	*Gg N_2O*
1990	27.61	220.84	1,618.86	107.92	1.079	1.696
1991	27.42	242.93	2,142.89	142.86	1.429	2.245
1992	27.42	265.01	2,142.89	142.86	1.429	2.245
1993	27.42	287.09	2,142.89	142.86	1.429	2.245
1994	27.61	309.18	2,142.89	142.86	1.429	2.245
1995	27.61	331.26	2,143.15	142.88	1.429	2.245
1996	27.61	353.35	1,571.89	104.79	1.048	1.647
1997	27.61	375.43	1,571.89	104.79	1.048	1.647
1998	27.61	397.51	1,571.89	104.79	1.048	1.647
1999	27.61	419.60	1,571.89	104.79	1.048	1.647
2000	27.61	441.68	1,572.18	104.81	1.048	1.647
2001	27.61	463.77	1,572.18	104.81	1.048	1.647
2002	27.61	485.85	1,572.18	104.81	1.048	1.647
2003	27.61	507.94	1,572.18	104.81	1.048	1.647
2004	27.61	530.02	1,572.18	104.81	1.048	1.647
2005	27.61	552.10	1,645.02	109.67	1.097	1.723
2006	27.61	552.10	1,645.02	109.67	1.097	1.723
2007	27.61	552.10	1,645.02	109.67	1.097	1.723
2008	27.61	552.10	1,653.39	110.23	1.102	1.732
2009	27.79	552.10	1,659.43	110.63	1.106	1.738
2010	27.79	552.10	1,657.17	110.48	1.105	1.736
2011	27.79	552.10	1,657.17	110.48	1.105	1.736
2012	27.61	552.10	1,657.17	110.48	1.105	1.736
2013	27.61	552.10	1,657.17	110.48	1.105	1.736
2014	27.61	552.10	1,657.17	110.48	1.105	1.736
2015	27.61	552.10	1,658.68	110.58	1.106	1.738
2016	27.61	552.10	2,170.21	144.68	1.447	2.274

6.10.3 Category-specific recalculations

No deviations are notable by comparing the 2018 submission with the comparison with 2017 submission.

6.11 Indirect N_2O emissions from managed soils (4(IV))

6.11.1 Description

Indirect N_2O emissions from N inputs of synthetic and organic fertilizer to managed soils of cropland and grassland are reported in the agriculture sector. N fertilization, both synthetic and organic one, in land use categories, other than cropland and grassland, is not occurring.
Concerning the N mineralization associated with loss of soil organic matter resulting from change of land use or management on mineral soils in all land use categories except for cropland remaining cropland, the related indirect N_2O emissions have been considered.

6.11.2 Methodological issues

N_2O emissions from nitrogen leaching and runoff have been assessed on the basis of the 2006 IPCC Guidelines (vol. 4, chapter 11, equation 11.10). 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 2006 IPCC default values, 0.3 kg N and 0.0075 kg N_2O-N/kg N for the $Frac_{LEACH-(H)}$ and for EF_5, indirect N_2O emissions have been estimated as reported in Table 6.35.

Table 6.35 Indirect N_2O emissions from managed soils - Nitrogen leaching and run-off

	F_{SOM}	**$Frac_{LEACH-(H)}$**	**EF_5**	**N_2Onet-min -N**	**N_2O emissions**
year	*kt N*	*kg N*	*kg N_20-N/kg N*	*kt N_2O-N*	*Gg N_2O*
1990	9.71	0.30	0.01	0.02	0.03
1991	10.90	0.30	0.01	0.02	0.04
1992	12.10	0.30	0.01	0.03	0.04
1993	13.30	0.30	0.01	0.03	0.05
1994	14.49	0.30	0.01	0.03	0.05
1995	15.69	0.30	0.01	0.04	0.06
1996	13.75	0.30	0.01	0.03	0.05
1997	11.80	0.30	0.01	0.03	0.04
1998	9.86	0.30	0.01	0.02	0.03
1999	7.92	0.30	0.01	0.02	0.03
2000	5.98	0.30	0.01	0.01	0.02
2001	5.98	0.30	0.01	0.01	0.02
2002	5.98	0.30	0.01	0.01	0.02
2003	5.98	0.30	0.01	0.01	0.02
2004	5.98	0.30	0.01	0.01	0.02
2005	5.98	0.30	0.01	0.01	0.02
2006	5.98	0.30	0.01	0.01	0.02
2007	5.98	0.30	0.01	0.01	0.02
2008	5.98	0.30	0.01	0.01	0.02
2009	5.98	0.30	0.01	0.01	0.02
2010	5.98	0.30	0.01	0.01	0.02
2011	4.78	0.30	0.01	0.01	0.02
2012	3.59	0.30	0.01	0.01	0.01
2013	2.39	0.30	0.01	0.01	0.01
2014	1.20	0.30	0.01	0.00	0.00
2015	0.0	0.30	0.01	0.00	0.00
2016	5.74	0.30	0.01	0.01	0.02

6.11.3 Category-specific recalculations

Recalculation is not applicable, since these estimates have been not reported in the previous submission.

6.12 Biomass Burning (4(V))

6.12.1 Description

Under this source category, CH_4 and N_2O 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. CO_2, CH_4 and N_2O 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.
For the period 1990-2016, 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), are available (ISTAT, several years [a]). In addition, for the period 2008-2016, a detailed database, provided by the Italian National Forest Service (CFS - Ministry of Agriculture, Food and Forest Policies), has been used; the database collects data related to any fire event occurred in 15 administrative Italian regions[57] (the 5 autonomous regions are not included), reporting, for each fire event, the following information:

- *burned area [ha]*
- *forest typology (27 classes in line with the NFI nomenclature)*
- *scorch height [m]*
- *fire's type (crown, surface or ground fire)*

Data and information related to fire occurrences in the 5 remaining autonomous regions are collected at regional level, with different level of disaggregation and details (for example, in Sardinia region, the amount of biomass burned is reported instead of the scorch height).
Therefore the data used in the estimation process may be subdivided into the following groups with similar characteristics:

a. time series from 2008 on for the 15 Regions: data related to burned area, divided into different forest types, scorch height and fire's type;
b. time series from 2008 on for the 5 autonomous regions/provinces: data related to burned area;
c. time series from 1990 to 2007 for the 20 Italian regions: data related to burned area.

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 Italian National Forest Service (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).
CO_2 emissions due to forest fires in forest land remaining forest land and land converting to forest land are included in Table 4.A.1 of the CRF, under carbon stock change in living biomass - losses.
Non CO_2 emissions from fires have been estimated and reported in CRF Table 4(V), while NO_x, CO and NMVOC emissions from fires have been reported in CRF Table 4. SO_2 emissions from fires are reported in 4H (Other - SO_2 from fires).

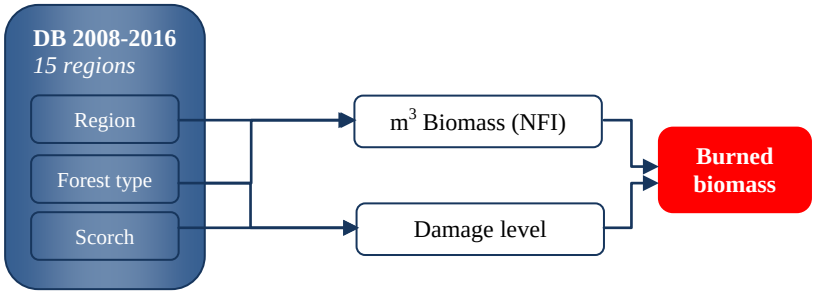
6.12.2 Methodological issues

In Italy, in consideration of national legislation[58], forest fires do not result in changes in land use; therefore conversion of forest and grassland does not take place. CO_2 emissions due to forest fires in forest land

[57] The Italian territory is subdivided in 20 administrative regions, 5 of which are autonomous: Valle d'Aosta, Friuli Venezia Giulia, Sardegna, Sicilia and Trentino Alto Adige, the latest subdivided in two autonomous provinces (Trento and Bolzano).
[58] Legge 21 novembre 2000, n. 353 - "Legge-quadro in materia di incendi boschivi" art. 10, comma 1 - http://www.camera.it/parlam/leggi/00353l.htm

remaining forest land and land converting to forest land are included in table 4.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 6.2.4.
On the basis of the different datasets available, in each year and group of regions, different approaches and assumptions have been followed to estimate non CO_2 emissions from forest fires.

a. The estimation of non CO_2 emissions from fires in the 15 regions has been carried out on the basis of the approach developed by Bovio (Bovio, 2007); the approach is aimed to assess forest fire damage and related biomass losses in Italy, taking into account two main elements: the fire intensity (assessed through the scorch height) and the forest typologies affected by fire. These two elements allow an assessment of the fraction of biomass burnt in a fire event. The estimation process has been carried out using the database containing around 32,700 records, related to any fire event fires on forest and other wooded land for the period 2008-2016, including information as the scorch height and the area per forest type.



In case of some data missing, record by record, a gap filling procedure has been adopted, using the following assumptions/data:

1. Scorch height data missing: the average damage level for the forest type/type of fire/region calculated over the 2008-2016 period has been attributed to the record.
2. No volume is associated with the record – this is due to the probable misclassification of the forest type by the surveyors, which have attributed a forest type that is not present in the region, thus no data from NFI can be attributed. In this case the average burned volume per region and fire's type has been attributed to the record. In case of no specific indication on fire's type, then the average of the most severe fire's type, by region, calculated over the complete dataset (2008-2016) has been used (i.e. highest average among averages calculated per fire's type in the region)
3. Scorch height and volume missing: In case information on both issues is missing the highest average burned biomass calculated per fire's type in each region has been attributed to the record.

b. The emissions from fires for the 5 autonomous regions/provinces has been estimated on the basis of the average values assessed for the 15 regions from 2008 on, using the following procedure:
   1. for each of the 15 regions (group a), the highest value of C released among the averages, calculated for the years from 2008 on, has been selected, per fire's type;
   2. the 15 regions have been clustered into three group with similar climatic conditions and forest types (Northen, Center and Southern Italy);
   3. the average values of carbon released for fire's type have been calculated for the three abovementioned clusters;
   4. the 5 autonomous regions have been classified according the 3 cluster identified at step 2;
   5. an average value of carbon released, computed at step 3, is associated to the 5 autonomous regions, according the belonging cluster;
   6. the emissions from fires are estimated by multiplying average value of carbon released per the burned area of each autonomous region.

c. The emissions from fires for the period 1990-2007 for the 20 Italian regions have been estimated on the basis of the maximum of average values computed among 2008 and 2016 (when the detailed database is available), taking into account the fire's type and each region. The selected value of released carbon is then multiplied by the burned area of the region in each year from 1990 to 2007.

CH_4, N_2O, CO and NO_x have been estimated following IPCC 2006 approach (eq. 2.27, vol. 4, chapter 4), multiplying the amount of C released from 1990 to 2016, calculated as abovementioned, by the emission ratios from EMEP/EEA 2009 (table 3.3, chapt. 11.B).

In Table 6.36 CH_4 and N_2O emissions resulting from biomass burning in forest land category are reported.

Table 6.36 CH_4 and N_2O emissions from biomass burning in forest land category

	Forest land remaining forest land		*Land converting to forest land*	
	CH_4	**N_2O**	**CH_4**	**N_2O**
year	*Gg*	*Gg*	*Gg*	*Gg*
1990	28.799	0.009	2.873	0.001
1991	9.676	0.003	1.027	0.000
1992	14.361	0.005	1.614	0.001
1993	37.931	0.012	4.498	0.001
1994	14.544	0.005	1.815	0.001
1995	5.804	0.002	0.760	0.000
1996	6.111	0.002	0.855	0.000
1997	20.079	0.006	2.992	0.001
1998	22.672	0.007	3.583	0.001
1999	11.385	0.004	1.902	0.001
2000	17.963	0.006	3.161	0.001
2001	11.412	0.004	2.107	0.001
2002	6.113	0.002	1.182	0.000
2003	13.141	0.004	2.653	0.001
2004	6.344	0.002	1.335	0.000
2005	6.057	0.002	1.329	0.000
2006	4.733	0.001	1.015	0.000
2007	34.151	0.011	7.153	0.002
2008	6.887	0.002	1.409	0.000
2009	7.801	0.002	1.559	0.000
2010	3.925	0.001	0.766	0.000
2011	7.672	0.002	1.462	0.000
2012	21.056	0.007	3.918	0.001
2013	4.039	0.001	0.734	0.000
2014	6.103	0.002	1.082	0.000
2015	6.471	0.002	1.120	0.000
2016	9.518	0.003	1.608	0.001

In Table 6.37 CO_2, CH_4 and N_2O emissions resulting from biomass burning in cropland and grassland categories are reported.

Table 6.37 CO_2, CH_4 and N_2O emissions from biomass burning in cropland and grassland categories

	Cropland			*Grassland*		
	CO_2	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
year	*Gg*	*Gg*	*Gg*	*Gg*	*Gg*	*Gg*
1990	39.821	0.217	0.007	5,031.295	27.443	0.863
1991	28.636	0.156	0.005	2,931.791	15.992	0.503
1992	25.136	0.137	0.004	2,878.362	15.700	0.493
1993	35.902	0.196	0.006	5,003.581	27.292	0.858
1994	36.668	0.200	0.006	3,897.218	21.258	0.668
1995	11.460	0.063	0.002	1,324.090	7.222	0.227
1996	15.475	0.084	0.003	1,652.351	9.013	0.283
1997	19.911	0.109	0.003	2,745.061	14.973	0.471
1998	33.915	0.185	0.006	4,102.555	22.378	0.703
1999	13.049	0.071	0.002	1,768.927	9.649	0.303
2000	23.181	0.126	0.004	2,944.882	16.063	0.505
2001	15.714	0.086	0.003	1,974.443	10.770	0.338
2002	8.454	0.046	0.001	1,056.715	5.764	0.181
2003	19.618	0.107	0.003	2,403.945	13.112	0.412
2004	16.153	0.088	0.003	1,718.803	9.375	0.295

	Cropland			*Grassland*		
	CO_2	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
year	*Gg*	*Gg*	*Gg*	*Gg*	*Gg*	*Gg*
2005	10.727	0.059	0.002	1,270.124	6.928	0.218
2006	9.666	0.053	0.002	1,095.090	5.973	0.188
2007	45.664	0.249	0.008	5,832.917	31.816	1.000
2008	14.816	0.081	0.003	2,089.724	11.398	0.358
2009	16.027	0.087	0.003	2,640.927	14.405	0.453
2010	8.552	0.047	0.001	1,748.889	9.539	0.300
2011	18.059	0.099	0.003	2,486.624	13.563	0.426
2012	33.948	0.185	0.006	4,272.524	23.305	0.732
2013	56.285	0.307	0.010	462.912	2.525	0.079
2014	5.964	0.033	0.001	1,196.200	6.525	0.205
2015	17.625	0.096	0.003	722.951	3.943	0.124
2016	15.068	0.082	0.003	848.430	4.628	0.145

6.12.3 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 Carbon Sinks should also provide data to improve estimate of emissions by biomass burning.

6.12.4 Uncertainty and time series consistency

Uncertainty estimates for the period 1990–2016 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). Input uncertainties dealing with activity data and emission factors have been assessed on the basis of the information provided in the 2006 IPCC Guidelines (IPCC, 2006).

6.12.5 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. Additional methodological information and a comparison of approaches for reporting forest fire-related biomass loss and greenhouse gas emissions in southern Europe may be found in the paper Chiriacò et al., 2013. All the LULUCF categories have been embedded in the overall QA/QC-system of the Italian GHG inventory.

6.12.6 Category-specific recalculations

Slight deviations are resulting from the comparison with 2017 submission sectoral estimates, due to the the estimation methodology (par. 6.12.2), that foresees a gap filling procedures for missing scorch height data to assess the damage level for the forest type/type of fire/region. In particular the comparison of emissions related to fires results in average[59] decrease of the emissions by 0.7% in forest land category and by 0.4% in grassland category, respectively. No deviations are resulting for cropland category.

[59] Average value on the period 1990-2014

6.12.7 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.
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 (considering the 20 administrative regions, 5 of which are autonomous) which are now characterized with different level of disaggregation and details (burned area, with reference to various land uses, forest land category, with reference to different forest typologies, specific parameters related to fire's type (crown or grazing fire), amount of burned biomass, etc.).

6.13 Harvested wood products (HWP) (4G)

6.13.1 Description

Under this source category, annual changes in carbon stocks and associated CO_2 emissions and removals from the Harvested Wood Products (HWP) pool are estimated, following the production approach described in the Annex to Volume 4, Chapter 12, of the 2006 IPCC Guidelines (IPCC, 2006), in line with Decision 2/CMP.7 and the guidance provided by the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (KP Supplement, IPCC 2014).
CO_2 emissions and removals from HWP have resulted key categories with Approach 2 concerning trend assessment.

6.13.2 Methodological issues

Emissions from this source are mainly influenced by the trend in forest harvest rates: in 2016, the net emissions from harvested wood products were 171.88 kt CO_2. The figure 6.9 shows the trend of HWP in use for the period 1961-2016, disaggregated into sawnwood, wood based panels and paper & paperboard.

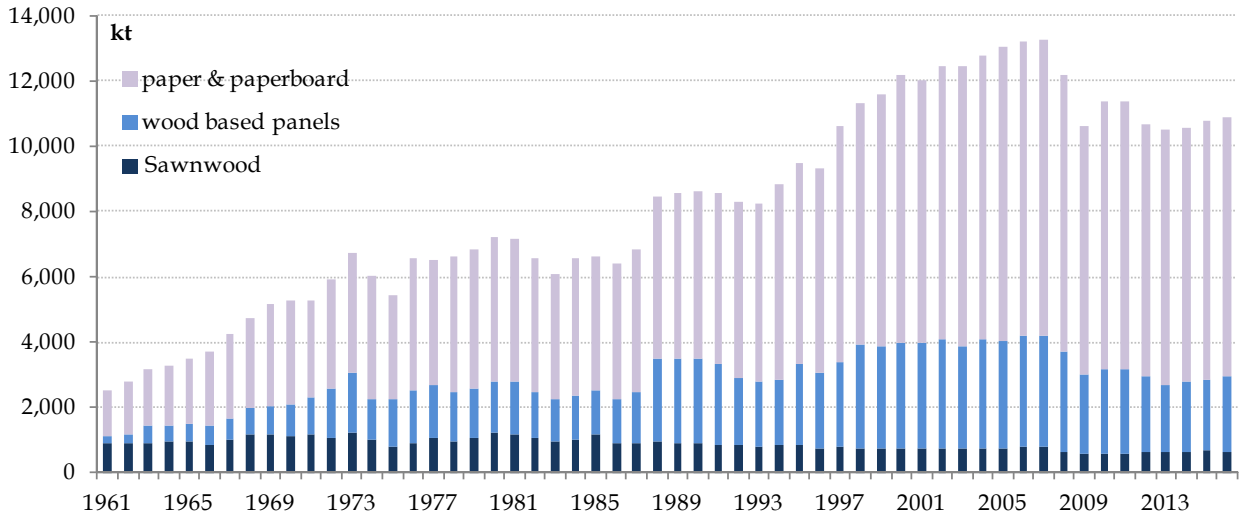


Figure 6.9 HWP in use for the period 1961-2016

The activity data (production of sawnwood, wood based panels and paper and paperboard) are derived from FAO forest product statistics (Food and Agriculture Organization of the United Nations: forest product statistics, http://faostat3.fao.org/download/F/FO/E).

Italy uses the same methodology to estimate emissions annual changes in carbon stocks and associated CO_2 emissions and removals from the HWP pools under UNFCCC and KP, following the decision Decision 2/CMP.7, paragraph 29, namely, that "*transparent and verifiable activity data for harvested wood products categories are available, and accounting is based on the change in the harvested wood products pool of the second commitment period, estimated using the first-order decay function*".
The estimates have been carried out on the basis of the KP Supplement (IPCC 2014) methodology. The Tier 2 approach, first order decay, was applied to the HWP categories (sawnwood, wood based panels and paper and paperboard) according to equation 2.8.5 (IPCC, 2014).
Equation 2.8.1 (IPCC, 2014) has been applied to estimate the annual fraction of the feedstock coming from domestic harvest for the HWP categories sawnwood and wood-based panels.
The change in carbon stocks was estimated separately for each product category; the default values (Table 2.8.1, IPCC 2014) have been applied. Emission factors for specific product categories were calculated with default half-lives of 35 years for sawnwood, 25 years for wood panels and 2 years for paper (Table 2.8.2, IPCC 2014).
The annual change in stock for the period 1961-2016, disaggregated into sawnwood, wood based panels and paper & paperboard, is reported in Figure 6.10.

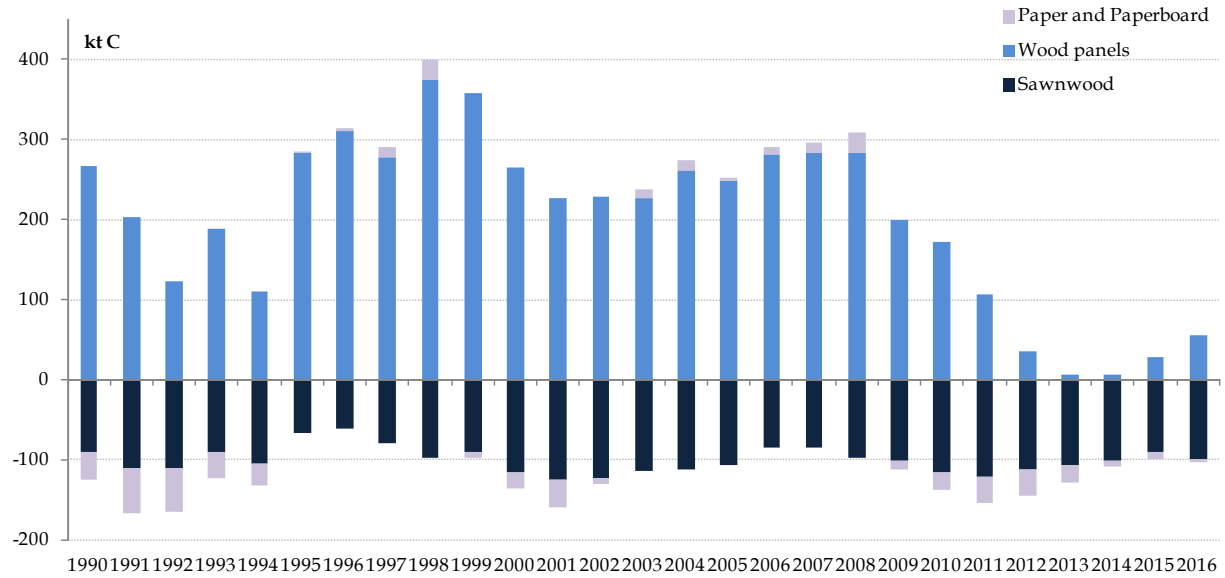


Figure 6.10 Annual change in stock (kt C) for the period 1990-2016

6.13.3 Uncertainty and time series consistency

Uncertainty estimates for the period 1990–2016 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). The uncertainties of activity data and emission factors used in the estimation process have assessed based on the uncertainties of the default factors provided in the KP Supplement (IPCC, 2014) and the uncertainties of exiting statistical data.

6.13.4 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. All the LULUCF categories have been embedded in the overall QA/QC-system of the Italian GHG inventory.

6.13.5 Category-specific recalculations

No deviations result from the comparison with 2017 submission.

6.13.6 Category-specific planned improvements

Planned improvements are related to the investigation on the end-use, the discard rates of HWP, as well as the final market use of wood in Italy. The main outcome of this investigation could be the set-up of country specific emission factors to be used in the estimation process. A review will also be undertaken aiming to better understand the interactions among the different sectors to which the HWP pool is related (i.e. LULUCF/forest land, the Energy sector and the Waste sector).

7 WASTE [CRF sector 5]

7.1 Sector overview

The waste sector comprises four source categories:

1 solid waste disposal (5A);
2 biological treatment of solid waste (5B);
3 incineration and open burning of waste (5C);
4 wastewater treatment and discharge (5D).

The waste sector share of GHG emissions in the national greenhouse gas total is presently 4.27% (and was 3.34% in 1990).

The trend in greenhouse gas emissions from the waste sector is summarised in Table 7.1. 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 5C, 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 5B, CH_4, N_2O and NMVOC emissions from compost production and CH_4 emissions from anaerobic digestion of solid waste are reported.

Emissions from methane recovered, used for energy purposes, in landfills and wastewater treatment plants are estimated and reported under category 1A4a.

Table 7.1 Trend in greenhouse gas emissions from the waste sector 1990 – 2016 (Gg)

GAS/SUBSOURCE	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
CO_2 (Gg)											
5C. Waste incineration	507.18	453.89	204.22	226.48	162.31	164.98	196.52	218.70	111.92	93.75	94.94
CH_4 (Gg)											
5A. Solid waste disposal on land	488.25	604.93	687.98	680.10	622.33	600.21	603.50	554.11	551.37	559.15	544.86
5B. Biological treatment of waste	0.19	0.43	1.86	3.66	4.65	4.74	4.74	4.96	5.36	4.83	4.91
5C. Waste incineration	2.00	2.32	2.23	2.46	2.33	2.31	2.32	2.23	2.10	2.32	2.41
5D. Wastewater treatment	128.90	122.10	114.78	110.68	105.84	103.48	102.69	101.08	100.01	99.28	99.51
N_2O (Gg)											
5B. Biological treatment of waste	0.07	0.16	0.68	1.33	1.69	1.72	1.72	1.80	1.95	1.75	1.78
5C. Waste incineration	0.12	0.12	0.09	0.09	0.08	0.08	0.08	0.08	0.07	0.07	0.07
5D. Wastewater treatment	4.25	4.14	4.40	4.44	4.51	4.36	4.43	4.54	4.54	4.53	4.53

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; N_2O emission from biological treatment of waste is a key category at level for 2016 and at trend assessment only considering the uncertainty; methane emission from wastewater treatment is a key source at level assessment with Approach 1 and Approach 2 and at trend assessment only with the Approach 2; N_2O emissions from wastewater treatment result as a key category at level and trend assessment only with the Approach 2, taking into account the uncertainty. When including the LULUCF sector in the key source analysis, methane emissions from landfills is a key category at level and trend assessment calculated with Approach 1 and Approach 2, whereas N_2O emission from biological treatment of waste is a key category only at trend assessment with the Approach 2, N_2O from wastewater treatment is a key category at level and trend assessment only with the Approach 2 and CH_4 emissions from wastewater treatment are not a key category at trend assessment.

Key-source identification in the waste sector with the IPCC Approach 1 and Approach 2 (without LULUCF) for 2016

5A	CH_4	Emissions from solid waste disposal sites	Key (L, T)
5B	N_2O	Emissions from biological treatment of waste	Key (L2, T2)
5D	CH_4	Emissions from wastewater treatment	Key (L, T2)
5D	N_2O	Emissions from wastewater treatment	Key (L2, T2)
5B	CH_4	Emissions from biological treatment of waste	Non-key
5C	CO_2	Emissions from waste incineration	Non-key
5C	CH_4	Emissions from waste incineration	Non-key
5C	N_2O	Emissions from waste incineration	Non-key

7.2 Solid waste disposal on land (5A)

7.2.1 Source category description

The source category solid waste disposal on land is a key category for CH_4, both in terms of level and trend. The share of CH_4 emissions is presently 31.8% (and was about 25.3% in the base year 1990) of the CH_4 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 33.0% in 2016. 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 2016, the percentage of municipal solid waste separate collection is about 52.5% (the legislative targets fixed 50% in 2009), characterized by a strong growth in recent years.
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 2016, the non hazardous landfills in Italy disposed 7,432 kt of MSW and 2,513 kt of industrial wastes, as well as 173 kt of sludge from urban wastewater treatment plants.
Since 1999, the number of MSW landfills has decreased by more than 500 plants up to 134 in 2016, 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 slowly.

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 on industrial sludge disposed into landfills for hazardous waste is ongoing and relates to the 2010 activity data.

7.2.2 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 (APAT-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 [a]; 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 7.1, 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.

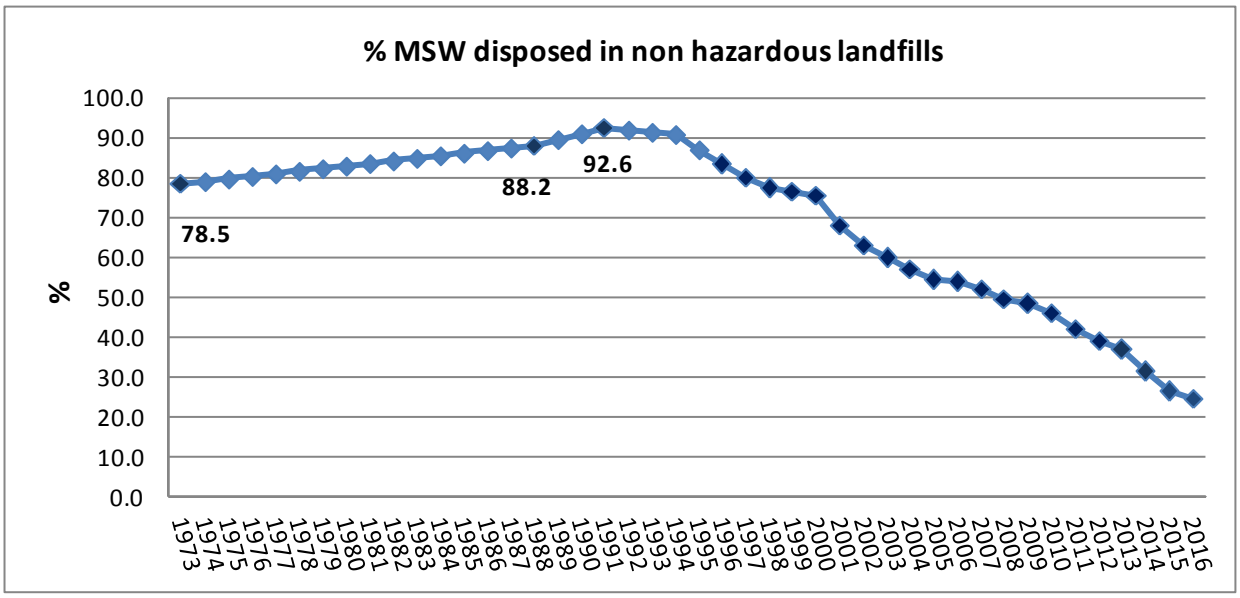


Figure 7.1 Percentage of MSW disposal on land (%)

In the following Table 7.2, 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 [a]).
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 [a]) 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 7.2.1.
Uncontrolled landfills have been monitored since 1982 when the D.P.R. 915/82 (Decree of the President of the Republic 915/82) introduced this requirement but the effective reduction of uncontrolled landfills occurred only following the D.Lgs. 22/97 with the implementation of European Directives. From 1997 the amount of waste disposed in uncontrolled landfills (landfills not fullfilling the technological standard but allowed with special permits) strongly reduced till 2000 when they were not allowed anymore. Since 2000 police forces as Corpo Forestale dello Stato and Carabinieri (NOE - Environmental Care Command) protect and supervise the compliance with the law; if an illegal disposal of waste is revealed they proceed to the seizure and site remediation.

Industrial waste

Industrial waste 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 of 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).
The time series of AMSW and domestic sludge disposed of into non hazardous landfills from 1990 is reported is also reported in Table 7.1.

Table 7.2 Trend of MSW production and MSW, AMSW and domestic sludge disposed in landfills, 1990 – 2016

ACTIVITY DATA	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
MSW production (Gg)	22,231	25,780	28,959	31,664	32,479	31,386	29,994	29,573	29,652	29,524	30,117
MSW disposed in landfills for non hazardous waste (Gg)	17,432	22,459	21,917	17,226	15,015	13,206	11,720	10,914	9,332	7,819	7,432
Assimilated MSW disposed in landfills for non hazardous waste (Gg)	2,828	2,978	2,825	2,914	3,508	2,883	2,292	2,512	2,913	3,222	2,513
Sludge disposed in managed landfills for non hazardous waste (Gg)	2,454	1,531	1,326	544	301	292	214	193	188	180	173
Total Waste to managed landfills for non hazardous waste (Gg)	16,363	21,897	26,069	20,684	18,825	16,380	14,226	13,619	12,433	11,221	10,117
Total Waste to unmanaged landfills for non hazardous waste (Gg)	6,351	5,071	0	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	18,825	16,380	14,226	13,619	12,433	11,221	10,117

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 7% in 2016.
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, several years [a]); 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, every three years, by the Ministry for the Environment, Land and Sea from 1995 (MATTM, 2005; MATTM several years [b]) 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. The latest data provided are those referring to the years 2013-2015.
Moreover, sewage sludge production is available from different sources also for the years 1987, 1991 (MATTM, several years [a]) 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 7.3, time series of sewage sludge production and landfilling is reported.

Table 7.3 Trend of total sewage sludge production and landfilling, 1990 – 2016

ACTIVITY DATA	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Total sewage sludge production (Gg)	3,272	2,437	3,402	4,299	3,359	3,407	2,616	2,487	2,544	2,582	2,619
Sewage sludge landfilled (Gg)	2,454	1,531	1,326	544	301	292	214	193	188	180	173
Percentage (%)	75.0	62.8	39.0	12.7	9.0	8.6	8.2	7.8	7.4	7.0	6.6

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- up to now) 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 Polettini, 2002).

In Tables 7.4, 7.5, 7.6 and 7.7 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 7.4 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%**	**62.73**
Garden and park	**3.6%**	**50%**	**48%**	**8.71**
Paper, paperboard	**29.7%**	**9%**	**50%**	**135.11**
Plastic	2.9%	2%	70%	
Inert	26.9%			
Sludge	**4.2%**	**75%**	**48%**	**5.05**
DOC				**211.61**

Table 7.5 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%**	**64.02**
Garden and park	**3.7%**	**50%**	**48%**	**8.89**
Paper, paperboard, textile and wood	**19.6%**	**9%**	**50%**	**89.29**
Plastic	6.3%	2%	70%	
Inert	6.2%			
Metal	2.6%			
Screened waste (< 2 cm)				
- organic	8.1%	**60%**	**48%**	**15.46**
- non organic	8.1%			
Sludge	**12.0%**	**75%**	**48%**	**14.40**
DOC				**192.06**

Table 7.6 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%**	**47.36**
Garden and park	**4.2%**	**50%**	**48%**	**10.09**
Paper, paperboard	**25.5%**	**8%**	**44%**	**103.36**
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%**	**7.55**
DOC				**209.92**

Table 7.7 Waste composition and Degradable Organic Carbon calculation, 2006 – 2016

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 streams have been categorized in three main types: rapidly biodegradable waste, moderately biodegradable waste and slowly biodegradable waste, as reported in Table 7.8. Methane emissions have been estimated separately for each mentioned biodegradability class and the results have been consequently added up.

Table 7.8 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 (L_0)

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 of 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:

$$L_0 = MCF * DOC * DOC_F * F * 16/12$$

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. On the basis of the last inventory review in the framework of the ESD (Effort Sharing Directive) (EEA, 2017), Italy has distinguished wetlands from dry areas by associating each type of area with landfills in their respective territories, more information are available in the following paragraph. As it is estimated that sewage sludge has been disposed of only into landfills localized in the dry zone, the values of methane generation potential for the rapidly biodegradable fraction are slightly different. The following Table 7.9 summarizes the methane generation potential values (L_0) generated, distinguished for managed and unmanaged landfills.

Table 7.9 Methane generation potential values by waste composition, landfill typology and moisture conditions

L_0 ($m3CH_4$/tRSU)	1950 - 1970		1971 - 1990		1991 - 2005		2006 - 2016	
	dry	wet	dry	wet	dry	wet	dry	wet
Rapidly biodegradable								
- Managed landfill	89.7	94.6	85.4	94.6	87.2	94.6	90.2	90.2
- Unmanaged landfill	53.8	56.7	51.3	56.7	52.3	56.7	54.1	54.1
Moderately biodegradable								
- Managed landfill	118.2	118.2	118.2	118.2	118.2	118.2	118.2	118.2
- Unmanaged landfill	70.9	70.9	70.9	70.9	70.9	70.9	70.9	70.9
Slowly biodegradable								
- Managed landfill	224.1	224.1	224.1	224.1	205.9	205.9	204.0	204.0
- Unmanaged landfill	134.5	134.5	134.5	134.5	123.5	123.5	122.4	122.4

Finally, oxidation factors have been assumed equal to 0.1 for managed landfills and 0 for unmanaged according to the IPCC 2006 Guidelines 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 t½).
The maximum value of *k* applicable to any single SWDS is determined by a large number of factors associated with the composition of the waste and the conditions at the site. The most rapid rates are

associated with high moisture conditions and rapidly degradable material such as food waste. The slowest decay rates are associated with dry site conditions and slowly degradable waste such as wood or paper. Thus, for each rapidly, moderately and slowly biodegradable fraction, and for each site conditions a different maximum methane generation rate constant has been assigned, as reported in Table 7.10. Different *k* values for rapidly, moderately and slowly biodegradable waste splitted up into dry or wet zones are applied to the different parts of the model.
The methane generation rate constant *k* values derive from the 2006 IPCC Guidelines. Italy has investigated more deeply the country specific conditions and revised the k-values considering the subdivision of the national territory in dry or wet zones on the basis of georeferenced data (30 km grid) consisting of the monthly average climatic summaries (period 1986-2015) of precipitation and evapotranspiration referring to the rainy period (October-December) and to the entire national territory provided by the Research Centre for Agriculture and Environments CREA-AA (CREA, 2017). Subsequently the ratio between precipitation (MAP = Mean Annual Precipitation) and evapotranspiration (PET = Potential Evapotranspiration) has been calculated and dry and wet zones distinguished following the 2006 Guidelines. Results have been reported in Figure 7.2., more information in (ISPRA, 2018).

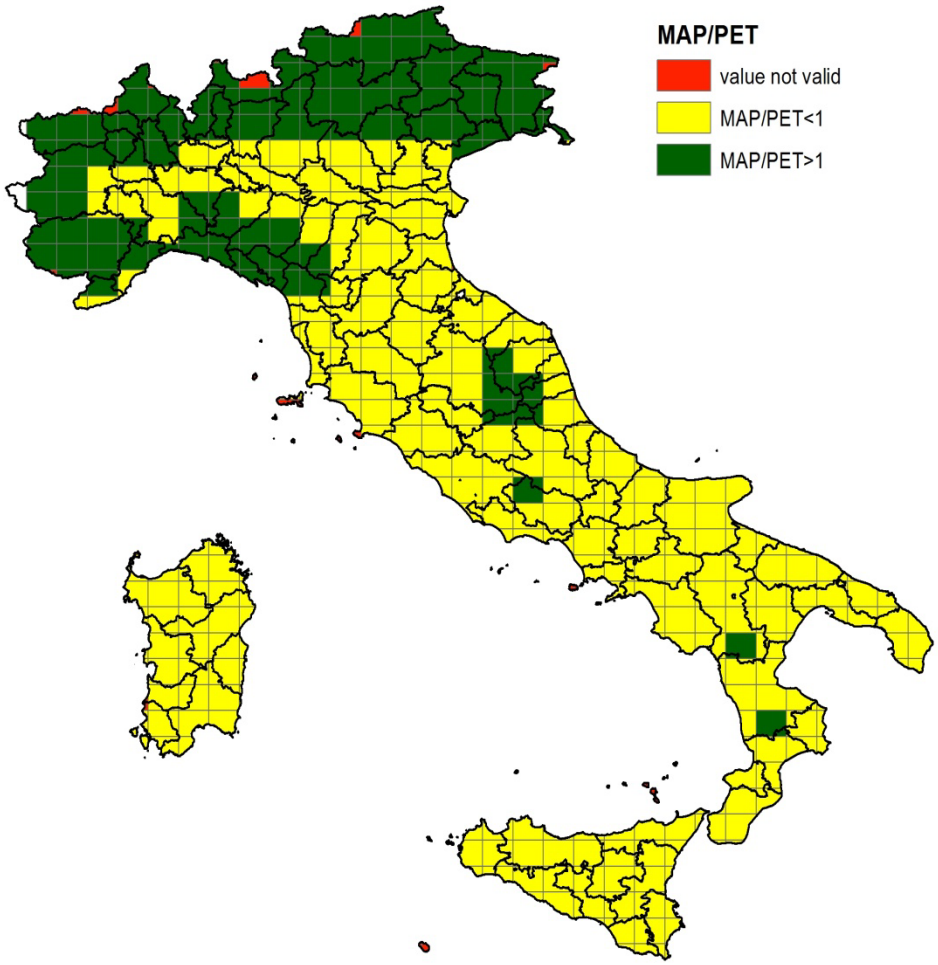


Figure 7.2 Distribution of moisture conditions as defined by the 2006 IPCC GL

On the basis of the location of the solid waste disposal sites and of the distribution of dry or wet zones, the appropriate k values have been set; in particular, as reported in Table 7.10: 1) dry zones, rapidly biodegradable waste half life=12 years and k=0.06, moderately biodegradable half life=14 years and k=0.05, slowly biodegradable half life=20 years and k=0.03; 2) wet zones, rapidly biodegradable waste half life=4 years and k=0.17, moderately biodegradable half life=7 years and k=0.10, slowly biodegradable half life=14 years and k=0.05.

Table 7.10 Half-life values and related methane generation rate constant

MOISTURE CONDITIONS	WASTE TYPE	Half life	Methane generation rate constant
DRY	Rapidly biodegradable	12 year	0.06
	Moderately biodegradable	14 years	0.05
	Slowly biodegradable	20 years	0.03
WET	Rapidly biodegradable	4 year	0.17
	Moderately biodegradable	7 years	0.10
	Slowly biodegradable	14 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 7.11.

Table 7.11 Average k values based on waste compositions

	1971 - 1990	1991 - 1995	1996 - 2005	2006 - 2016
K dry	0.05	0.05	0.05	0.05
K wet	0.12	0.11	0.11	0.11

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 (EC, 1999); 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 7.12 consumptions and low calorific values are reported for the year 2016.

Table 7.12 1A4a biomass detailed activity data. Year 2016

Fuels		Consumption (Gg)	LCV (TJ/Gg)
Wood and similar	Wood	257.09	10.47
	Steam Wood	0.00	31.40
Incinerated waste (biomass)		2939.78	9.20
Biogas from landfills		292.43	53.23
Biogas from wastewater plants		25.33	53.23

The total CH_4 recovered is the sum of methane flared and methane used for energy purposes (see figure 7.3). Until 2000, the methane used for energy production is estimated starting from the electricity produced annually (E=GWh*3.6=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:

$$((E/0.3)/50.038)*1000= CH_4 \text{ Mg/year}$$

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 TERNA (National Independent System Operator).
Since 2001, TERNA provides directly the amounts of biogas recovered for energy purposes, in this case the LCV has been derived from the comparison with the supplied energy data.
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 56% of the total, in 1998, to 65% since 2002. In particular, the flared quantity of methane in 1990, reported by (De Poli and Pasqualini, 1991), is equal to 1,170,000 m^3/day which result in 108,858 Mg/y and, in 1990, this amount corresponds to the total methane recovered. Since 1991 TERNA (National Independent System Operator) supplies the amount of biogas collected with energy recovery while (ASJA, 2003) and (Acaia, 2004) supply the percentage (flared / with energy recovered) equal to 35% in 2000 (survey on landfills in the Lombardy region, year 2000, 32 plants) and 30% in the following years (Asja landfills produced 35% of energy from landfill gas at the national level in 2001-2002). After 2020 this value, 30 % flared of total biogas collected, has been keep constant not considering further improving in efficiency in recovering methane for energy purposes with respect to the total methane collected. Since 2002 the efficiency is estimated on the basis of an interpolation over the period 2002-2020.
Furthermore, following the recommendation of 2016 ESD- review (EU, 2016), Italy has started to collect plant data derived from IPPC permits. The completion of this search takes time as there are no available data base but it is necessary to make a documentary study, plant by plant. The documents analyzed at the time (some of these are available on the website https://ippc-aia.arpa.emr.it/CercaImpiantiTipo.aspx) seem to confirm current estimates (biogas flared = 30/35% of collected biogas). For next submissions, when the analyzed data will constitute a representative sample, the estimates will be updated for the years 2012-2014 and, consequently, for the time series.
Total methane collected is estimated, in 2016, equal to 46% of the total methane produced.

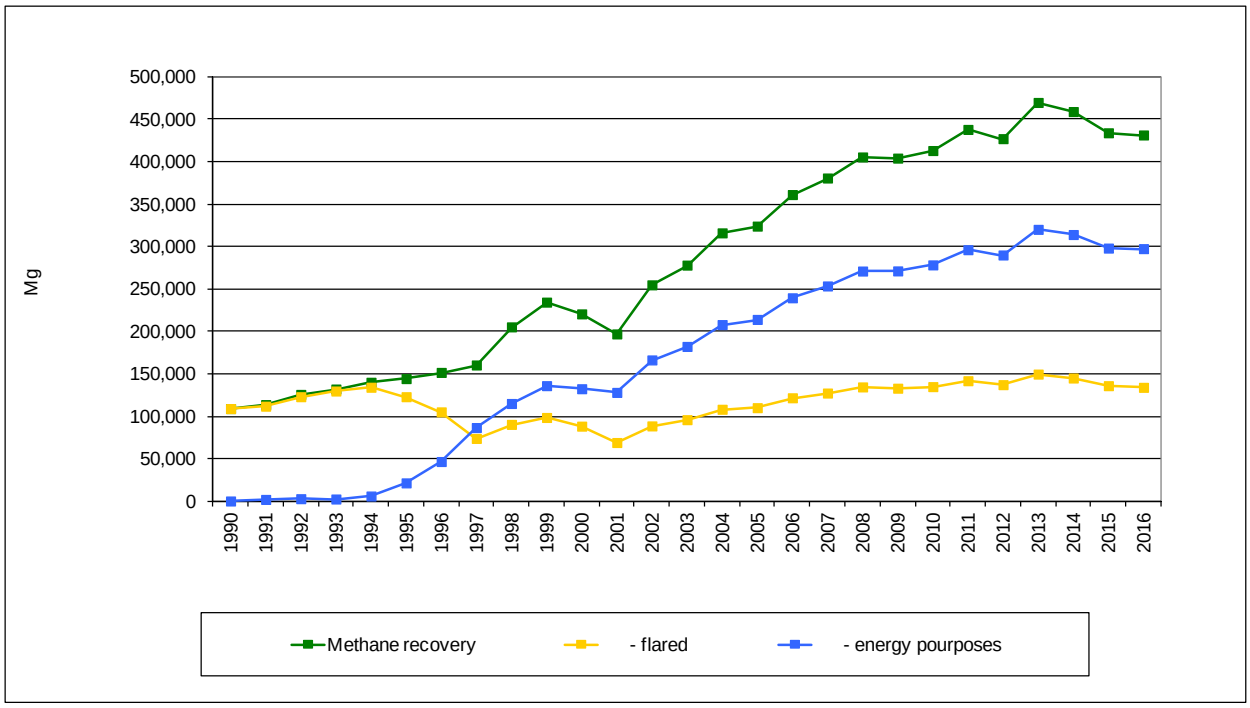


Figure 7.3 Methane recovery distinguished in flared amount and energy purposes (Mg)

CH_4 and NMVOC emission time series

The time series of CH_4 emissions is reported in Table 7.13; 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 7.13 VOC produced, recovered and CH_4 and NMVOC net emissions, 1990 – 2016 (Gg)

EMISSIONS	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Managed Landfills											
VOC produced (Gg)	396.4	565.5	772.3	916.7	977.4	983.6	982.3	974.9	966.4	955.2	941.3
VOC recovered (Gg)	108.9	144.1	220.4	323.7	412.7	437.6	426.7	469.3	458.6	433.6	431.0

EMISSIONS	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
VOC recovered (%)	27.5	25.5	28.5	35.3	42.2	44.5	43.4	48.1	47.5	45.4	45.8
CH_4 net emissions (Gg)	255.5	374.3	490.3	526.7	501.7	485.0	493.6	449.1	451.1	463.3	453.3
NMVOC net emissions (Gg)	3.4	4.9	6.5	6.9	6.6	6.4	6.5	5.9	5.9	6.1	6.0
Unmanaged Landfills											
VOC produced (Gg)	235.9	233.6	200.3	155.4	122.3	116.7	111.4	106.4	101.6	97.1	92.8
VOC recovered (Gg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CH_4 net emissions (Gg)	232.8	230.6	197.7	153.4	120.7	115.2	109.9	105.0	100.3	95.8	91.6
NMVOC net emissions (Gg)	3.1	3.0	2.6	2.0	1.6	1.5	1.4	1.4	1.3	1.3	1.2

7.2.3 Uncertainty and time-series consistency

The uncertainty in CH_4 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 22.4%, 10% and 20% for activity data and emission factors, respectively, as suggested by the IPCC Guidelines (IPCC, 2006).
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 7.13) are influenced, apart from the amount of waste landfilled, also from waste composition and site conditions, 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 to 2008 it is quite stable. Since 2009, due to the increasing in collection and recycling, but also to the economic crisis, the amount of waste disposed of in landfills is significantly decreased. It is important to remind 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 (only those similar to the municipal ones), which are subjected to fluctuation.
As previously reported, four waste compositions have been used, changing from 1950 to 2015 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 2011 and a reduction in the last years.
At the same time, biogas recovery has increased up to 2013, but from 2000 the recovery rate is higher: in 2013 the methane recovered is about 48% of the methane produced. Methane emissions for 2013 result mainly from the amount of waste landfilled in the previous three years (2010-2012) and the observed decline is explained by the sharp decrease in the amount of solid waste disposed in landfills in these years. In fact the amount of waste landfilled in 2013 were 28% less than those in 2010.

7.2.4 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.
Finally, an important improvement in waste data collection has been implemented by ISPRA and the Regional Agencies for the Protection of the Environment, consequently the waste statistical report includes the urban waste data referred to last years allowing a timely reporting.

7.2.5 Source-specific recalculations

Recalculations in the sector are due, as reported in 7.2.2 – methane generation rate constant, to an update in k-values following the suggestion of ESD review (EEA, 2017). The application of k dry values has led to a slower rate of emission and therefore a stronger reduction in the distant years compared with the recent ones, with respect to the previous submission.
Consequently, CH_4 net emissions for managed landfills shows a different behaviour from the previous submissions, increasing from 255 Gg to 453 Gg. CH_4 emissions from unmanaged landfills has a decreasing trend because of no waste has been disposed of from 2000. Activity data have not changed.

In Table 7.14, municipal and industrial (assimilated to MSW) wastes disposed into non hazardous landfills are reported also for Submission 2018.

Table 7.14 MSW disposed into landfills time series, 1990 – 2016 (t), AMSW disposed into landfills time series, 1990 – 2016 (t), and differences in percentage between Submission 2018 and Submission 2017.

Year	Submission 2018			Submission 2017			% MSW	% AMSW	% 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	15,537,822	3,180,904	18,718,726	-	-	-
2010	15,015,119	3,508,400	18,523,519	15,015,119	3,508,400	18,523,519	-	-	-
2011	13,205,749	2,882,686	16,088,435	13,205,749	2,882,686	16,088,435	-	-	-
2012	11,720,316	2,291,946	14,012,262	11,720,316	2,291,946	14,012,262	-	-	-
2013	10,914,353	2,511,711	13,426,064	10,914,353	2,511,711	13,426,064	-	-	-
2014	9,331,898	2,912,908	12,244,806	9,331,898	2,912,908	12,244,806	-	-	-
2015	7,818,795	3,221,646	11,040,441	7,818,795	3,221,646	11,040,441			
2016	7,431,611	2,512,938	9,944,549						

In Table 7.15 differences in percentage between emissions from landfills reported in the updated time series and 2017 submission are presented.

Table 7.15 Differences in percentage between emissions from landfills reported in the updated time series and 2017 submission

EMISSIONS	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015

EMISSIONS	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Managed Landfills										
VOC produced (Gg)	-39%	-17%	-16%	-16%	-13%	-12%	-11%	-10%	-8%	-7%
VOC recovered (Gg)	0%	0%	0%	2%	-1%	0%	3%	1%	3%	-5%
CH_4 net emissions (Gg)	-47%	-21%	-22%	-23%	-20%	-20%	-19%	-18%	-16%	-8%
NMVOC net emissions (Gg)	-47%	-21%	-22%	-23%	-20%	-20%	-19%	-18%	-16%	-8%
Unmanaged Landfills										
VOC produced (Gg)	-6%	14%	31%	50%	58%	59%	60%	61%	62%	62%
VOC recovered (Gg)	-	-	-	-	-	-	-	-	-	-
CH_4 net emissions (Gg)	-6%	14%	31%	50%	58%	59%	60%	61%	62%	62%
NMVOC net emissions (Gg)	-6%	14%	31%	50%	58%	59%	60%	61%	62%	62%

7.2.6 Source-specific planned improvements

Currently, more recent data on the fraction of CH_4 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.

7.3 Biological treatment of solid waste (5B)

7.3.1 Source category description

Biological treatment of solid waste is a key category for N_2O emissions at level (for 2016) and trend assessment but only with the Approach 2. Under this source category CH_4 and N_2O emissions from compost production and CH_4 emissions from anaerobic digestion of waste have been reported. NMVOC emissions from compost production have been estimated too. The amount of waste treated in composting and digestion plants has shown a great increase from 1990 to 2016 (from 283,879 Mg to 7,414,861 Mg for composting and from 79,440 Mg to 2,330,252 Mg for anaerobic digestion).

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 [a]; AUSITRA-Assoambiente, 1995); on the basis of this information the whole time series has been reconstructed. Regarding anaerobic digestion, the same sources of information have been used to reconstruct the time series until 2004 while ISPRA publishes yearly more accurate data from 2005.

7.3.2 Methodological issues

Composting

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).

In previous submissions, literature data (Hogg, 2001) have been used for the emission factor, 0.029 g CH_4 kg^{-1} treated waste, corresponding to the minimum of the range proposed by 2006 IPCC Guidelines on a wet weight basis. This choice has been taken because in the 2006 IPCC Guidelines the default value (4 g CH_4/kg

waste treated) is clearly shifted towards high values because most of world plants does not use advanced technologies.
The majority of references reported in Table 4.1 of 2006 IPCC Guidelines that have found high emission factors referred to composting time of 10-14 months, low turning frequency and no aeration system. In Italy, almost all of the plants are industrial plants (216/279 >1000 Mg/year in 2014), with enclosed areas for rotting and decomposition served by biofilters, turning when needed (to maintain the right porosity) and, above all, forced ventilation or suction system. Following the discussion started during the effort sharing decision review (EU, 2016) a specific survey on methane emission factor from composting and the relationship with technologies and management practices has been conducted (ISPRA, 2017) resulting in a new emission factor equal to 0.65 kg CH_4/Mg waste treated on a wet weight basis.
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 7.16 and in Figure 7.3, activity data expressed in wet weight, CH_4, N_2O and NMVOC emissions are reported.

Anaerobic digestion
The anaerobic digestion plants too are subdivided in the same two different kinds: plants that treat a selected waste and mechanical-biological treatment plants.
It is assumed that 100% of the input waste to the plants from selected waste is treated as anaerobic digestion, while in mechanical-biological treatment plants 15% of the input waste is considered as anaerobically digested. The default IPCC 2006 emission factor has been used. Since the plants are closed systems, emissions are related to the possibility of gas leaks estimated in 5 % of potential emissions.

Table 7.16 CH_4, N_2O and NMVOC emissions from biological treatment of solid waste, 1990 – 2016

	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016
Activity data										
Amount of waste to composting process (Mg ww)	283,879	657,215	2,834,309	5,550,888	7,030,808	7,150,442	7,483,499	8,104,905	7,288,305	7,414,861
Amount of waste to anaerobic digestion (Mg ww)	79,440	127,433	467,803	1,407,203	1,976,357	2,293,812	2,447,977	2,280,095	2,303,170	2,330,252
CH_4										
Compost production (Gg)	0.185	0.427	1.842	3.608	4.570	4.648	4.864	5.268	4.737	4.820
Anaerobic digestion (Gg)	0.003	0.005	0.019	0.056	0.079	0.092	0.098	0.091	0.092	0.093
N_2O										
Compost production (Gg)	0.068	0.158	0.680	1.332	1.687	1.716	1.796	1.945	1.749	1.780
NMVOC										
Compost production (Gg)	0.014	0.033	0.144	0.282	0.357	0.363	0.380	0.412	0.370	0.377

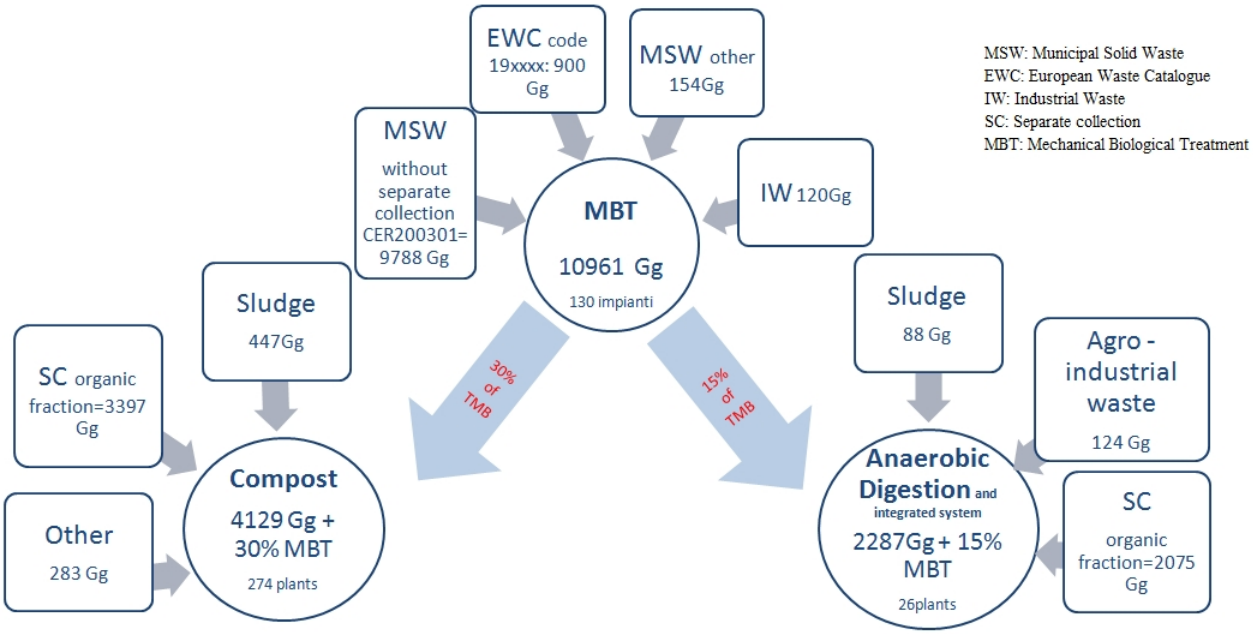


Figure 7.4 Waste treated in compost and anaerobic plants in 2016

7.3.3 Uncertainty and time-series consistency

The uncertainty in CH_4 emissions from biological treatment of waste is estimated to be about 100% in annual emissions, 20% and 100% concerning activity data and emission factors respectively. The uncertainty in N_2O emissions from biological treatment of waste is estimated to be about 100% in annual emissions, 20% and 100% concerning activity data and emission factors respectively.

7.3.4 Source-specific QA/QC and verification

This source category is covered by the general QA/QC procedures.

7.3.5 Source-specific recalculations

No recalculations occur except for the update of 2015 activity data.

Table 7.17 CH_4 and N_2O recalculations for biological treatment of solid waste, 1990 – 2015

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
CH_4										
Compost production (Gg)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Anaerobic digestion (Gg)	0%	0%	0%	0%	0%	0%	0%	0%	0%	-30%
N_2O										
Compost production (Gg)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

7.3.6 Source-specific planned improvements

Anaerobic digestion of solid waste is under investigation to collect more information about technologies and emission factors.

7.4 Waste incineration (5C)

7.4.1 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 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, see Table 7.12) 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 5C (Waste incineration). For 2016, more than 98% 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 5C: the total residues amount and carbon content have been estimated by both IPCC and national factors. The detailed methodology is reported in Chapter 5 (5.6.2).

CH_4 and N_2O emissions from biogenic, plastic and other non-biogenic wastes have been calculated.

7.4.2 Methodological issues

Regarding GHG emissions from incinerators, the methodology reported in the IPCC Good Practice Guidance (IPCC, 2000) has been applied, combined with that reported in the CORINAIR Guidebook (EMEP/CORINAIR, 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, SO_2 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 [a]; 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; Fondazione per lo sviluppo sostenibile e FISE UNIRE, 2016.).
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 CH_4 and N_2O 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 7.18, emission factors are reported in kg per tons of waste treated, for municipal, industrial, hospital waste, waste oils and sewage sludge.

Table 7.18 Waste incineration emission factors

POLLUTANT/WASTE TYPOLOGY	NMVOC (kg/t)	CO (kg/t)	CO_2 fossil (kg/t)	N_2O (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 7.19, 7.20, 7.21, 7.22), 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, CO_2 emission factor for municipal waste has been calculated considering a carbon content equal to 23%; moreover, on the basis of the IPCC Guidelines (IPCC, 2006) and referring to the average content analysis on a national scale (De Stefanis P., 2002), a distinction was made between CO_2 from fossil fuels (generally plastics) and CO_2 from renewable organic sources (paper, wood, other organic materials). Only emissions from fossil fuels, which are equivalent to 35% for municipal waste, were included in the inventory; this fraction is not expected to change significantly. Regarding the other waste components, C in sludge is considered completely organic, while C in industrial and hospital waste are considered completely fossil carbon according to the national definitions of these type of wastes. Mortal remains are not part of hospital waste but are included in the activity data used to estimate emissions from crematories; C in this case is considered completely organic. The average carbon content of incinerated waste varies in time and can be calculated as a weighted average among the different waste fractions, resulting in about 62% of fossil fraction in 1990 and about 76% in 2016 with respect to a total amount of incinerated waste equal to 745 Gg in 1990 and 105 Gg in 2016 (see Table 7.23). At the time, as the incineration of waste is not a key category, but rather in terms of emission of carbon dioxide is almost negligible, it is believed that the estimate is sufficiently accurate even if investigations are ongoing.

CO_2 emission factor for industrial, oils and hospital waste has been derived as the average of values of investigated industrial plants. On the other hand, CO_2 emissions from the incineration of sewage sludge were not included at all, while all emissions relating to the incineration of hospital and industrial waste were considered.
In Table 7.23 activity data are reported by type of waste.

Table 7.19 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_2O					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 7.20 Industrial waste and oils emission factors

INDUSTRIAL AND OIL WASTE	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_2O			100
CH_4			59.80
NMVOC			7,400
CO_2			1,200 (kg/t)

Table 7.21 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_2O			100
CH_4			59.80
NMVOC			7,400
CO_2			1,200 (kg/t)

Table 7.22 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_2O			100
CH_4			59.80
NMVOC			251.16
CO_2			700 (kg/t)

Table 7.23 Amount of waste incinerated by type, 1990 – 2016 (Gg)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Total Waste incinerated	1,656	2,149	3,062	4,964	6,977	6,797	6,709	7,002	7,426	7,534	7,636
- with energy recovery	911	1,558	2,750	4,721	6,796	6,615	6,518	6,794	7,308	7,430	7,531
- without energy recovery	745	591	312	244	181	183	192	208	118	103	105
MSW incinerated	1,026	1,437	2,325	3,220	4,337	4,733	4,257	4,314	4,712	4,698	4,523
- with energy recovery	626	1,185	2,161	3,168	4,284	4,695	4,255	4,314	4,712	4,698	4,523
- without energy recovery	399	251	164	52	53	38	2	0	0	0	0
Industrial Waste incinerated											
Other waste	*473*	*536*	*604*	*1,602*	*2,499*	*1,945*	*2,308*	*2,564*	*2,591*	*2,708*	*2,984*
- with energy recovery	258	330	508	1,446	2,399	1,849	2,192	2,431	2,552	2,674	2,951
- without energy recovery	215	206	96	155	100	96	115	133	39	33	34
Hospital waste	*134*	*152*	*110*	*126*	*135*	*103*	*118*	*98*	*99*	*102*	*103*
- with energy recovery	25	41	77	106	113	71	70	49	44	57	58
- without energy recovery	109	111	34	21	23	33	48	49	54	45	45
Sludge	*20.72*	*23.18*	*21.50*	*15.60*	*5.98*	*16.36*	*26.73*	*26.01*	*25.08*	*25.10*	*25.41*
- with energy recovery	0.00	0.00	3.40	0.00	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	5.98	16.36	26.73	26.01	25.08	25.10	25.41
Waste oil	*2.66*	*1.41*	*0.82*	*0.67*	*0.18*	*0.18*	*0.22*	*0.32*	*0.21*	*0.46*	*0.27*
- with energy recovery	1.77	0.94	0.55	0.54	0.18	0.18	0.22	0.32	0.21	0.46	0.27
- without energy recovery	0.89	0.47	0.27	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00

CH_4 and N_2O emissions from agriculture residues removed, collected and burnt 'off-site', as a way to reduce the amount of waste residues, are reported in the waste incineration sub-sector.

Removable residues from agriculture production are estimated for each crop type (cereal, green crop, permanent cultivation) taking into account the amount of crop produced, the ratio of removable residue in the crop, the dry matter content of removable residue, the ratio of removable residue burned, the fraction of residues oxidised in burning, the carbon and nitrogen content of the residues. Most of these wastes refer especially to pruning 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 3.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 3F, described in details in Chapter 5.
On the basis of carbon and nitrogen content of the residues, CH_4 and N_2O emissions have been calculated, both accounting nearly for 100% of the whole emissions from waste incineration. CO_2 emissions have been calculated but not included in the inventory as biomass. All these parameters refer both to the IPCC Guidelines (IPCC, 2006) 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, several years). Emission factors are from EMEP/EEA Air Pollutant Emission Inventory Guidebook (EMEP/EEA, 2009).

In Table 7.24 time series of cremation as well as annual deaths and crematoria in Italy are reported.

Table 7.24 Cremation time series (activity data), 1990 – 2016

	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016
Cremations (no. of corpses)	5,809	15,436	30,167	48,196	77,379	101,842	110,712	118,323	137,168	141,555
Deaths (no. of corpses)	543,700	555,203	560,241	567,304	587,488	612,883	600,744	598,364	653,000	615,261
Mortal remains (no.)	1,000	1,750	1,779	9,880	18,899	29,009	29,588	30,242	34,178	36,608
Cremation percentage	1.07	2.78	5.38	8.50	13.17	16.62	18.43	19.77	21.01	23.01
Crematoria (no.)	NA	31	35	43	53	58	63	67	70	77

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 CH_4 and N_2O, assumed equal to MSW emission factor because not available from 2009 Guidebook. CO_2 emissions have been not calculated for the inventory as human body is 'biomass'.

In Table 7.25 emission factors for cremation are reported.

Table 7.25 Cremation emission factors

POLLUTANT/WASTE TYPOLOGY	NMVOC (kg/body)	CO (kg/body)	N_2O (kg/t)	NO_x (kg/body)	SO_2 (kg/body)	CH_4 (kg/t)
Cremation	0.013	0.141	0.1	0.309	0.544	0.06

7.4.3 Uncertainty and time-series consistency

The combined uncertainty in emissions from waste incineration is estimated to be about 22.4%, 10% and 20% for activity data and emission factors respectively.
The time series of activity data, distinguished in Municipal Solid Waste and other (including cremation), is shown in Table 7.26; CO_2 emission trends for each type of waste category are reported in Table 7.27, both for plants without energy recovery, reported under 5C, and plants with energy recovery, reported under

1A4a. In Table 7.28 N_2O and CH_4 emissions are summarized, including those from open burning and cremation.
In the period 1990-2016, total CO_2 emissions have increased by 385%, but whereas emissions from plants with energy recovery have increased by nearly 835%, emissions from plants without energy recovery decreased by 81% (Table 7.26). While CO_2 emission trend reported in 5C is influenced by the amount of waste incinerated in plant without energy recovery, CH_4 and N_2O emission trend are related to the open burning, as already reported above.

Table 7.26 Waste incineration activity data, 1990 – 2016 (Gg)

Activity Data	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
MSW Production (Gg)	22,231	25,780	28,959	31,664	32,479	31,386	29,994	29,573	29,652	29,524	30,117
MSW Incinerated (%)	4.6%	5.6%	8.0%	10.2%	13.4%	15.1%	14.2%	14.6%	15.9%	15.9%	15.0%
- in energy recovery plants	2.8%	4.6%	7.5%	10.0%	13.2%	15.0%	14.2%	14.6%	15.9%	15.9%	15.0%
MSW to incineration (Gg)	1,026	1,437	2,325	3,220	4,337	4,733	4,257	4,314	4,712	4,698	4,523
Industrial, Sanitary, Sewage Sludge and Waste Oil to incineration (Gg)	631	712	737	1,744	2,640	2,064	2,453	2,688	2,715	2,835	3,113
Cremation (no. of corpses)	5,809	15,436	30,167	48,196	77,379	87,871	101,842	110,712	118,323	137,168	141,555
Total Waste to incineration, excluding cremation (5C and 1A4a) (Gg)	**1,656**	**2,149**	**3,062**	**4,964**	**6,977**	**6,797**	**6,709**	**7,002**	**7,426**	**7,534**	**7,636**

Table 7.27 CO_2 emissions from waste incineration (without and with energy recovery), 1990 – 2016 (Gg)

CO_2 Emissions	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Incineration of domestic or municipal wastes (Gg)	115.47	72.64	47.30	15.02	15.31	11.00	0.44	0.00	0.00	0.00	0.00
Incineration of industrial wastes (except flaring) (Gg)	257.99	247.11	115.74	186.50	119.88	114.97	138.37	159.93	46.57	40.19	40.69
Incineration of hospital wastes (Gg)	131.07	132.73	40.36	24.61	27.12	39.00	57.72	58.77	65.35	53.57	54.25
Incineration of waste oil (Gg)	2.66	1.41	0.82	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Incineration of corpses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Waste incineration (5C) (Gg)	507	454	204	226	162	165	197	219	112	94	95
Waste incineration reported under 1A4a (Gg) – not biomass	526	791	1,328	2,781	4,254	3,662	3,946	4,225	4,479	4,638	4,920
Waste incineration reported under 1A4a (Gg) - biomass	337	637	1,161	1,702	2,301	2,522	2,286	2,318	2,531	2,524	2,430
Total waste incineration - fossil(Gg)	1,033	1,245	1,532	3,007	4,416	3,827	4,143	4,443	4,591	4,732	5,014

Table 7.28 N_2O and CH_4 emissions from waste incineration (cremation and open burning included), 1990 – 2016 (Gg)

GAS/SUBSOURCE	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
N_2O (Gg)											
Waste incineration (5C)	0.12	0.12	0.09	0.09	0.08	0.08	0.08	0.08	0.07	0.07	0.07
MSW incineration reported under 1A4a – not biomass	0.05	0.08	0.13	0.27	0.40	0.36	0.38	0.40	0.42	0.44	0.46
MSW incineration reported under 1A4a – biomass	0.04	0.08	0.14	0.21	0.28	0.31	0.28	0.28	0.31	0.31	0.29
CH_4 (Gg)											
Waste incineration (5C)	2.00	2.32	2.23	2.46	2.33	2.31	2.32	2.23	2.10	2.32	2.41
MSW incineration reported under 1A4a – not biomass	0.03	0.05	0.08	0.16	0.24	0.21	0.22	0.24	0.25	0.26	0.27

GAS/SUBSOURCE	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
MSW incineration reported under 1A4a – biomass	0.02	0.05	0.08	0.12	0.17	0.18	0.17	0.17	0.18	0.18	0.18

7.4.4 Source-specific QA/QC and verification

Several verification were carried out on the basis of the analysis of documentation supplied in the framework of IPPC permits and of environmental reports.

7.4.5 Source-specific recalculations

Recalculations occur in 2014-2015 because of the update of industrial waste activity data (Table 7.29).

Table 7.29 Differences in percentages between time series reported in the updated time series and 2017 submission

GAS/SUBSOURCE	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
CO_2 (Gg)										
Waste incineration (5C)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-15.71%
MSW incineration reported under 1A4a	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	2.00%
N_2O (Gg)										
Waste incineration (5C)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-2.25%
MSW incineration reported under 1A4a	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	1.77%
CH_4 (Gg)										
Waste incineration (5C)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.33%
MSW incineration reported under 1A4a	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	1.77%

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). These investigations have led, in the previous submission, to the right allocation of some plants erroneously reported as incinerators whilst boilers and cement kiln facility already considered in the energy sector have been deleted.

7.4.6 Source-specific planned improvements

An assessment of the changes in GHG EFs across the time series with the aim of reflecting efficiency improvements or other changes with time is planned for the future.

7.5 Wastewater handling (5D)

7.5.1 Source category description

Under source category 5D, CH_4 and N_2O are estimated both from domestic and industrial wastewater.
The principal by-product of the anaerobic decomposition of the organic matter in wastewater is methane gas. Normally, CH_4 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 CH_4 (IPCC, 2006).

In 2016, nearly the 99% of population is served by sewer systems, whereas 83% of population is served by wastewater treatment plants (BLUE BOOK, several years; COVIRI, several years; ISTAT [d], [e], several years). In 1990, the percentage of population served by sewer system was 57%, whereas only 52% of population was served by wastewater treatment plants (BLUE BOOK, several years; COVIRI, several years; ISTAT [d], [e], several years).
In Italy, domestic wastewater follow the treatment systems and discharge pathways reported in Figure 7.4, whereas in brown are enhanced CH_4 sources.

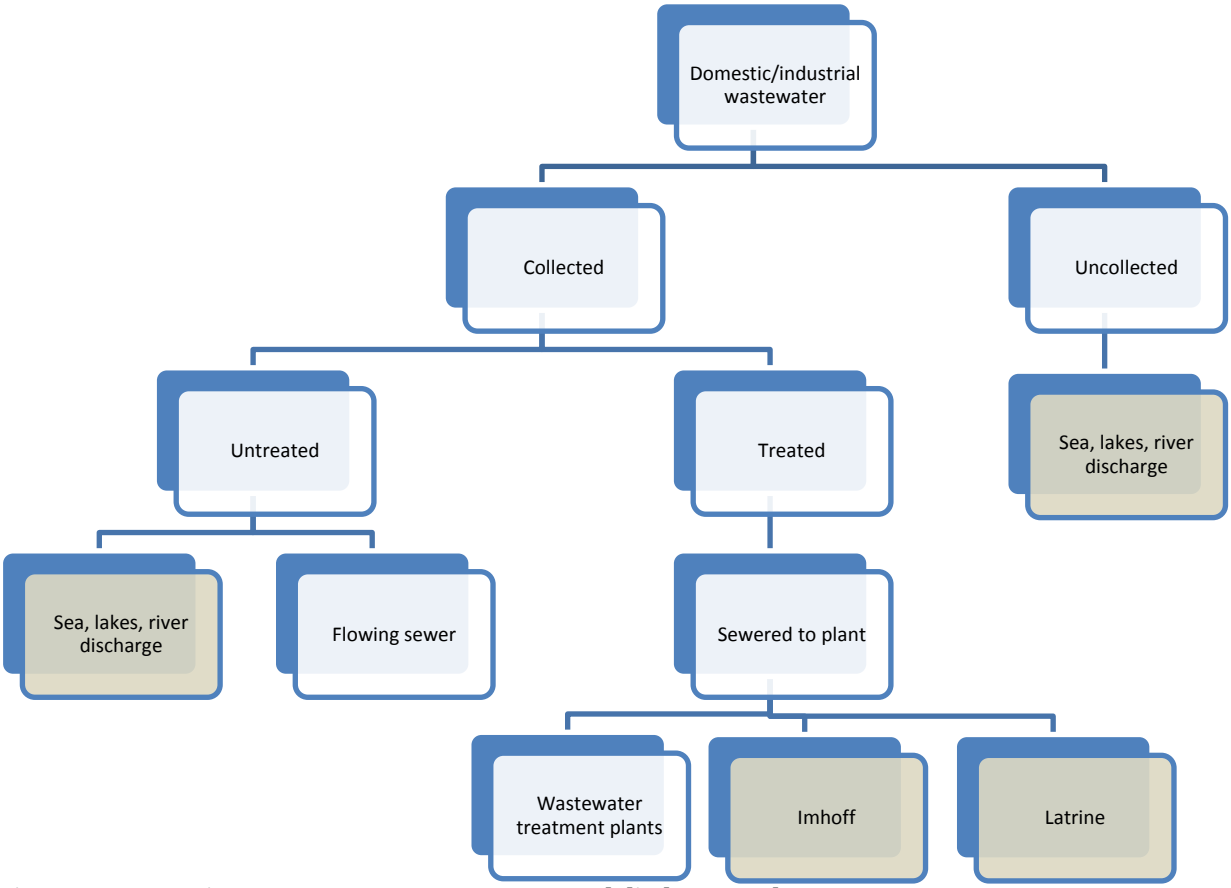


Figure 7.4 Domestic wastewater treatment system and discharge pathways

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 urban areas, 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.
On the contrary, in rural areas, wastewaters are treated in Imhoff tanks or in other on-site systems, such as latrines.
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, as reported in Table 7.12.

7.5.2 Methodological issues

Emissions from domestic wastewater – CH_4

CH_4 emissions from domestic wastewater are estimated using a Tier 2 approach, according to new 2006 IPCC Guidelines (IPCC, 2006).

The general equation used to estimate CH_4 emissions from domestic wastewater is:

$$CH_4 \text{ emissions} = [\Sigma_{i,j} (U_i * T_{i,j} * EF_j)] * (TOW - S) - R \text{ (kg } CH_4\text{/yr)}$$

where:

TOW = total organics in wastewater in inventory year (kg BOD/yr)
S = organic component removed as sludge in inventory year (kg BOD/yr)
U_i = fraction of population in income group i in inventory year
$T_{i,j}$ = degree of utilisation of treatment/discharge pathway or system, j, for each income group fraction i in inventory year
i = income group: rural and urban high income (urban low income is not considered in national inventory, for the typical Italian urbanization)
j = each treatment/discharge pathway or system
EFj = emission factor (kg CH_4/kg BOD)
R = amount of CH_4 recovered in inventory year (kg CH_4/yr)

An in-depth analysis of national circumstances has been made, collecting many statistical data on population and on urban wastewater treatment plants (BLUE BOOK, several years; COVIRI, several years; ISTAT, 1984; ISTAT, 1987; ISTAT, 1991; ISTAT, 1993; ISTAT [a], [b], 1998; ISTAT [d], [e], several years).
Some data, such as the degree of collected or treated wastewater are available for specific year, so the entire time series has been reconstructed with interpolation of data.

In the following tables (7.30, 7.31, 7.32), domestic wastewater population data are reported.

Table 7.30 Population data for domestic wastewater, 1990 – 2016 (*1000)

Population Activity Data	1990	1995	2000	2005	2010	2015	2016
Total Population	57,104	57,333	57,844	58,752	60,626	60,666	60,589
Urban high-income Population	53,272	53,623	54,255	55,330	57,280	57,440	57,388
Rural Population	3,831	3,710	3,589	3,422	3,347	3,225	3,201
Population served by collected wastewater systems (%)	57.0	69.8	86.0	83.0	90.1	97.5	98.9
Population served by wastewater treatment plants (%)	51.9	58.0	60.0	69.0	76.1	82.2	83.4

Table 7.31 Urban high-income Population for domestic wastewater, 1990 – 2016 (*1000)

Urban high-income Population	1990	1995	2000	2005	2010	2015	2016
Population not served by collected wastewater systems	22,900	16,190	7,596	9,406	5,655	1,453	609
Population served by collected wastewater systems	30,372	37,433	46,659	45,924	51,624	55,987	56,779
Pop. collected and treated	15,775	21,705	27,996	31,687	39,295	46,000	47,337
Pop. collected untreated	14,597	15,728	18,664	14,236	12,329	9,987	9,442
sea/lake/river discharge	8,758	9,437	11,198	8,542	7,398	5,992	5,665
flowing sewer discharge	5,839	6,291	7,465	5,695	4,932	3,995	3,777

Table 7.32 Rural Population data for domestic wastewater, 1990 – 2016 (*1000)

Rural Population	1990	1995	2000	2005	2010	2015	2016

Population not served by collected wastewater systems	1,647	1,120	502	582	330	82	34
Population served by collected wastewater systems	2,184	2,590	3,087	2,840	3,016	3,144	3,167
Pop. treated in Imhoff tanks	506	776	1,014	561	762	1,043	1,062
Pop. treated in latrines	1,679	1,814	2,073	2,279	2,254	2,100	2,105

The emission factor for a wastewater treatment and discharge pathway and system is a function of the maximum CH_4 production potential B_0 and the methane correction factor (MCF) for the wastewater treatment and discharge system, as indicated as following:

$$EF_j = B_0 * MCF_j$$

The default B_0 value (0.6 kg CH_4/kg BOD) and default MCF values have been used.

Type of treatment and discharge pathway or system	**MCF**
Untreated system	
Sea, river and lake discharge	0.1
Flowing sewer	0
Treated system	
Centralized, aerobic treatment plants	0.05
Anaerobic digester for sludge	0.8
Imhoff tanks	0.5
Latrines	0.1

The total amount of organically degradable material in the wastewater is calculated from the human population and the BOD generation per person:

$$TOW = P * BOD * 0.001 * I * 365$$

where:
TOW = total organics in wastewater in inventory year (kg BOD/yr)
P = country population in inventory year (person)
BOD = country specific per capita BOD in inventory year (g/person/day)
0.001 = conversion from grams to kg BOD
I = correction factor for additional industrial BOD discharged into sewers (I = 1.25, IPCC 2006).

The organic load in biochemical oxygen demand per person is equal to 60 g BOD_5 $capita^{-1}$ d^{-1}, as defined by national legislation and expert estimations (Legislative Decree 11 May 1999, no.152; Masotti, 1996; Metcalf and Eddy, 1991). In the following table 7.33, the total amount of organically degradable material expressed in tons, calculated for each treatment/discharge pathway or system is reported.

Table 7.33 Total organically degradable material in domestic wastewater, 1990 – 2016 (t BOD)

TOW (t BOD)	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**
Urban high-income Population							
TOW uncollected wastewater	626,899	443,188	207,932	257,490	154,816	39,786	16,678
TOW wastewater treatment plant	431,834	594,178	766,379	867,439	1,075,701	1,259,239	1,295,849
TOW sludge	215,917	297,089	383,189	433,720	537,850	629,620	647,924
TOW untreated (sea/lake/river)	239,754	258,334	306,551	233,832	202,510	164,038	155,085
TOW untreated (flowing sewer)	159,836	172,223	204,368	155,888	135,007	109,359	103,390
Rural Population							
TOW uncollected wastewater	45,088	30,665	13,755	15,925	9,045	2,234	930
TOW Imhoff	13,842	21,246	27,755	15,358	20,853	28,565	29,075
TOW latrines	45,956	49,656	56,740	62,395	61,716	57,498	57,629

As previously reported, in Italy wastewater handling is managed mainly using a secondary treatment, with aerobic biological units. The stabilization of sludge occurs in aerobic or anaerobic reactors covered and provided of gas recovery. 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%.
CH_4 emissions from sludge have been subtracted from the total amount of CH_4 produced, because emissions from sludge from wastewater treatment are considered in landfills, agricultural soils and incineration.
Moreover, CH_4 recovery has been distinguished between flaring and CH_4 recovery for energy generation, which has been reported in the Energy Sector.

Emissions from domestic wastewater –N_2O
Nitrous oxide (N_2O) emissions can occur as direct and indirect emissions. Direct emissions occur from nitrification and denitrification in wastewater treatment plants, whereas indirect emissions are those from wastewater after disposal of effluent into waterways, lakes or sea.
Emissions from advanced centralised wastewater treatment plants are typically much smaller than those from effluent and are estimated using the method reported in Box 6.1 of the Volume 5, Chapter 6 of new 2006 IPCC Guidelines (IPCC, 2006).

Direct emissions

$$N_2O_{PLANTS} = P * T_{PLANT} * F_{IND\text{-}COM} * EF_{PLANT}$$

where:
N_2O_{PLANTS} = total N_2O emissions from plants in inventory year (kg N_2O/yr)
P = human population
T_{PLANT} = degree of utilization of modern, centralised wastewater treatment plants (%)
$F_{IND\text{-}COM}$ = fraction of industrial and commercial co-discharged protein (default = 1.25)
EF_{PLANT} = emission factor, 3.2 g N_2O/person/year

Indirect emissions

$$N_2O_{EMISSIONS} = N_{EFFLUENT} * EF_{EFFLUENT} * 44/28$$

where:
$N_2O_{EMISSIONS}$ = N_2O emissions in inventory year (kg N_2O/yr)
$N_{EFFLUENT}$ = nitrogen in the effluent discharged to aquatic environments (kg N/yr)
$EF_{EFFLUENT}$ = emission factor for N_2O emissions from discharged to wastewater (kg N_2O-N/kg N)

Moreover:

$$N_{EFFLUENT} = N_{EFFLUENT\,TOT} - N_{SLUDGE} = (P * Protein * F_{NPR} * F_{NON\text{-}CON} * F_{IND\text{-}COM}) - N_{SLUDGE}$$

where:
$N_{EFFLUENT}$ = nitrogen in the effluent discharged to aquatic environments (kg N/yr)
P = human population
Protein = annual per capita protein consumption (kg/person/yr)
F_{NPR} = fraction of nitrogen in protein (default = 0.16 kg N/kg protein)
$F_{NON\text{-}COM}$ = fraction of non consumed protein added to the wastewater
$F_{IND\text{-}COM}$ = fraction of industrial and commercial co-discharged protein (default = 1.25)
N_{SLUDGE} = nitrogen removed with sludge (kg N/yr)

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 nitrogen in the effluent discharged to aquatic environments and is not accounted for twice.
For the parameter $F_{NON-COM}$ the value of 1.1 it is assumed, because, even if Italy is a developed country, garbage disposals of food that is not consumed and may be washed down the drain are not used.

Emissions from industrial wastewater – CH_4
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 CH_4 kg^{-1} COD, suggested in the 2006 IPCC Guidelines (IPCC, 2006), has been used for the whole time series.
It is assumed that industrial wastewaters are treated 85% aerobically and 15% anaerobically (IRSA-CNR, 1998).

Data have been collected for several industrial sectors (iron and steel, refineries, organic chemicals, food and beverage, paper and pulp, textiles and leather industry). The total amount of organic material, for each industry selected, has been calculated multiplying the annual production (t $year^{-1}$) by the amount of wastewater consumption per unit of product (m^3 t^{-1}) and by the degradable organic component (kg COD $(m^3)^{-1}$). Moreover, the fraction of industrial degradable organic component removed as sludge has been assumed equal to zero. The yearly industrial productions are reported in the national statistics (ISTAT, several years [a], [b] and [c]), whereas the wastewater consumption factors and the degradable organic component are either from 2006 IPCC Guidelines (IPCC, 2006) 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 7.34 detailed references for 2016 are reported: for these national data, slightly differences within the years can occur.

Emissions from industrial wastewater – N_2O
N_2O emissions from industrial wastewater have been estimated on the basis of the emission factors equal to 0.25 g N_2O/m^3 of wastewater production (EMEP/CORINAIR, 2007). EMEP/EEA Guidelines, after 2007 version, does not report any N_2O E.F but, about the methodology to estimate N_2O emissions from industrial wastewater, they refer to 2006 IPCC Guidelines. In 2006 IPCC Guidelines it is written that industrial wastewater may be treated on site or released into domestic wastewater. In the national inventory, the fraction of industrial wastewater relased into domestic wastewater it is estimated because of the parameter $F_{IND-COM}$. For the fraction treated on site 0.25 g N_2O/m^3 has been applied to the volume of wastewater generated for type of industry.
The wastewater production is resulting from the model for the estimation of methane emissions from industrial wastewater.

Table 7.34 Wastewater generation and COD values, 2016.

	Wastewater generation (m^3/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	3.87	ANPA-ONR, 2001	2.7	ANPA-ONR, 2001
Wine and Vinegar	3.8	ANPA-ONR, 2001	0.2	ANPA-ONR, 2001
Beer and Malt	5	Assobirra, several years	2.9	IPCC, 2000

	Wastewater generation (m^3/t)	References	COD (g/l)	References
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	0.10	UNIC, several years	4.71	UNIC, several years

7.5.3 Uncertainty and time-series consistency

The combined uncertainty in CH_4 and N_2O emissions from wastewater handling is estimated to be about 102% in annual emissions 100% and 20% for activity data and emission factor respectively, as derived by the IPCC Guidelines (IPCC, 2000; IPCC, 2006).

Concerning domestic wastewater, CH_4 emission trends are shown in Table 7.35, whereas the emission trend for N_2O emissions is shown in Table 7.36.

Table 7.35 CH_4 emissions from domestic wastewater, 1990 – 2016 (t)

CH_4 Emissions (t)	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**
Urban high-income Population							
CH_4 uncollected wastewater	37,614	26,591	12,476	15,449	9,289	2,387	1,001
CH_4 wastewater treatment plant	6,478	8,913	11,496	13,012	16,136	18,889	19,438
CH_4 anaerobic digestion	103,640	142,603	183,931	208,185	258,168	302,217	311,004
CH_4 untreated (sea/lake/river)	14,385	15,500	18,393	14,030	12,151	9,842	9,305
CH_4 untreated (flowing sewer)	0	0	0	0	0	0	0
Rural Population							
CH_4 uncollected wastewater	2,705	1,840	825	956	543	134	56
CH_4 Imhoff	4,153	6,374	8,327	4,608	6,256	8,569	8,722
CH_4 latrines	2,757	2,979	3,404	3,744	3,703	3,450	3,458
CH_4 total produced	171,732	204,800	238,852	259,983	306,245	345,489	352,983
CH_4 recovered	103,640	142,603	183,931	208,185	258,168	302,217	311,004
CH_4 flared	103,640	141,883	182,468	207,845	254,428	286,917	295,596
CH_4 energy recovery	0	719	1,463	340	3,740	15,300	15,408
CH_4 total emissions	**68,092**	**62,197**	**54,921**	**51,798**	**48,077**	**43,271**	**41,980**

Table 7.36 N_2O emissions from domestic wastewater, 1990 – 2016 (t)

N_2O Emissions (t)	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**
N_2O emissions from wastewater effluent (Indirect emissions)	3,933	3,820	4,073	4,069	4,177	4,032	4,220
N_2O emissions from wastewater treatment plants (Direct emissions)	87.4	85.0	92.5	156.5	153.6	146.7	145.6
N_2O total emissions	4,021	3,905	4,166	4,226	4,330	4,179	4,366

The amount of total industrial wastewater production is reported, for each sector, in Table 7.37.
CH_4 emission trend for industrial wastewater handling for different sectors is shown in Table 7.38, whereas the emission trend for N_2O emissions from industrial wastewater handling is shown in Table 7.39.

Concerning CH_4 emissions from industrial wastewater, neither wastewater flow nor average COD value change much over time, therefore emissions are stable and mainly related to the production data.

Table 7.37 Total industrial wastewater production by sector, 1990 – 2016 (1000 m^3)

Wastewater production (1000 m^3)	1990	1995	2000	2005	2010	2015	2016
Iron and steel	9.53	7.78	6.76	6.86	6.17	2.97	3.17
Oil refinery	NA	NA	NA	NA	NA	NA	NA
Organic chemicals	210.94	212.32	215.05	214.74	214.12	213.88	213.84
Food and beverage	179.12	177.38	182.74	185.66	186.26	177.91	187.88
Pulp and paper	377.17	402.95	387.28	366.02	232.69	202.64	231.92
Textile industry	108.46	103.05	101.57	75.49	64.36	48.90	47.13
Leather industry	23.62	25.00	27.22	18.32	14.25	13.03	12.69
Total	908.84	928.48	920.61	867.09	717.85	659.33	696.63

Table 7.38 CH_4 emissions from anaerobic industrial wastewater treatment, 1990 – 2016 (kt)

CH_4 Emissions (kt)	1990	1995	2000	2005	2010	2015	2016
Iron and steel	0.036	0.029	0.025	0.026	0.023	0.027	0.011
Oil refinery	5.850	5.625	4.250	4.750	4.750	4.750	4.750
Organic chemicals	23.794	23.911	24.173	24.177	24.069	23.999	24.015
Food and beverage	22.946	22.112	22.871	23.197	23.447	23.070	22.575
Pulp and paper	0.923	0.986	1.055	0.997	0.544	0.578	0.552
Textile industry	4.067	3.864	3.809	2.831	2.414	2.169	1.834
Leather industry	3.192	3.378	3.677	2.901	2.517	2.449	2.272
Total	60.81	59.91	59.86	58.88	57.76	57.04	56.01

Table 7.39 N_2O emissions from industrial wastewater, 1990 – 2016 (kt)

N_2O Emissions (kt)	1990	1995	2000	2005	2010	2015	2016
Industrial wastewater	0.227	0.232	0.230	0.217	0.179	0.165	0.174

7.5.4 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.

7.5.5 Source-specific recalculations

Minor recalculation is occurred due to update of population and activity data.

7.5.6 Source-specific planned improvements

Further improvements are welcome as soon as additional data will be available. We expect that environmental reports from industry will be improved each passing year.

8 RECALCULATIONS AND IMPROVEMENTS

8.1 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 2015 have been submitted as well as the CRF for the year 2016. Explanatory information on the recalculations involving methodological changes between the 2017 and 2018 submissions are reported in Table 8.1.

The revisions that lead to relevant changes in GHG emissions are pointed out in the specific sectoral chapters and summarized in the following section 8.4.1.

8.2 Implications for emission levels

The time series reported in the 2018 submission is summarised in Table 8.2 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 0.3% for 1990 and a decrease of 0.03% for 2015. Considering the national total with the LULUCF sector, the year 1990 has decreased by 0.26% and the 2015 emission levels increased by 0.19%.

Detailed explanations of these recalculations are provided in the sectoral chapters.

Table 8.1 Explanations of the main recalculations in the 2018 submission

Implementing Regulation Article 16: Reporting on major changes to methodological descriptions	
Please report the major changes to the methodological descriptions in the national inventory report since its submission due on 15 April of the previous year, in the table below:	

Member State:	ITALY		
Reporting year:	2018		

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please **mark the relevant cell** where the latest NIR includes major changes in methodological descriptions compared to the NIR of the previous year	Please **mark the relevant cell** where this is also reflected in recalculations compared to the previous years' CRF	If the cell is marked please provide a reference to the relevant section or pages in the NIR and if applicable some more detailed information such as the sub-category or gas concerned for which the description was changed.
Total (Net Emissions)			
1. Energy			
A. Fuel Combustion (sectoral approach)			
1. Energy industries			
2. Manufacturing industries and construction			
3. Transport	X	X	Copert 5 has been used to estimate road transport emissions (Chapter 3, road transport 1Ab category, all gases)
4. Other sector			
5. Other			
B. Fugitive emissions from fuels			
1. Solid fuels			
2. Oil and natural gas and other emissions from energy production			
C. CO2 transport and storage			
2. Industrial processes and product use			
A. Mineral industry			
B. Chemical industry			
C. Metal industry			
D. Non-energy products from fuels and solvent use			
E. Electronic industry			
F. Product uses as substitutes for ODS	X	X	Methodology to estimate emissions from domestic refrigeration has been changed according to the 2006 Guidelines (Chapter 4)
G. Other product manufacture and use			

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please **mark the relevant cell** where the latest NIR includes major changes in methodological descriptions compared to the NIR of the previous year	Please **mark the relevant cell** where this is also reflected in recalculations compared to the previous years' CRF	If the cell is marked please provide a reference to the relevant section or pages in the NIR and if applicable some more detailed information such as the sub-category or gas concerned for which the description was changed.
H. Other			
3. Agriculture			
A. Enteric fermentation			
B. Manure management			
C. Rice cultivation			
D. Agricultural soils	X	X	Update of the value of FracLEACH-(H) based on a country specific methodology
E. Prescribed burning of savannahs			
F. Field burning of agricultural residues			
G. Liming			
H. Urea application			
I. Other carbon containing fertilisers			
J. Other			
4. Land use, land-use change and forestry			
A. Forest land			
B. Cropland			
C. Grassland			
D. Wetlands			
E. Settlements			
F. Other land			
G. Harvested wood products			
H. Other			
5. Waste			
A. Solid waste disposal	X	X	According to the review process and technical correction an assessment and review of the basic parameters to estimate methane from landfills have been implemented resulting in updated emission time series (Chapter 7, paragraph 7.2)
B. Biological treatment of solid waste			
C. Incineration and open burning of waste			
D. Wastewater treatment and discharge			
E. Other			
6. Other (as specified in Summary 1.A)			
KP LULUCF			
Article 3.3 activities			

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please **mark the relevant cell** where the latest NIR includes major changes in methodological descriptions compared to the NIR of the previous year	Please **mark the relevant cell** where this is also reflected in recalculations compared to the previous years' CRF	If the cell is marked please provide a reference to the relevant section or pages in the NIR and if applicable some more detailed information such as the sub-category or gas concerned for which the description was changed.
Afforestation/reforestation			
Deforestation			
Article 3.4 activities			
Forest management			
Cropland management (if elected)			
Grazing land management (if elected)			
Revegetation (if elected)			
Wetland drainage and rewetting (if elected)			

NIR Chapter	**DESCRIPTION**		**REFERENCE**
	Please mark the cell where the latest NIR includes major changes in descriptions compared to the previous year NIR		**If the cell is marked please provide some more detailed information for example reference to pages in the NIR**
Chapter 1.2 Description of national inventory arrangements			

Table 8.2 Differences in time series between the 2018 and 2017 submissions due to recalculations

	subm	1990	1995	2000	2005	2010	2012	2013	2014	2015
Net CO_2 emissions/removals (Gg CO_2-eq.)	2018	434,595	429,231	453,502	466,752	393,234	372,256	329,721	314,121	319,310
	2017	429,383	424,409	448,393	462,220	392,706	369,634	328,345	311,813	320,136
Differences		*1.21%*	*1.14%*	*1.14%*	*0.98%*	*0.13%*	*0.71%*	*0.42%*	*0.74%*	*-0.26%*
CO_2 emissions (without LULUCF) (Gg CO_2-eq.)	2018	439,944	451,979	470,768	495,234	424,873	391,990	363,400	348,476	355,483
	2017	434,968	447,513	466,241	491,570	425,304	390,325	362,936	347,071	357,199
Differences		*1.14%*	*1.00%*	*0.97%*	*0.75%*	*-0.10%*	*0.43%*	*0.13%*	*0.40%*	*-0.48%*
CH_4 emissions (Gg CO_2-eq.)	2018	49,719	50,657	51,669	48,565	47,126	46,936	44,236	43,475	43,424
	2017	55,759	52,548	54,001	51,337	49,048	48,764	45,543	44,561	43,500
Differences		*-10.83%*	*-3.60%*	*-4.32%*	*-5.40%*	*-3.92%*	*-3.75%*	*-2.87%*	*-2.44%*	*-0.17%*
CH_4 emissions (without LULUCF) (Gg CO_2-eq.)	2018	48,236	50,311	50,737	48,206	46,769	45,724	44,046	43,132	43,133
	2017	54,242	52,199	53,067	50,979	48,694	47,556	45,356	44,225	43,212
Differences		*-11.07%*	*-3.62%*	*-4.39%*	*-5.44%*	*-3.95%*	*-3.85%*	*-2.89%*	*-2.47%*	*-0.18%*
N_2O emissions (Gg CO_2-eq.)	2018	27,246	28,059	29,053	28,413	19,699	19,826	18,703	18,213	18,192
	2017	27,761	29,129	30,018	28,926	20,172	20,362	19,200	18,737	18,759
Differences		*-1.86%*	*-3.67%*	*-3.22%*	*-1.78%*	*-2.35%*	*-2.63%*	*-2.59%*	*-2.80%*	*-3.02%*
N_2O emissions (without LULUCF) (Gg CO_2-eq.)	2018	26,423	27,231	28,374	27,799	19,057	19,066	18,145	17,627	17,636
	2017	26,949	28,318	29,347	28,319	19,537	19,608	18,645	18,153	18,203
Differences		*-1.95%*	*-3.84%*	*-3.31%*	*-1.84%*	*-2.46%*	*-2.76%*	*-2.68%*	*-2.90%*	*-3.12%*
HFCs	2018	444	869	2,479	7,089	11,356	12,860	13,479	14,091	14,468
(Gg CO_2-eq.)	2017	444	820	2,105	6,060	9,581	10,687	11,383	11,928	12,264
Differences		*0.00%*	*6.04%*	*17.76%*	*16.98%*	*18.53%*	*20.33%*	*18.40%*	*18.14%*	*17.97%*
PFCs (Gg CO_2-eq.)	2018	2,907	1,492	1,488	1,940	1,520	1,499	1,705	1,564	1,688
	2017	2,907	1,492	1,488	1,940	1,520	1,499	1,705	1,564	1,688
Differences		*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
SF_6	2018	410	681	605	550	394	445	421	359	441
(Gg CO_2-eq.)	2017	408	679	603	547	391	442	418	356	430
Differences		*0.52%*	*0.32%*	*0.37%*	*0.55%*	*0.77%*	*0.68%*	*0.72%*	*0.84%*	*2.62%*
NF_3 (Gg CO_2-eq.)	2018			13	33	20	25	26	28	28
	2017			13	33	20	25	26	28	28
Differences				*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
Total (with LULUCF) (Gg CO_2-eq.)	2018	515,321	511,066	538,809	553,343	473,349	453,846	408,291	391,852	397,552
	2017	516,662	509,153	536,621	551,064	473,438	451,414	406,622	388,987	396,806
Differences		*-0.26%*	*0.38%*	*0.41%*	*0.41%*	*-0.02%*	*0.54%*	*0.41%*	*0.74%*	*0.19%*
Total (without LULUCF) (Gg CO_2-eq.)	2018	518,363	532,640	554,464	580,851	503,989	471,609	441,222	425,277	432,878
	2017	519,917	531,098	552,864	579,449	505,047	470,142	440,470	423,324	433,025
Differences		*-0.30%*	*0.29%*	*0.29%*	*0.24%*	*-0.21%*	*0.31%*	*0.17%*	*0.46%*	*-0.03%*

8.3 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 2017, emission levels of the year 1990, as total emissions in CO_2 equivalent without LULUCF, slightly changed (-0.30%). If considering emission levels with LULUCF, a decrease by 0.26% is observed in total figures, in CO_2 equivalent, for 1990.

The trend 1990- 2015, without LULUCF, does not show a significant change from the previous to this year submission; the reduction in emissions, 1990-2015, is equal now to 16.5 % whereas it was 16.7% in the last year submission.

8.4 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.

8.4.1 Recalculations

The key differences in emission estimates occurred since the last year submission are reported in Table 8.1 and Table 8.2. No main recalculations occurred for this year submission, as for the last year submission when main recalculations were due to the application of the 2006 IPCC Guidelines, involving emission factors, parameters and methodologies.

Besides the usual updating of activity data, recalculations may be distinguished in methodological changes, source allocation and error corrections.
All sectors were involved in changes due to updates of activity data and some emission factor.
Specifically:

Energy. The whole time series of road transport emissions has been recalculated because of the application of the new version of the model COPERT 5. Waste fuel consumption for commercial heating activity data has been updated from 2014 because the update of activity data for industrial waste. The energy conversion factor has been updated according to the international statistics. CO_2 emission factors have been slightly revised from 2005 for some fuels. Solid fuel consumptions for all categories and natural gas and biogas fuel consumption for heating have been updated on the basis of the last submission of energy balance provided by the Ministry of Economic Development to the Joint Questionnaire OECD/IEA/EUROSTAT. Emissions from aviation have been recalculated from 2005 on the basis of information on activity data and emission factors provided by Eurocontrol.

IPPU. Major recalculations occurred for F-gases as a consequence of the revision of domestic refrigeration and fire protection sub-sources. Commercial refrigeration sub-source has been changed because professional appliances, such as blast chillers, that were included in the domestic refrigeration category, are considered as commercial appliances. Morever data on SF_6 consumption in particle accelerators used for medical purposes have been collected and consequently emission estimates have been estimated.

Agriculture. CH_4 emissions have been recalculated because of the update of the methane estimate from enteric fermentation for sheep by applying the Tier 2 methodology and the update of the methane emission factors from storage of the dairy cattle and swine categories on the basis of the elaboration of data collected in the 2010 General Agricultural Census and the Farm Structure Survey 2013. N_2O emissions have been recalculated because of the update of NH_3 and NO_x emissions from housing and storage and the update of the average value of $Frac_{LEACH-(H)}$ for the entire national territory based on a country specific methodology. Minor recalculations occurred in this submission due to the update of the activity data of bedding materials added to managed manure for application to soils. Limestone and dolomite application average emission factor has been updated for the whole time series. Other activity data have been updated for the last years resulting in minor recalculations.

LULUCF. Activity data have been updated and errors corrected as a result of the implementation of the For-est model coded in R open source language.

Waste. Recalculations occurred in this sector for the update of the model parameters for estimate methane emissions from landfills from 1990. In particular methane generation rate k-values have been revised considering the subdivision of the national territory in dry or wet zones. For waste incineration, recalculations are due to the update of few plants industrial waste activity data from 2014.

8.4.2 Response to the UNFCCC review process

A complete list of improvements following the UNFCCC review process is reported in Annex 12. In 2017, there was no review for the Italian inventory.
Improvements regarded the completeness and transparency of the information reported in the NIR.

Most of the recommendations were addressed in the 2017 submission. More information on the trend emissions has been provided in the energy sector as some improvements in emission estimates for aviation and of reporting for lubricants, more information on methodology used to estimate emissions for industrial processes (especially for F-gases estimations) and updated estimates for CO_2 from solvent use, agriculture sector (manure management and lime application) and LULUCF 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. For the waste sector emission estimates have been updated for landfills and compost production categories.

8.4.3 Planned improvements (e.g., institutional arrangements, inventory preparation)

Specific improvements are identified in the relevant chapters and specified in the 2018 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 and improved. 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. Energy data submitted to the international organizations in the framework of the Joint Questionnaire OECD/IEA/EUROSTAT will be compared with the national energy statistics used up to now with the aim to reduce the differences with the international statistics.
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, for agriculture, further improvements are expected for the grazing, housing, storage systems and land spreading information collected by 2016 Agricultural Survey, while for waste sector the availability of additional information on waste composition.
For the LULUCF, the third NFI field surveys will allow using of IPCC carbon stock change method to estimate emissions and removals for forest land remaining forest land category.

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

9 KP-LULUCF

9.1 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), cropland management (CM) and grazing land management (GM). The estimates for emissions and removals under Articles 3.3 and 3.4 are consistent with the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (2013 KP Supplement, IPCC, 2014) and the relevant UNFCCC Decisions (15/CMP.1, 16/CMP.1, 2/CMP.6, 2/CMP.7).

9.1.1 Definition of forest and any other criteria

The forest definition to be used in the second commitment period is the same definition adopted for the first commitment period. The forest definition adopted by Italy is in line with the definitions of 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.
Following 2013 ERT's finding, plantations, previously not included in areas subject to art. 3.3 and 3.4 activities, have been classified as forest and reported in the appropriate Art. 3.3 and 3.4 categories.

9.1.2 Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

Italy has elected cropland management (CM) and grazing land management (GM) as additional activities under Article 3.4. Following the Decision 2/CMP.7, the forest management (FM) has to be compulsorily accounted as an activity under Article 3.4.

9.1.3 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 three Italian National Forest Inventories (IFN1985, IFNC2005 and the on-going INFC2015). *Deforestation* data have been detected by the surveys carried out in the framework of the NFIs (with reference to the years 2005 and 2012; the years 2006-2011 have been assessed through linear interpolation; 2013, 2014 and 2015 data have been deduced by a linear extrapolation); administrative records at NUT2 level collected by the National Institute of Statistics related to deforested area have been used for the period 1990-2005.
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.
Lands subject to *cropland management* activity are consistent with the cropland lands in the UNFCCC reporting. CM data have assessed on the basis of the IUTI data, related to 1990, 2000 and 2008 and 2012; 2013, 2014, 2015 and 2016 data have been deduced by a linear extrapolation for the period 2012-2016. The

same activity data deduced for UNFCCC reporting (cropland category) were therefore used to report for *cropland management*.
Land subject to *grazing land management* have been assessed on the basis of the definition included in the Annex to the the decision 16/CMP.1[60]. Lands under GM in Italy are those predominantly covered by herbaceous vegetation (introduced or indigenous) for a period longer than five years, used for grazing or fodder harvesting and /or under practices to control the amount and type of vegetation. In the current submission, only the area related to the 'improved grazing land' have been reported; this area corresponds to lands subject to inspections and certifications procedures, in accordance with the EU Regulations[61] on organic production, as well as by the Rural Development Regulations[62] related to the organic farming measure. Data of grazing lands managed with organic practices has been derived from the National System on Organic Farming (SINAB, http://www.sinab.it/) of the Ministry of Agriculture, Food and Forest Policies (MIPAAF).

9.1.4 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

In line with guidance provided by the 2013 KP Supplement (IPCC, 2014), an hierarchy has been established among the activities subject to article 3.3, FM and elected article 3.4. Land subject to article 3.3 activities and FM are mandatory and take precedence over elected 3.4 activities.
Italy has elected CM and GM as additional activities under Article 3.4, therefore it is necessary to establish a hierarchy between the abovementioned activities: in Italian context, the CM activity has an higher hierarchical order than GM activity. Furthermore, land converted from cropland to grassland is assumed to be converted into natural grassland, thus included in the CM activity.

9.2 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 for land subject to Article 3.3 and to FM activities have been identified with the administrative boundaries of Italian regions (NUTS2 level). The reporting area boundaries for GM and CM have been identified with the administrative boundaries of Italy (NUTS1 level). These areas include multiple units of land subject to *afforestation/reforestation* and *deforestation* and land areas subject to *forest management*, *cropland management* and *grazing land management*. 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, IFNC2005 and the on-going INFC2015). 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

[60] *Grazing land management* is the system of practices on land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced.
[61] Commision Regulation (EC) n. 889/2008: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008R0889&from=EN; Council Regulation (EC) n. 834/2007: http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=URISERV:f86000&from=IT; Council Regulation (EEC) n. 2092/91**:** http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31991R2092:EN:HTML
[62] Regulation (EEC) n. 2078/92: http://ec.europa.eu/agriculture/envir/programs/evalrep/text_en.pdf;
Council Regulation (EC): n. 1257/1999 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31999R1257&from=en;
Council Regulation (EC) n. 1698/2005: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32005R1698&from=en;
Regulation (EU) n. 1305/2013: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0487:0548:EN:PDF

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). A specific survey was dedicated to the soils pool, gaining data on soils carbon stock by 1,500 sampling areas selected in the IFNC2005 original grid. The third national forest inventory, IFNC2015, has the same three-phase sampling design of the previous NFI (INFC2005); the first phase of INFC2015 (interpretation of orhophotos) has been carried out in 2013, resulting in an assessment of forest land area; the forest inventory second phase (ground survey) is currently ongoing, planned to provide results by 2019.
Data of land subject to *grazing land management* has been derived from the National System on Organic Farming (SINAB, http://www.sinab.it/) of the Ministry of Agriculture, Food and Forest Policies (MIPAAF). Total organic area is reported in the SINAB at national level since 1990. Quantitative information on the different subcategories, including organic grazing land, is available from the year 1999. The data related to the land subject to the organic grazing land from 1990 to 1998 has been deduced applying the average proportion of organic grazing land to the total organic area (22.6%) calculated on the basis of SINAB data.

9.2.1 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.

9.2.2 Methodology used to develop the land transition matrix

The land transition matrix is shown in Table NIR-2 (Table 9.1). 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 1990–2016 have been assembled on the basis of the IUTI[63] data, related to 1990, 2000 and 2008. For 2012, land use and land use changes data were assessed through the survey, carried out in the framework of the III NFI, on an IUTI's subgrid (i.e. 301,300 points, covering the entire country). Annual figures for 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. *Deforestation* data have been detected by the surveys carried out in the framework of the NFIs (with reference to the years 2005 and 2012); administrative records at NUT2 level collected by the National Institute of Statistics related to deforested area have been used for the period 1990-2005. Activities planned in the framework of the registry for carbon sinks are expected to refine these estimates, providing detailed information on the final land use of the deforested area; in the current submission, 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).
Due to the technical characteristics of the IUTI assessment (i.e. classification of orthophotos), it was technically impossible to have a clear distinction among some subcategories in *cropland* and *grassland* categories (i.e. annual pastures versus grazing land). Therefore it has been decided to aggregate the *cropland* and *grassland* categories, as detected by IUTI, and then disaggregate them into the different subcategories, using as proxies the national statistics (ISTAT, [b], [c]) related to annual crops and perennial woody crops. The *cropland* area has been identified as the area of land subject to *cropland management*. Data of land subject to *grazing land management* has been derived from the National System on Organic Farming (SINAB, http://www.sinab.it/) of the Ministry of Agriculture, Food and Forest Policies (MIPAAF); the area reported under GM is currently a subset of the area reported under UNFCCC, *grassland* category.

[63] Detailed information on IUTI is reported in Annex 10

Table 9.1 Land transition matrices - Areas and changes in areas in 1990, 2013, 2014, 2015 and 2016 [kha]

	1990						
kha	3.3			3.4			
	Aff.-Ref.	Deforestation	FM	CM	GM	Other	total (beginning of year)
Aff.-Ref.	**73.77**						74
Deforestation		**14.44**					14
FM		0.72	**7,511.12**				7,512
CM				**10,704.36**			10,704
GM					**2.99**		3
Other	78.68					**11,747.51**	11,826
Total (end of 1990)	152	15.17	7,511	10,704	3	11,748	30,134

	2013						
kha	3.3			3.4			
	Aff.-Ref.	Deforestation	FM	CM	GM	Other	total (beginning of year)
Aff.-Ref.	**1,670.08**						1,670
Deforestation		**40.39**					40
FM		3.69	**7,467.76**				7,471
CM				**8,939.12**		0.00	8,939
GM					**290.70**		291
Other	58.31				92.14	**11,571.40**	11,722
Total (end of 2013)	1,728	44.08	7,468	8,939	383	11,571	30,134

	2014						
kha	3.3			3.4			
	AR	D	FM	CM	GM	Other	total (beginning of year)
AR	**1,728.40**						1,728
D		**44.08**					44
FM		3.69	**7,464.06**				7,468
CM				**8,939.12**		0.00	8,939
GM					**382.84**		383
Other	58.31				21.23	**11,491.85**	11,571
Total (end of 2014)	1,787	47.78	7,464	8,939	404	11,492	30,134

	2015						
kha	3.3			3.4			
	AR	D	FM	CM	GM	Other	total (beginning of year)
AR	**1,786.71**						1,787
D		**47.78**					48
FM		3.69	**7,460.37**				7,464
CM				**8,939.12**			8,939
GM					**404.07**		404
Other	58.31				22.13	**11,411.41**	11,492
Total (end of 2015)	1,845	51.47	7,460	8,939	426	11,411	30,134

	2016						
kha	3.3			3.4			
	AR	D	FM	CM	GM	Other	total (beginning of year)
AR	**1,845.03**						1,845
D		**51.47**					51
FM		3.69	**7,456.68**				7,460
CM				**8,939.12**			8,939
GM					**426.20**		426
Other	58.31			80.48	0.00	**11,272.62**	11,411
Total (end of 2016)	1,903	55.17	7,457	9,020	426	11,273	30,134

9.2.3 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 9.1) for land subject to Article 3.3 and to FM activities; boundaries of reporting areas have been identified with the administrative boundaries of Italian regions (NUTS2 level). The reporting area boundaries for GM and CM have been identified with the administrative boundaries of Italy (NUTS1 level). ID-codes have been assigned following the denomination of the different regions.

Figure 9.1 Geographical locations of the reporting regions and their identification codes

9.3 Activity-specific information

9.3.1 Methods for carbon stock change and GHG emission and removal estimates

9.3.1.1 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. 6.2.4.

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. Additional information on the methodological aspects may be found in Federici et al., 2008; 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 have been used to deduce the carbon stock changes in the pools, on the basis of the results of the II National Forestry Inventory and the national forest definition. The model has been applied at regional scale (NUTS2) because of availability of forest-related statistical data: model input data for the forest area, per region and inventory typologies, were the Italian forest inventories (NFI1985, NFI2005), while the results of the first phase of the NFI2015 were used in forest area assessment.

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. 9.3.1.2.

Methods for estimating carbon stock changes for lands subject to *cropland management* activity are the same as those used for the UNFCCC greenhouse gas inventory: details are given in par. 6.3.4. In line with the 2013 KP Supplement (IPCC, 2014) and 2006 IPCC Guidelines (IPCC, 2006), carbon stock changes have been estimated only for the living biomass of perennial woody crops, on the basis of carbon gains and losses,

computed applying a value of biomass C stock at maturity. Tier 1 method has been followed for dead wood and litter, assuming that the abovementioned pools are at equilibrium, and no carbon stock changes are occurring. Soils carbon stock changes have been assessed to be not occurring, as no management changes can be documented. CO_2 emissions from cultivated organic soils subject to CM activity have been estimated, using default emission factor for warm temperate, reported in Table 5.6 of 2006 IPCC Guidelines (vol.4, chapter 5). The area organic soils, updated on the basis of the FAOSTAT database, have been assessed through the stratification of different global datasets:

- the area covered by organic soils have been defined by extracting the Histosols classes from the *Harmonized World Soil Database*[64]
- the cultivated area has been identified from the global land cover dataset, GLC2000[65], using the three "cropland" classes.

Carbon stock changes related to land subject to *grazing land management* have been estimated on the basis of the guidance of 2013 KP Supplement (IPCC, 2014). In particular no change in carbon stocks in the living biomass pool has been assumed; Tier 1 method has been followed for dead wood and litter, assuming that the abovementioned pools are at equilibrium, and no carbon stock changes are occurring. Changes in carbon stocks in mineral soils have been estimated following the 2006 IPCC Guidelines (eq. 2.25, vol.4, chapter 2), on the basis of country specific SOC_{ref} deduced by the default reference soil organic carbon stocks for mineral soils (table 2.3, vol.4, chapter 2, IPCC, 2006). The assessment of the country specific SOC_{ref} has been carried out using the following layers: Climatic Zone layer[66], Corine Land Cover 2006[67], italian soil map (Costantini et al., 2013). The country specific SOC_{ref} have been stratifies into three macroareas in Italy: north (78.5 t C ha^{-1}) , center (71.3 t C ha^{-1}) and south (46.2 t C ha^{-1}). Default stock change factors (F_{LU}, F_{MG}, F_I) have been selected on the basis of national circumstances as reported in table 9.2.

Table 9.2 Stock change factors

	Improved grassland	*nominally managed (not degraded)*
F_{LU}	1.00	1.00
F_{MG}	1.14	1.00
F_I	1.11	1.11

Italy uses 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 and for land subject to art. 3.4 of the Kyoto Protocol.

Concerning carbon stock changes resulting from *deforestation* activities, for the current submission a conservative approach was applied, hypothesising that the total deforested area is converted into settlements. Activities planned in the framework of the registry for carbon sinks are expected to refine these estimates, providing detailed information on the final land use of the deforested area. 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). 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. 6.2.4. 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. 6.12.2. CO_2 emissions due to forest fires in areas subject to art. 3.3 and *forest management* activities have been included in corresponding tables: in particular, CO_2 emissions from biomass burning in land subject to art 3.3 activities are included in Table 4(KP-I)A.1.1, Losses (Aboveground and belowground pools), while CO_2 emissions from burnt areas under *forest management* are included in Table 4(KP-I)B.1, Forest Management,

[64] FAO/IIASA/ISRIC/ISSCAS/JRC, 2012. Harmonized World Soil Database (version 1.2). FAO, Rome, Italy and IIASA, Laxenburg, Austria.

[65] EC-JRC. 2003. Global Land Cover 2000 database. Available at http://bioval.jrc.ec.europa.eu/products/glc2000/glc2000.php

[66] European Commission's Joint Research Centre (JRC): Climatic Zones http://esdac.jrc.ec.europa.eu/projects/renewable-energy-directive

[67] Corine Land Cover 2006: http://sia.eionet.europa.eu/CLC2006

Losses (Aboveground and belowground pools). GHG emissions from biomass burning from lands subject to CM and GM activities have been reported in the table (KP-II)4.

9.3.1.2 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 minerals 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 Biosoil[68] (for soils) and a Life+ project FutMon[69] (*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 9.3 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.

Table 9.3 Relations soil - aboveground carbon per ha

	Inventory typology	Relation soil – aboveground C per ha	R^2	Standard error
stands	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
coppices	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
plantations	eucalyptuses coppices	y = 0.2683x + 70.208	0.073	33.39
	other broadleaves coppices	y = 0.2683x + 70.208	0.073	33.39

[68] 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
[69] 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

	Inventory typology	Relation soil – aboveground C per ha	R^2	Standard error
	poplars stands	y = 0.2502x + 79.115	0.0925	44.10
	other broadleaves stands	y = 0.2502x + 79.115	0.0925	44.10
	conifers stands	y = 0.2218x + 73.005	0.0713	40.14
protective	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 9.4 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 9.4 Soil Organic Content (SOC) per hectare, for the different inventory typologies

	Inventory typology	**1990** *t C ha^{-1}*	**1995** *t C ha^{-1}*	**2000** *t C ha^{-1}*	**2005** *t C ha^{-1}*	**2010** *t C ha^{-1}*	**2013** *t C ha^{-1}*	**2015** *t C ha^{-1}*	**2016** *t C ha^{-1}*
stands	norway spruce	85.42	84.86	84.32	83.99	83.87	83.82	83.78	83.77
	silver fir	87.17	86.23	85.34	85.07	84.96	84.94	84.97	84.98
	larches	83.77	83.14	82.56	82.40	82.51	82.57	82.62	82.64
	mountain pines	83.81	84.64	85.34	86.37	87.32	87.92	88.40	88.63
	mediterranean pines	83.23	84.88	86.27	87.86	88.94	89.55	90.24	90.52
	other conifers	80.05	80.79	81.39	82.22	83.11	83.62	84.05	84.25
	european beech	98.73	98.50	98.39	98.69	98.93	99.23	99.62	99.82
	turkey oak	94.76	95.04	95.30	95.91	96.22	96.46	96.82	96.98
	other oaks	89.21	89.55	89.89	90.63	91.14	91.45	91.78	91.92
	other broadleaves	89.88	89.97	89.99	90.53	90.96	91.23	91.55	91.70
coppices	european beech	83.23	82.80	82.45	82.43	82.72	82.97	83.24	83.36
	sweet chestnut	84.10	87.09	89.55	92.15	94.79	96.42	97.62	98.17
	hornbeams	76.40	76.08	75.82	75.73	75.78	75.85	75.95	75.99
	other oaks	75.53	75.95	76.18	76.41	76.65	76.86	77.06	77.14
	turkey oak	79.18	78.68	78.26	78.03	77.97	78.03	78.15	78.20
	evergreen oaks	79.62	79.44	79.28	79.29	79.36	79.49	79.68	79.74
	other broadleaves	78.61	80.22	81.51	82.76	83.91	84.53	84.97	85.16
	conifers	80.00	80.43	80.81	81.41	82.07	82.52	82.87	83.04
plantations	eucalyptuses coppices	83.72	87.06	88.15	88.83	88.99	88.68	88.93	88.84
	other broadleaves coppices	84.15	86.95	88.25	89.14	89.80	90.04	90.19	90.22
	poplars stands	87.84	91.09	93.49	95.70	97.33	97.93	98.28	98.39
	other broadleaves stands	86.85	86.68	86.87	87.44	88.14	88.63	89.03	89.22
	conifers stands	82.30	84.01	86.25	89.31	92.69	94.92	96.51	97.25
protective	rupicolous forest	76.80	77.31	77.81	78.44	79.07	79.42	79.71	79.85
	riparian forest	83.66	83.16	82.77	82.54	82.70	82.77	82.84	82.87

Carbon stock changes in mineral soils have been reported in the following Table 9.5 and Figure 9.2, for the different inventory typologies.

Table 9.5 Carbon stock changes in mineral soils (Soil Organic Matter (SOM) pool)

	1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Inventory typology	*Gg C*	*Gg C*	*Gg C*	*Gg C*	*Gg C*	*Gg C*	*Gg C*	*Gg C*	*Gg C*	*Gg C*	*Gg C*
stands	1,970	2,354	2,193	2,520	2,081	1,962	1,796	2,086	2,109	2,154	2,098
coppices	3,431	3,786	3,640	3,790	3,221	3,127	3,092	3,291	3,334	3,368	3,247
rupicolous and riparian forests	568	648	627	661	494	470	444	496	496	495	492
plantations	229	198	195	196	126	122	105	107	106	113	100
Total	**6,199**	**6,987**	**6,654**	**7,167**	**5,923**	**5,680**	**5,437**	**5,979**	**6,044**	**6,129**	**5,937**

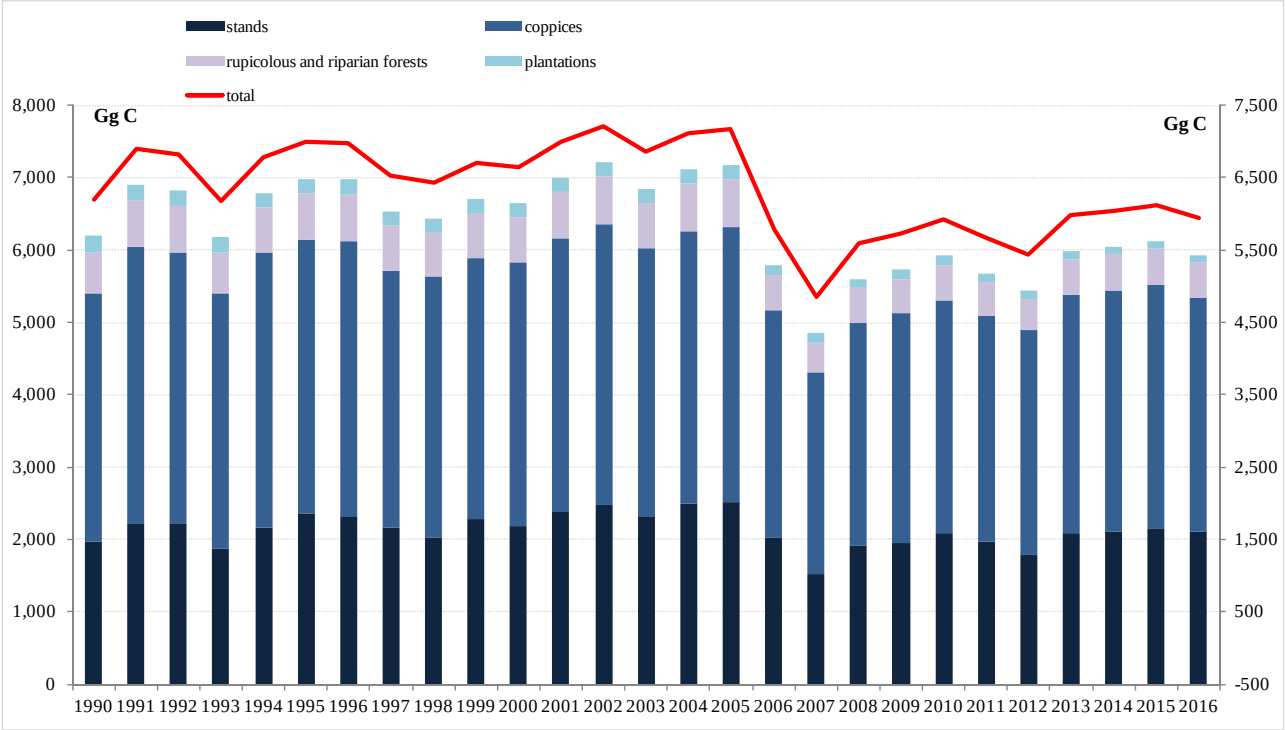


Figure 9.2 Carbon stock changes in mineral soils in the period 1990-2015 (SOM pool)

A comparison of the model results versus data measured in the framework of II NFI (INFC2005) may be carried out on the basis of the outcomes of the soil survey of NFI2005.
In the following Table 9.6 estimated carbon stocks for SOM are provided:

Table 9.6 Comparison between estimated and NFI 2005 carbon stocks for SOM

	NFI2005	**For-est model**	*differences*	
	t C= Mg	*t C= Mg*	*t C= Mg*	*%*
SOM	703,524,894	710,577,508	7,052,614	**-1.00**

Montecarlo analysis has been carried out for the CO_2 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 9.7, the results of the uncertainty assessment for soils pool are reported.

Table 9.7 Montecarlo uncertainty assessment for soils pool

Uncertainties for the different subcategories, year 2010	
	soils
stands	44.65
coppices	67.35
rupicolous and riparian forests	58.52
total	**49.33**

9.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

No indirect or natural greenhouse-gas removals were accounted for. Concerning activities under Article 3, paragraph 3, all removals accounted for by those activities are to be considered anthropogenic since they are

the result of direct human-induced activities. Further, all Art 3.3 activities have occurred after 1990, thus the dynamic effect of age is not relevant. With regard to activities under Article 3, paragraph 4, the net-net accounting approach, as well as the FMRL construction applied, completely address the issue of CO_2 removals factoring out.

9.3.1.4 Changes in data and methods since the previous submission (recalculations)

A comprehensive comparison of 2018 and 2017 submissions has been carried out.
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 activity data and from the detection and correction of computation errors. With reference to the ARD activities, the 2017 submission results in a slight deviation for the Afforestation/Reforestation activities (average decrease of 0.1%) and no deviations for Deforestation activities, respect the previous estimates. In Table 9.8 deviations, related to the ARD activities, resulting from the comparison of the 2018 submission against the previous estimates are reported.

Table 9.8 Deviations for ARD activities resulting from the comparison of the 2017 and 2016 submissions

	1990-2015	
	AR	D
pools	*%*	*%*
aboveground	0.00	0.00
belowground	0.00	0.00
litter	0.00	0.00
deadwood	0.00	0.00
soils	-0.98	0.00
total	**-0.10**	**0.00**

With reference to forest management, cropland management and grazing land management no deviations result by comparing the 2018 and 2017 submissions.

9.3.1.5 Uncertainty estimates

It was assumed that uncertainty estimates for forest land also apply for lands under FM (par. 6.2.5). The uncertainties related to the different pools are reported, for 2016, in Table 9.9.

Table 9.9 Uncertainties for the year 2016

Aboveground biomass	E_{AG}	42.64%
Belowground biomass	E_{BG}	52.14%
Dead mass	E_D	42.89%
Litter	E_L	43.80%
Overall uncertainty	**E**	**35.37%**

The uncertainties for Article 3.3 activities estimates are expected to be higher. It can be assumed that the given uncertainty analysis in Table 9.3 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.
Concerning *cropland management*, it was assumed that the uncertainty assessment carried out for cropland category also apply to land subject to CM. Additional details are reported in par. 6.3.5. A Montecarlo analysis has been carried out to assess uncertainty for cropland category (considering both cropland remaining cropland and land converted to cropland). A detailed description of the results is reported in Annex 1.
Concerning *grazing land management*, it was assumed that the uncertainty assessment carried out on the basis of information and values included in the 2013 KP Supplement (IPCC, 2014) and the 2006 IPCC

Guidelines (IPCC, 2006). The uncertainties for emissions and removals related to the GM activities have been estimated to be equal to 17,7% (1990), 18,72% (2013), 19,01% (2014) and 19,04% (2015) and 17.23% (2016).

9.3.1.6 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. 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). For 2012, land use and land use changes data were assessed through the survey, carried out in the framework of the III NFI, on an IUTI's subgrid (i.e. 301,300 points, covering the entire country). Verification and validation activities have been undertaken and the resulting time series have been discussed with the institutions involved in the data providing (i.e. National Forest Service, Ministry of Agricultural, Food and Forestry Policies (MIPAAF), Forest Monitoring and Planning Research Unit (CRA-MPF)).
An in-depth verification process has been carried out to compare the implied carbon stock change per area (IEF), related to the aboveground and belowground pools, with the IEFs reported by other Parties. The 2014 submission has been considered to deduce the different IEFs; in Figure 9.3 and 9.4 the comparison is showed, taking into account the IEFs for both the AR and FM activities, for the aboveground and belowground pools.

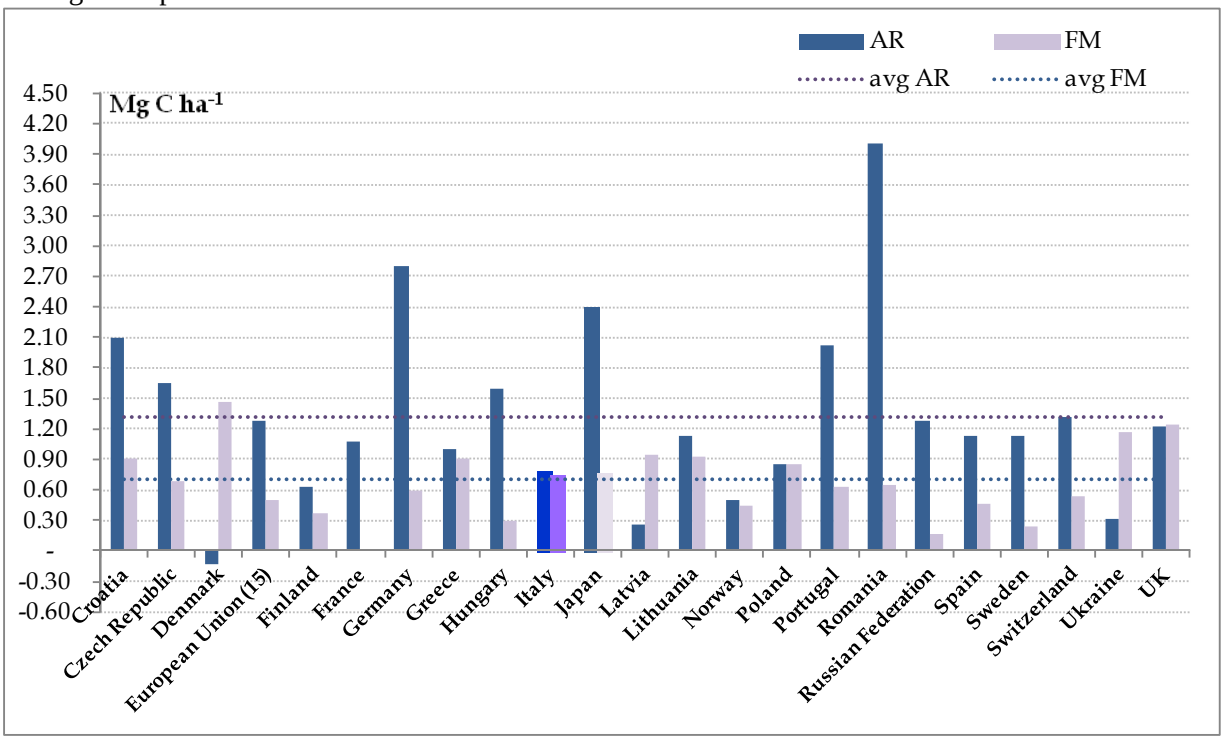


Figure 9.3 Implied carbon stock change per area related to the aboveground biomass

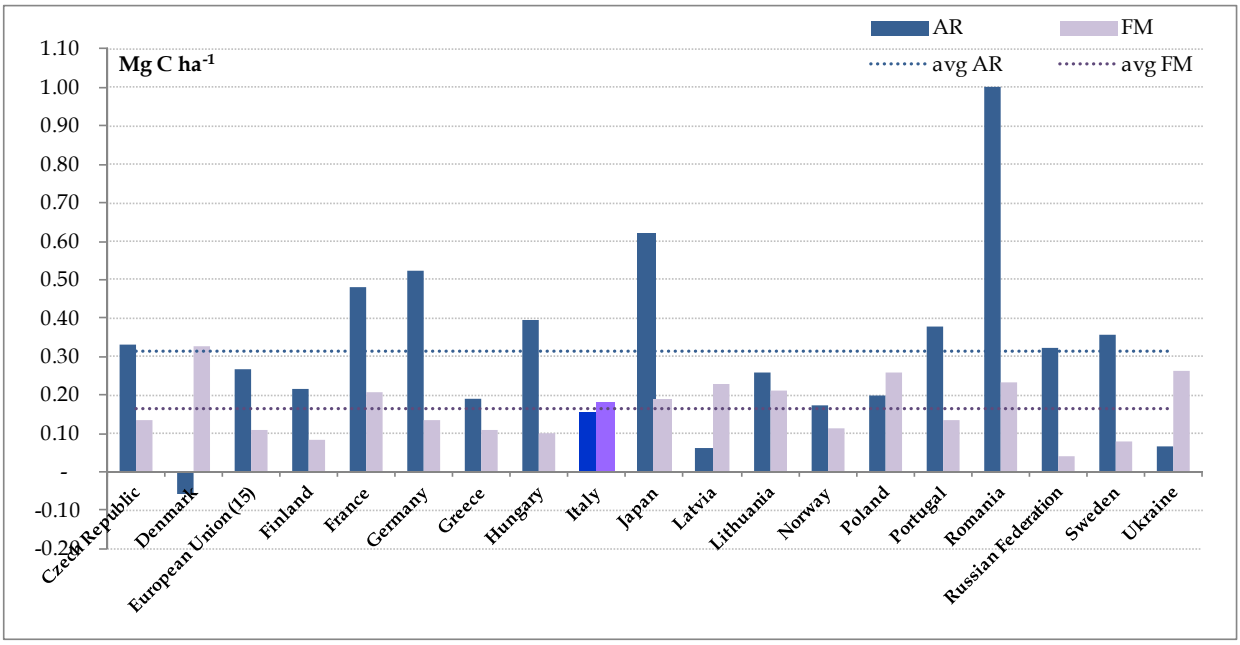


Figure 9.4 Implied carbon stock change per area related to the belowground biomass

9.3.1.7 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. 9.1.3, 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.

9.4 Article 3.3

9.4.1 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 9.11) are included in the reporting of these activities:

- Planted or seeded croplands;
- Planted or seeded grasslands;
- Abandoned arable lands, which are naturally forested, through planting, seeding and/or the human-induced promotion of natural seed sources.

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 legislation[70]. 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.

[70] In particular: Law Decree n. 227/2001; Law n. 353/2000; Law 1497/1939; Law Decree n. 3267/1923; 985, Law n. 431

On the basis of the definitions provided in the Decision 16/CMP.1[71], 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 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 constrains 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 9.10 Cumulative area estimates (kha) under Article 3.3 activities Afforestation/Reforestation for different periods

Afforestation /Reforestation	**1990-2008**	**1990-2009**	**1990-2010**	**1990-2011**	**1990-2012** *kha*	**1990-2013**	**1990-2014**	**1990-2015**	**1990-2016**
Abruzzo	59.1	61.7	64.2	66.8	69.4	72.0	74.6	77.3	79.9
Basilicata	45.5	47.6	49.6	51.7	53.8	55.9	58.0	60.1	62.2
Calabria	81.7	85.4	89.1	92.9	96.6	100.4	104.2	108.1	111.9
Campania	60.7	63.1	65.4	67.7	70.0	72.3	74.6	76.9	79.2
Emilia-Romagna	91.3	94.9	98.5	102.1	105.7	109.3	112.8	116.4	120.0
Friuli-Venezia Giulia	55.2	57.4	59.5	61.7	63.8	66.0	68.1	70.2	72.3
Lazio	88.7	92.7	96.7	100.7	104.8	108.9	113.0	117.1	121.3
Liguria	54.4	56.6	58.8	61.0	63.2	65.4	67.7	69.9	72.1
Lombardia	100.6	104.5	108.4	112.2	116.0	119.8	123.6	127.4	131.2
Marche	46.8	48.6	50.4	52.2	54.0	55.7	57.5	59.2	61.0
Molise	21.0	22.1	23.2	24.4	25.5	26.7	27.8	29.0	30.2
Piemonte	142.9	148.4	153.9	159.5	164.9	170.4	175.9	181.3	186.8
Puglia	24.4	25.6	26.8	28.0	29.2	30.4	31.6	32.8	34.1
Sardegna	83.5	86.7	90.0	93.2	96.4	99.6	102.8	106.0	109.2
Sicilia	46.1	48.3	50.5	52.7	55.0	57.2	59.5	61.8	64.1
Toscana	170.2	176.8	183.4	190.0	196.5	203.1	209.6	216.1	222.6
Trentino Alto Adige	122.2	126.6	131.1	135.5	139.9	144.2	148.5	152.8	157.1
Bolzano-Bozen	*56.2*	*57.7*	*59.0*	*60.3*	*61.6*	*62.8*	*63.9*	*65.0*	66.1
Trento	*65.9*	*69.0*	*72.1*	*75.2*	*78.3*	*81.4*	*84.6*	*87.8*	91.0
Umbria	59.0	61.5	64.0	66.5	69.0	71.5	74.0	76.5	79.0
Valle d'Aosta	16.8	17.4	18.1	18.8	19.4	20.1	20.7	21.4	22.1
Veneto	66.5	69.1	71.7	74.3	76.9	79.5	82.0	84.6	87.2
Italia	**1,436.8**	**1,495.1**	**1,553.5**	**1,611.8**	**1,670.1**	**1,728.4**	**1,786.7**	**1,845.0**	**1,903.3**

[71] "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.

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. *Deforestation* data have been detected by the surveys carried out in the framework of the NFIs (with reference to the years 2005 and 2012; the years 2006-2011 have been assessed through linear interpolation; 2013, 2014, 2015 and 2016 data have been deduced by a linear extrapolation); administrative records at NUT2 level collected by the National Institute of Statistics related to deforested area have been used for the period 1990-2005. Activities planned in the framework of the registry for carbon sinks are expected to refine these estimates, providing detailed information on the final land use of the deforested area; in the current submission, a conservative approach was applied hypothesising that the total deforested area is converted into settlements.

9.4.2 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)

9.4.3 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.

9.4.4 Information related to the natural disturbances provision under article 3.3

Italy intends to apply the provisions to exclude emissions from natural disturbances for the accounting for afforestation and reforestation (AR) under art. 3.3 during the second commitment period in accordance with decision 2/CMP.7, annex, paragraph 33.
The AR background level of emissions associated with annual natural disturbances have developed, on the basis of country-specific information, in accordance with the paragraphs 33(a) and (b) of Annex to Decision 2/CMP.7 and related guidance provided by the 2013 KP Supplement (IPCC, 2014).
In Table 9.11 the total and the area specific emissions from disturbance for the calibration period for AR activities have been reported.

Table 9.11 Total and area specific emissions from disturbances for the calibration period for AR

Total and area specific emissions from disturbances for the calibration period for AR																											
Disturbance type*	Inventory year during the calibration period																										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
	Total annual emission [Gg CO_2 eq.]																										
Wildfires	599	214	336	938	378	158	178	624	747	396	659	439	246	553	278	277	212	1491	294	325	160	305	817	153	226	233	335
Insect attacks and disease infestations																											
extreme weather events																											
geological disturbances																											
other																											
SUM	599	214	336	938	378	158	178	624	747	396	659	439	246	553	278	277	212	1,491	294	325	160	305	817	153	226	233	335
For all land under AR	Total area [kha]																										
	74	148	221	295	369	443	516	590	664	738	811	885	959	1033	1106	1177	1231	1379	1437	1495	1553	1612	1670	1728	1787	1845	1903
	Area-specific emissions (Emissions per unit of land area under AR, Mg CO_2 eq. ha^{-1})**																										
	8.12	1.45	1.52	3.18	1.03	0.36	0.35	1.06	1.12	0.54	0.81	0.50	0.26	0.54	0.25	0.24	0.17	1.08	0.20	0.22	0.10	0.19	0.49	0.09	0.13	0.13	0.18

*** In any year, emissions per unit of land area are calculated as the Sum divided by the total area under AR*

The background level has been developed following the default method outlined in the 2013 KP Supplement (IPCC, 2014), applying the following steps:

(1) Calculation of the arithmetic mean of the area-specific annual emissions for AR summed over disturbance types using all years in the calibration period.
(2) Calculation of the corresponding standard deviation (SD) of the annual emissions;
(3) Checking whether any emission estimate is greater than the arithmetic mean plus twice the SD. In this case, such estimate(s) has(ve) been removed from the dataset and go back to step (1) above using the reduced dataset.

When no further outliers can be identified, the arithmetic mean and twice the SD, as calculated in the last step of the iterative process, define the background level and the margin, respectively.
The expectation of net credits has been avoided comparing the emissions resulting by the application of step (3) above with the mean minus twice the SD (in this case emissions should not be removed from the dataset).
The main components related to background level and margin estimation process for AR activities have been reported in Table 9.12.

Table 9.12 Components of background level and margin for AR activities

Calibration period	1990 - 2016
Method used	IPCC default
Background level	0.44 Gg CO_2 eq.
Margin	0.69 Gg CO_2 eq.
Background level plus margin	1.13 Gg CO_2 eq.
Number of excluded years	4
Excluded years	1990, 1991, 1992, 1993

9.4.5 Information on Harvested Wood Products under article 3.3

Annual changes in carbon stocks and associated CO_2 emissions and removals from the Harvested Wood Products (HWP) pool under article 3.3 are estimated, following the production approach described in the Annex to Volume 4, Chapter 12, of the 2006 IPCC Guidelines (IPCC, 2006), in line with Decision 2/CMP.7 and the guidance provided by the 2013 KP Supplement (IPCC, 2014). HWPs originating from *deforestation* activity are not occurring. Emissions from HWPs originated from *afforestation/reforestation* activities have been included in the emissions estimated from HWPs from *forest management* activities.

9.5 Article 3.4

9.5.1 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.

9.5.2 *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.

9.5.2.1 *Conversion of natural forest to planted forest*

Conversion of natural forest to planted forest is not occurring. Therefore no related emissions have to be accounted for.

9.5.2.2 *Forest Management Reference Level (FMRL)*

The forest management reference level (FMRL[72]) for Italy, inscribed in the appendix to the annex to decision 2/CMP.7, is equal to –21.182 Mt CO_2 eq. per year assuming instantaneous oxidation of HWP, and –22.166 Mt CO_2 eq. applying a first-order decay function for HWP.
Italy is one of the member States of the EU for which the JRC of the European Commission developed projections in collaboration with two EU modeling groups. The FMRL[73] is the averages of the projected forest management (FM) data series for the period 2013-2020, taking account of policies implemented before mid-2009, with emissions/removals from harvested wood product (HWP) using the first order decay functions, and assuming instant oxidation. Aboveground and belowground biomass, dead organic matter and HWP are included in the FMRL. Non-CO_2 GHGs from forest wildfires are also included in the submission.

9.5.2.3 *Technical Corrections of FMRL*

According to Decision 2/CMP.7, methodological consistency between the FMRL and reporting for *forest management* during the second commitment period has to be ensured, applying technical correction if necessary.
Following the guidance provided by the 2013 KP Supplement (IPCC, 2014) the methodological elements listed in paragraph 2.7.5.2 (IPCC, 2014) have been analysed, providing a description on the detected inconsistencies (Table 9.14).

Table 9.14 Methodological elements triggering a methodological inconsistency between the FMRL and FM reporting

Criteria	Description
The method used for GHG reporting (for Forest land remaining forest land or Forest Management) changed after the adoption of FMRL	The FMRL has been calculated with the EU models G4M (IIASA) and EFISCEN (EFI). Estimates of emissions and removals under FM activities have been carried out with the growth model For-est, used to estimate the net change of carbon in the five reporting pools.

[72] Submission of information on forest management reference levels by Italy:
http://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_italy_2011.pdf
Communication of 11 May 2011 regarding harvested wood products value by Italy:
http://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_italy_corr.pdf
[73] When constructing the FMRL, the following elements were taken into account: (a) removals or emissions from forest management as shown in GHG inventories and relevant historical data, (b) age-class structure, (c) forest management activities already undertaken, (d) projected forest management activities under business as usual, (e) continuity with the treatment of forest management in the first commitment period.

Criteria	Description
Forest characteristics and related management[74]	Availability of new data resulting from the ongoing NFI and consequent recalculations of the reported data under FM and *Forest Land Remaining Forest Land used* to establish the reference level
Harvested wood products	The estimates have been carried out on the basis of the 2013 KP Supplement (IPCC 2014) methodology

The recommendation received in the technical assessment (UNFCCC, 2011, §3.7) of the FMRL highlighted the need to make a "technical adjustment to the FMRL when final agreement on the HWP estimation is reached".
The changes related to the methodological elements listed in Table 9.14 are triggering a methodological inconsistency between the FMRL and FM reporting, to be addressed through a technical correction (TC). Therefore to ensure methodological consistency between the FMRL and reporting for Forest Management during the second commitment period, the FMRL has been recalculated ($FMRL_{corr}$) in order to deduce the technical correction to the FRML.
The rationale for the calculating the $FMRL_{corr}$ is basically to address the elements of methodological inconsistency as listed in the Table 9.14. The key element is the use, in the elaboration of the $FMRL_{corr}$, of the same model used in the FM reporting (i.e. the For-est model, as described in paragraphs 6.2.4 and 9.3.1.1); in addition the latest available activity data (i.e. forest areas, harvest statistics, fires occurances) have been used and the HWP have been estimated following the 2013 KP Supplement (IPCC, 2014) methodology.
The resulting $FMRL_{corr}$ and the related technical correction is provided in the following Table 9.15.

Table 9.15 Techical correction and $FMRL_{corr}$

	Emissions and removals (*Gg yr^{-1}*)
FMRL	-22,166
$FMRL_{corr}$	-23,846
difference in %	8%
Technical Correction	-1,680
Accounting Parameter	23,846

9.5.2.4 Information related to the natural disturbances provision under article 3.4

Italy intends to apply the provisions to exclude emissions from natural disturbances for the accounting for forest management (FM) under art. 3.4 during the second commitment period in accordance with decision 2/CMP.7, annex, paragraph 33.
The FM background level of emissions associated with annual natural disturbances has been developed, on the basis of country-specific information, in accordance with the paragraphs 33(a) and (b) of Annex to Decision 2/CMP.7 and related guidance provided by the 2013 KP Supplement (IPCC, 2014).
In Table 9.16 the total and the area specific emissions from disturbance for the calibration period for FM activities have been reported.

[74] This includes, among others: age-class structure, increment, species composition, rotation lengths, management practices, etc.

Table 9.16 Total and area specific emissions from disturbances for the calibration period for FM

Total and area specific emissions from disturbances for the calibration period for FM																												
Disturbance type*	Inventory year during the calibration period																											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
	Total annual emission [Gg CO_2 eq.]																										
Wildfires	6,003	2,017	2,993	7,906	3,031	1,210	1,274	4,185	4,726	2,373	3,744	2,379	1,274	2,739	1,322	1,262	986	7,118	1,435	1,626	818	1,599	4,389	842	1,272	1,349	1,984
Insect attacks and disease infestations																											
extreme weather events																											
geological disturbances																											
other																											
SUM	6,003	2,017	2,993	7,906	3,031	1,210	1,274	4,185	4,726	2,373	3,744	2,379	1,274	2,739	1,322	1,262	986	7,118	1,435	1,626	818	1,599	4,389	842	1,272	1,349	1,984
For all land under FM	Total area [kha]																										
	7511	7510	7510	7509	7508	7508	7507	7506	7505	7505	7504	7503	7502	7502	7501	7497	7494	7490	7486	7483	7479	7475	7471	7468	7464	7460	7457
	Area-specific emissions (Emissions per unit of land area under FM, Mg CO_2 eq. ha^{-1})**																										
	0.80	0.27	0.40	1.05	0.40	0.16	0.17	0.56	0.63	0.32	0.50	0.32	0.17	0.37	0.18	0.17	0.13	0.95	0.19	0.22	0.11	0.21	0.59	0.11	0.17	0.18	0.27

** *In any year, emissions per unit of land area are calculated as the Sum divided by the total area under FM*

The background level has been developed following the default method outlined in the 2013 KP Supplement (IPCC, 2014), applying the following steps:

(1) Calculation of the arithmetic mean of the annual emissions for FM summed over disturbance types using all years in the calibration period.
(2) Calculation of the corresponding standard deviation (SD) of the annual emissions;
(3) Checking whether any emission estimate is greater than the arithmetic mean plus twice the SD. In this case, such estimate(s) has(ve) been removed from the dataset and go back to step (1) above using the reduced dataset.

When no further outliers can be identified, the arithmetic mean and twice the SD, as calculated in the last step of the iterative process, define the background level and the margin, respectively.
The expectation of net credits has been avoided comparing the emissions resulting by the application of step (3) above with the mean minus twice the SD (in this case the emissions should not be removed from the dataset).
The main components related to background level and margin estimation process for FM activities have been reported in Table 9.17.

Table 9.17 Components of background level and margin for FM activities

Calibration period	1990 - 2016
Method used	IPCC default
Background level	1,689 Gg CO_2 eq.
Margin	1,374 Gg CO_2 eq.
Background level plus margin	3,063 Gg CO_2 eq.
Number of excluded years	7
Excluded years	1990, 1993, 1997, 1998, 2000, 2007, 2012

9.5.2.5 Information on Harvested Wood Products under article 3.4

Annual changes in carbon stocks and associated CO_2 emissions and removals from the Harvested Wood Products (HWP) pool under article 3.4 are estimated, following the production approach described in the Annex to Volume 4, Chapter 12, of the 2006 IPCC Guidelines (IPCC, 2006), in line with Decision 2/CMP.7 and the guidance provided by the 2013 KP Supplement (IPCC, 2014).
Emissions from this source are mainly influenced by the trend in forest harvest rates: in 2016, the net emissions and removals from harvested wood products were -235.89 kt CO_2. Details on HWPs in use from 1961 onwards are reported in Figure 6.9 (§6.13.2).
The activity data (production of sawnwood, wood based panels and paper and paperboard) are derived from FAO[75] forest product statistics. Italy uses the same methodology to estimate emissions annual changes in carbon stocks and associated CO_2 emissions and removals from the HWP pools under UNFCCC and KP, following the decision Decision 2/CMP.7, paragraph 29, namely, that "*transparent and verifiable activity data for harvested wood products categories are available, and accounting is based on the change in the*

[75] Food and Agriculture Organization of the United Nations: forest product statistics, http://faostat3.fao.org/download/F/FO/E

harvested wood products pool of the second commitment period, estimated using the first-order decay function".

The estimates have been carried out on the basis of the 2013 KP Supplement (IPCC 2014) methodology. The Tier 2 approach, first order decay, was applied to the HWP categories (sawnwood, wood based panels and paper and paperboard) according to equation 2.8.5 (IPCC, 2014). Equation 2.8.1 (IPCC, 2014) has been applied to estimate the annual fraction of the feedstock coming from domestic harvest for the HWP categories sawnwood and wood-based panels.

The change in carbon stocks was estimated separately for each product category; the default values (Table 2.8.1, IPCC 2014) have been applied. Emission factors for specific product categories were calculated with default half-lives of 35 years for sawnwood, 25 years for wood panels and 2 years for paper (Table 2.8.2, IPCC 2014).
The annual change in stock for the period 1961-2016, disaggregated into sawnwood, wood based panels and paper & paperboard, is reported in Figure 9.5.

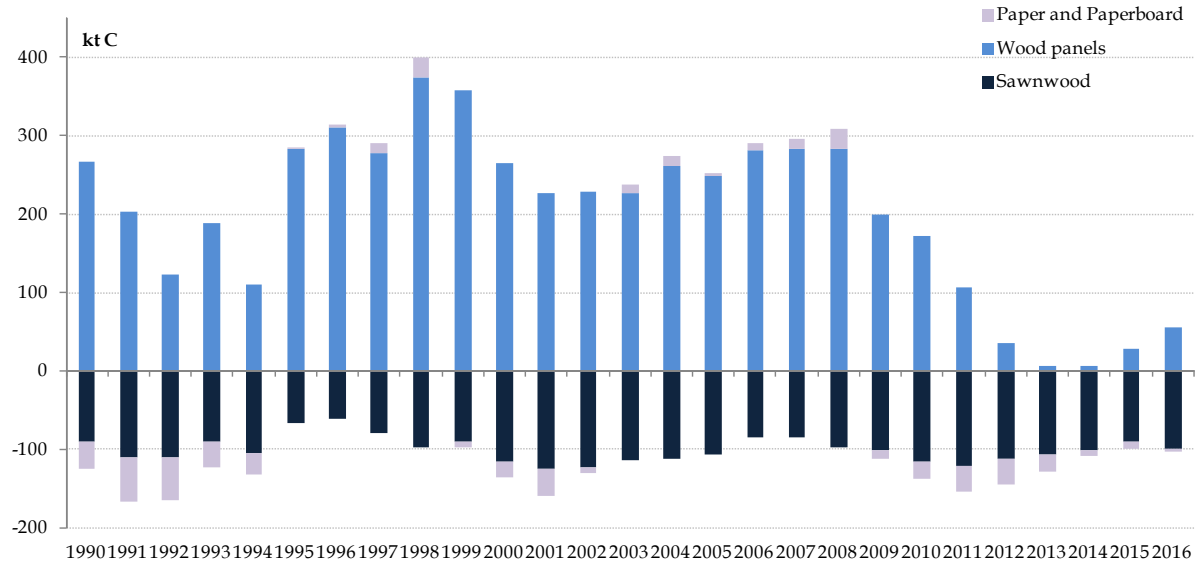


Figure 9.5 Annual change in stock (kt C) for the period 1990-2016

Additional information on uncertainties and planned improvement for HWPs are reported in paragraphs 6.13.3 and 6.13.6.

9.5.3 Information relating to Cropland Management, Grazing Land Management, Revegetation and Wetland Drainage and Rewetting if elected, for the base year

As reported in Table 9.18, part of the area subject to *cropland management* activities in 1990 is no longer reported under CM or other art. 3.3 or art. 3.4 elected activity in 2014. In principle, once land has been reported under any Article 3.3 or 3.4 activity during a commitment period, it must continue to be reported.
For CM, the guidance provided in 2013 KP Supplement (IPCC, 2014) acknowledges the abovementioned case of "moving land", specifying, if this area is not transferred to another reported activity, to account as zero in that year the related associated emissions and removals.

Table 9.18 Area subject to CM and GM activities in 1990 (base year), in 2013, 2014, 2015 and 2016

	1990 *kha*	**2013** *kha*	**2014** *kha*	**2015** *kha*	**2016** *kha*
Cropland management	10,704	8,939	8,939	8,939	9,020
Grazing land management	3	383	404	426	426

9.6 Other information

9.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

Key category analysis for KP-LULUCF was carried out according to the section 2.3.6 of the 2013 KP Supplement (IPCC, 2014). In the following Table 9.19 a summary overview for key categories for LULUCF activities under Kyoto Protocol is reported.

Table 9.19 Summary overview for key categories for LULUCF activities under Kyoto Protocol

Key categories of emissions and removals	**Gas**	**Criteria used for key category identification**		**Comments**
		Associated category in UNFCCC inventory is key	Category contribution is greater than the smallest key category in the UNFCCC inventory (including LULUCF)	
Forest Management	CO_2	*Forest land remaining forest land*	Yes	key (L, T)
Afforestation and Reforestation	CO_2	*Land converted to forest land*	Yes	key (L, T)
Deforestation	CO_2	*Land converted to Settlements*	Yes	key (L, T)
Cropland managememt	CO_2	*Cropland remaining cropland*	Yes	key (L, T)
Grazing land management	CO_2	*Grassland remaining Grassland*	Yes	key (L2, T)

The figures have been compared with Table 1.6 Key categories for the latest reported year (2016) based on level of emissions (including LULUCF).

9.7 Information relating to Article 6

Italy is not participating in any project under Article 6 (Joint Implementation).

10 INFORMATION ON ACCOUNTING OF KYOTO UNITS

10.1 Background information

In accordance with paragraph 1 of annex II to decision 3/CMP.11 and with paragraph 4 of decision 10/CMP.11, the following Standard Electronic Format report has been submitted to the UNFCCC Secretariat in electronic format along with this document:

- information on Kyoto Protocol units for the second commitment period for the reported year 2017 (RREG1_IT_2017_2_2.xlsx and RREG1_IT_2017_2_2.xml).

The report, containing the information required in paragraph 11 of the annex to decision 15/CMP.1 and adhering to the SEF guidelines, includes data 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 to and from registries of other Parties to the Kyoto Protocol. The contents of the report can also be found in Annex 8 of this document.

10.2 Summary of information reported in the SEF tables

Information on Kyoto Protocol units belonging to the second commitment period, as reported in the SEF tables for year 2017, is summarized below.

At the beginning of 2017 the holdings in the Italian registry were as follow:

- a total of 1,108,946 ERUs in holding accounts;
- a total of 3,838,096 CERs in holding accounts;
- no AAUs, no RMUs, no tCERs, no lCERs were held in any account.

At the end of 2017 the holdings in the Italian registry were as follow:

- a total of 1,108,946 ERUs in holding accounts;
- a total of 4,104,754 CERs in holding accounts;
- no AAUs, no RMUs, no tCERs, no lCERs were held in any account.

During 2017 the Italian registry received from the CDM registry 647,472 CERs while 387,635 CERs were externally transferred to other national registries. There were no external transactions involving AAUs, ERUs, RMUs, tCERs or lCERs.

In year 2017 Italy carried over a total of 6,821 CERs.

During the reporting period (1st January 2017 - 31st December 2017) there were no internal transactions (including retirement), no transactions between PPSR accounts, no share of proceeds transactions, no expiries, cancellations or replacements. Moreover, no corrective transactions relating to additions and subtractions, replacement or retirement took place.

Full details are available in the SEF tables reported in Annex 8.

10.3 Discrepancies and notifications

During the reporting period no discrepant transactions, no CDM notifications and no non-replacements occurred. No invalid units were present as of 31 December 2017.
Therefore the relevant reports (R2, R3, R4, R5) are empty and have not been included.

Since no discrepancies occurred in 2017, there's been no need to take any action or to make any change in the registry.

10.4 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/index.php?p=publicinfo or via the Union Registry website https://ets-registry.webgate.ec.europa.eu/euregistry/IT/public/reports/publicReports.xhtml

All required information is provided with the following exceptions:

- paragraph 45(d)(e): account number, representative identifier name and contact information is deemed as confidential according to Annex III and VIII (Table III-I and VIII-I) of Commission Regulation (EU) No 389/2013;
- 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 110 of Commission Regulation (EU) No 389/2013.

Public information available at the above mentioned links is updated on a monthly basis.

10.5 Calculation of the commitment period reserve (CPR)

Parties are required by decision 11/CMP.1 under the Kyoto Protocol and paragraph 18 of Decision 1/CMP.8 to establish and maintain a commitment period reserve as part of their responsibility to manage and account for their assigned amount. According to paragraph 6 of the Annex to decision 11/CMP.1, the commitment period reserve equals the lower of either 90% of a Party's assigned amount or 100% of its most recently reviewed inventory, multiplied by 8.
For the purposes of the joint fulfillment, the commitment period reserve applies to the EU, its Member States and Iceland individually.

The Italian commitment period reserve is calculated either as:

2,410,291,421 t CO_2 equivalent * 0.9 = 2,169,262,279 t CO_2 equivalent

or:

433,024,539 t CO_2 equivalent (emission level 2015) * 8 = 3,464,196,309 t CO_2 equivalent

The Italian commitment period reserve is therefore 2,169,262,279 t CO_2 equivalent.

10.6 KP-LULUCF accounting

Italy will account for Article 3.3 and 3.4 LULUCF activities at the end of the commitment period.
In Table 10.1, information on accounting for the KP-LULUCF activities based on the reporting for the years 2013, 2014, 2015 and 2016 are given.

Accounting quantities for cropland management and grazing land management under art. 3.4 of the Kyoto Protocol have been assessed as the level of emissions and removals in the commitment period less the duration of the reporting period (2013-2016) in years times the level of emissions and removals from these elected activities in the base year (paragraph 10 of Decision 2/CMP.7).

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Base Year[2]	NET EMISSIONS/REMOVALS					Accounting parameters	Accounting quantity [4]
		2013	2014	2015	2016	Total[3]		
	(kt CO_2 eq)							
A. Article 3.3 activities								
A.1. Afforestation/reforestation		-7,842	-8,384	-8,853	-8,372	-33,451		-33,451
Excluded emissions from natural disturbances[5]		NO	NO	NO	NO	NO		NO
A.2. Deforestation		2,012	2,023	2,033	2,044	8,112		8,112
B. Article 3.4 activities								
B.1. Forest management						-122,988		-27,604
Net emissions/removals		-30,214	-31,199	-32,465	-29,110	-122,988		
Excluded emissions from natural disturbances[5]		NO	NO	NO	NO	NO		NO
Forest management reference level (FMRL)[9]							-22,166.00	
Technical corrections to FMRL[10]							-1,680.06	
Forest management cap[11]							145,142	-27,604
B.2. Cropland management (if elected)	-120	397	337	350	-656	427		905
B.3. Grazing land management (if elected)	-5	-642	-672	-706	-706	-2,726		-2,705

Table 10.1 Information table on accounting for activities under art. 3.3 and 3.4 of the Kyoto Protocol, for 2013, 2014, 2015 and 2016

(1) All values are reported in table 4(KP) and tables 4(KP-I).A.1.1, 4(KP-I).B.1.1, 4(KP-I).B.1.2 and 4(KP-I).B.1.3 of the CRF for the relevant inventory year as reported in the current submission and are automatically entered in this table.
(2) Net emissions and removals from cropland management, grazing land management, revegetation and/or wetland drainage and rewetting, if elected, in the Party's base year, as established by decision 9/CP.2.
(3) Cumulative net emissions and removals for all years of the commitment period reported in the current submission.
(4) 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.
(5) A Party that has indicated their intent to apply the natural disturbance provisions may choose to exclude emissions from natural disturbances either annually or at the end of the commitment period.
(6) Any subsequent removals on lands from which emissions from natural disturbances have been excluded is subtracted from the accounting quantity of the respective activity.
(7) A debit is generated in case the newly established forest does not reach at least the expected carbon stock at the end of the normal harvesting period. Total debits from carbon equivalent forests are subtracted from the accounting quantity forest management.
(8) In case of a projected forest management reference level, Parties should not fill in this row.
(9) Forest management reference level as inscribed in the appendix of the annex to decision 2/CMP.7, in kt CO_2 eq per year.
(10) Technical corrections in accordance with paragraphs 14 and 15 of the annex to decision 2/CMP.7 and reported in table 4(KP-I)B.1.1 in kt CO_2 eq per year.
(11) For the second commiment period, additions to the assigned amount of a Party resulting from forest management shall, in accordance with paragraph 13 of the annex to decision 2/CMP.7, not exceed 3.5 per cent of the national total emissions excluding LULUCF in the base year times eight.

11 INFORMATION ON CHANGES IN NATIONAL SYSTEM

No changes with respect to the last year submission occurred in the Italian National System.
In the context of the establishment of the National System for policies, measures and projections there has been a strenghthening of roles and obligations for statistical data flow, some of which are useful for the inventory scope. ISPRA is also responsible for this system.

12 INFORMATION ON CHANGES IN NATIONAL REGISTRY

12.1 Previous Review Recommendations

The SIAR Report for Italy from last year reported no recommendations.

12.2 Changes to National Registry

The following changes to the national registry of Italy have occurred in 2017.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	No change of name or contact occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	The version of the EUCR released after 8.0.7 (the production version at the time of the last submission) introduced minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model is provided in Annex A. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 8.0.7 of the national registry are listed in Annex B. Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B). No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	No changes regarding security occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change 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	No change of the registry internet address occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 8.0.7 of the national registry are listed in Annex B. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission.
1/CMP.8 paragraph 23 PPSR account	Since 16 November 2016 the Union Registry provides the technical possibility to open a PPSR account. However, prior to opening it, the PPSR account type must be first introduced into the EU legislative framework. This was done by the Annex of Commission Delegated Regulation 2015/1844. This provision, however, will become applicable, according to Article 2 of the Delegated Regulation, on "the date of publication by the Commission in the Official Journal of the European Union of a communication on the entry into force of the Doha Amendment to the Kyoto Protocol". Consequently, for the moment and until the Doha Amendment enters into force, we are not in a position to open the PPSR account in our National Registry.

13 INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14

13.1 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 $MtCO_2$ per year for each year of the "commitment period" (UNFCCC, 2007).
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 1[76] 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 9[77], 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 13.2, 13.3) and priority actions (section 13.4, 13.5). Future improvements/research activities are expected for next submissions (section 13.6).

13.2 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 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

[76] **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."
[77] **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."

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, 2018).

Key questions on economic, social and environmental impacts in relation to third countries are listed in Table 13.1.

Table 13.1 Questions in relation to impacts on Third countries

Economic	Social	Environmental
• 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?	• 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?	• 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, 2009[a]

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. EU leaders agreed on 23 October 2014 the domestic 2030 targets of greenhouse gas reduction of at least 40% compared to 1990 and at least 27% for renewable energy and energy savings by 2030. 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 DEVPEM[78] a companion to the OECD-country PEM[79] 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.

13.3 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 4.8 in the Sixth National Communication (MATTM, 2014). 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.

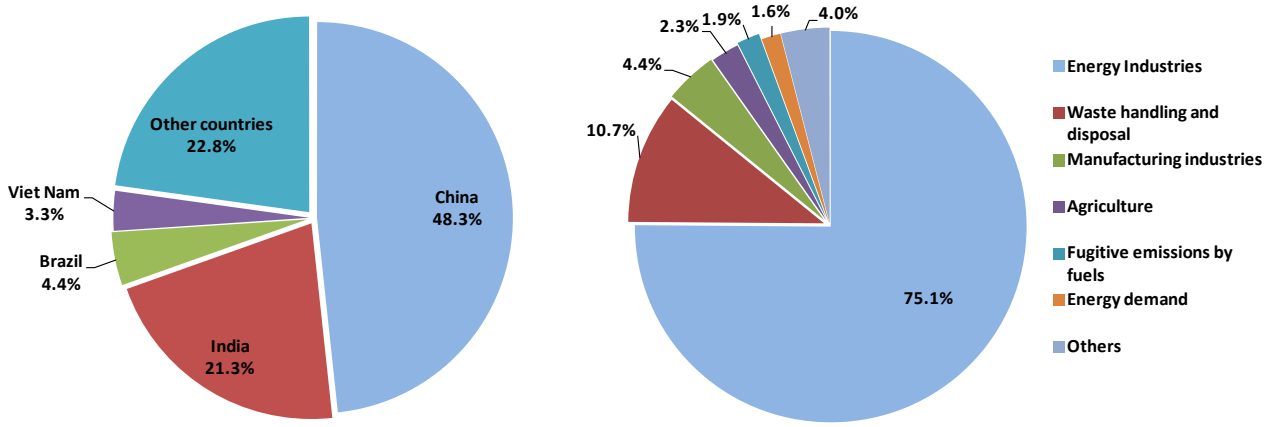
[78] DEVPEM, Development Policy Evaluation Model
[79] PEM, Policy Evaluation Model examine the effects of agricultural policies in member countries

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, 2018[a]). On 05 February 2018, the UNFCCC CDM Database reported a total of 7,791 registered project activities out of 8,146 projects. With data as of 31 December 2017, 83.8% of CDM projects were registered in Asia and the Pacific Region, 12.8% in Latin America and Caribbean, 2.8% in Africa, and 0.6% in Countries with economies in transition. The distribution of registered projects by scope activity was mainly: energy industries (75.1%), waste handling and disposal (10.7%) and manufacturing industries (4.4%). Registered projects by Host Party were mainly in China (48.3%), India (21.3%), Brazil (4.4%) and Viet Nam (3.3%).

The distribution of global CDM projects by Host country and scope is presented in Figure 13.1.



Source: UNFCCC (UNFCCC, 2018[b])

Figure 13.1 CDM projects by Host country and scope (as for 31/12/2017)

Italy as investor Party, contributes with 1.6% of world-wide CDM project portfolio. Up to 05 February 2018 Italy is involved in 128 CDM registered projects. Italy is involved directly, as government, in 52 registered CDM (MATTM, 2011).Projects by dimension are 60.2% large scale and 39.8% small scale. Italy is the only proposer for 40.6% of the CDM projects.

In Annex A8.2.4 a complete list of CDM projects is available. Italian CDM projects by Host country and scope are illustrated in tables 13.2 and 13.3 respectively.

Table 13.2 Italian CDM projects by Host country

Country	**n°**	**%**
China	52	40.6
India	12	9.4
Brazil	6	4.7
Nepal	5	3.9
Uganda	5	3.9
Kenya	5	3.9
Republic of Moldova	4	3.1
Argentina	4	3.1
Tunisia	3	2.3
Other	32	25.0
Total	**128**	**100**

Table 13.3 Italian CDM projects by scope (there are project with multiple scopes)

Scope	n°	%
Energy industries (renewable/non renewable)	81	53.3
Waste handling and disposal	20	13.2
Afforestation and reforestation	16	10.5
Manufacturing industries	16	10.5
Fugitive emissions from production and consumption of halocarbons and sulphur hexafluoride	8	5.3
Energy demand	7	4.6
Other	4	2.6
Total	**152**	**100**

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 Carbono, 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, *Poechos I* Hydroelectric project (Peru), CERs are approve only if the project complies also with social and environmental conditions (Endesa Carbono, 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 (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]). Up to 31 Jenuary 2015 the JI database from IGES source shows only one large scale project (Track 1) with Italy involved. The task of the project is to reduce GHG emissions fuel switch (IGES, 2018).
Voluntary validation of sustainable development is taking place at international level for CDM and JI projects. The UNEP database (2018) 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. In 2014 the CDM Board published a tool to report about the contribution of CDM projects to sustainable development (UNFCCC[c], 2018). The SD Tool is a voluntary tool for describing sustainable development co-benefits (SDC) of CDM project activities or programmes of activities enables CDM project developers to highlight the sustainable development benefits of their projects or PoAs by using a check list of predefined criteria and indicators. 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 1st January 2018, the UNEP database reports 761 JI projects (track1+track2) from which 604 projects are registered (91.9% track 1+8.1% track 2). Up to 1st February 2018 the UNEP database reports 8,362 CDM projects with 7,796 registered from which 6 projects are validated with CCB, 138 with GS, and 30 with SD tool (Sustainable Development tool).

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 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 a 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 (Cóndor et al., 2010).
A UNFCCC report 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[a]).
For this section we have accessed project databases (UNFCCC, 2018[a]; Carbon Finance, 2018; UNEP, 2018) 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 (Biomas), India (small hydroelectric and wind) and China (hydropower), and Sirohi (2007) for projects in India (biomass, F-gas, hydroelectric). For forestry CDM projects, Cóndor 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.

13.4 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 13.4 (OECD, 2018). 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[a]): 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[b]).

Table 13.4 Financial resources to developing countries and multilateral organisations from Italy (2015 and 2016 data are updated on 22 December 2017)

	Italy								
	2001-02	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
NET DISBURSEMENTS					**USD million**				
I. Official Development Assistance (ODA) (A + B)	**1980**	**3297**	**2996**	**4326**	**2737**	**3430**	**4009**	**4003**	**5087**
ODA as % of GNI	**0.18**	**0.16**	**0.15**	**0.20**	**0.14**	**0.17**	**0.19**	**0.22**	**0.27**
A. Bilateral Official Development Assistance	724	875	759	1703	624	867	1372	1829	2420
of which: General budget support	-1	9	5	1	6	7	8	6	1
Core support to national NGOs	64	-	15	-	1	99	93	118	137
Investment projects	-107	37	-34	310	-17	9	42	32	6
Administrative costs	34	59	42	53	35	36	40	36	21
Other in-donor expenditures	10	5	5	526	272	406	843	985	1666
of which: Refugees in donor countries	8	-	3	525	247	404	840	983	1665
Imputed student costs							1	1	1
B. Contributions to Multilateral Institutions	1255	2423	2237	2623	2113	2563	2637	2174	2667
of which: UN	198	205	170	150	188	217	200	161	155
EU	691	1862	1557	1924	1516	1605	1662	1424	1773
IDA	183	214	386	179	166	329	377	198	214
Regional Development Banks	61	24	6	206	105	229	178	135	286
II. Other Official Flows (OOF) net (C + D)	-158	-72	-151	-214	196	161	96	43	51
C. Bilateral Other Official Flows (1 + 2)	-158	-72	-151	-214	196	161	96	43	51
1. Official export credits(1)	16	-28	-28	117	97	90	48	-	-
2. Equities and other bilateral assets(1)	-173	-44	-123	-330	100	71	48	-	-
D. Multilateral Institutions	-	-	-	-	-	-	-	-	-
III. Officially supported export credits(2)	1271	463	882	1234	725	2031	584	1414	802
IV. Private Flows at Market Terms (long-term) (1 to 3)	-2504	1719	5731	6456	7436	11024	3896	10033	13286
1. Direct investment	930	129	4366	7530	8016	8643	3369	9715	8046
2. Bilateral portfolio investment	-3434	1590	1365	-1074	-580	2381	527	317	5239
3. Securities of multilateral agencies	-	-	-	-	-	-	-	-	-
V. Grants by Private Voluntary Agencies(3)	16	162	150	111	91	58	121	128	86
VI. Total Resource Flows (long-term) (I to V)	**605**	**5569**	**9608**	**11912**	**11186**	**16703**	**8706**	**15621**	**19309**
Total Resource Flows as a % of GNI	**0.05**	**0.27**	**0.47**	**0.55**	**0.56**	**0.81**	**0.41**	**0.86**	**1.04**

Source: OECD (OECD, 2016) http://www.oecd.org/dac/stats/statisticsonresourceflowstodevelopingcountries.htm

(1) no more updated by OECD since 2018 submission.

(2) item reported as **"2. Private export credits"** under title IV up to 2017 submission.

(3) item reported as title "III. Grants by Private Voluntary Agencies " up to 2017 submission.

Italian multilateral cooperation on climate change has been performed with different United Nations organizations, funds, and institutions[80]. 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-wide[81]. Funding climate change and related topics in developing

[80] 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).

[81] Italian bilateral cooperation with the Asian and Middle East countries (China, Iraq, Thailand and India), Mediterranean and African region (Algeria, Egypt, Israel, Tunisia, Morrocco), Central and Eastern European countries (Albania, Bosnia, Croatia, Bulgaria, Serbia, Montenegro, Macedonia,

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 Sixth National Communication from Italy (MATTM, 2014).
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). 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 adverse effects through the use of the OECD-DAC guidelines (MAE, 2010[c]). 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.

13.5 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 Sixth National Communication under the UNFCCC, Chapter 5 Projections and effects of policies and measures and Chapter 7 Financial resources and transfer of technology (MATTM, 2014). 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]). 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).

Poland, Romania, Turkey, Hungary, Kyrgyzstan and Tajikistan), and Latin America, the Caribean and the Pacific Islands (Belize, Argentina, Mexico, Cuba, Brazil, 14 countries of the South Pacific Small Islands Developing States).

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, 2014).

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 CO_2 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, 2014).

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, 2014). 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 CO_2 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.

13.6 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]).

13.7 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[b]).

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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. In this document whenever the term *category* is used, it includes both sources and sinks. 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 2016, 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, 28 categories were individuated according to Approach 1, whereas 31 categories were carried out by Approach 2. Including the LULUCF sector in the analysis, 35 categories were selected according to Approach 1 and 35 with Approach 2.
For the year 2016, 27 categories were individuated by the Approach 1 accounting for 95% of the total emissions, without LULUCF; for the trend 27 key categories were also selected. Repeating the key category analysis for the full inventory including the LULUCF sector, 32 categories were individuated accounting for 95% of the total emissions and removals in 2016, and 33 key categories in trend assessment.
The application of the Approach 2 to the 2016 emission levels gives as a result 27 key categories accounting for the 90% of the total levels with uncertainty; when applying the trend analysis the number of the key categories is equal to 31.
The application of the Approach 2 including the LULUCF categories results in 29 key categories, for the year 2016, accounting for the 90% of the total levels with uncertainty; for the trend analysis including LULUCF categories, the results were 30 key categories.

A1.2 Approach 1 key category assessment

As described in the 2006 IPCC Guidelines (IPCC, 2006), 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:

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

$$L_{x,t} = \frac{\left|E_{x,t}\right|}{\sum_{y}\left|E_{y,t}\right|}$$

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:

$$\text{Category Trend Assessment} = (\text{Source or Sink Category Level Assessment}) \cdot |\text{Source or Sink Category Trend - Total Trend}|$$

$$T_{x,t} = \left|E_{x,0}\right| \Big/ \sum_y \left|E_{y,0}\right| \cdot \left| \left[\left(E_{x,t} - E_{x,0}\right) \Big/ \left|E_{x,0}\right| \right] - \left[\left(E_t - E_0\right) \Big/ \sum_y \left|E_{y,0}\right| \right] \right|$$

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:

$$T_{x,t} = \left| E_{x,t} \Big/ \left|E_{x,0}\right| \right|$$

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 last year 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 2016

CATEGORIES	2016 CO_2 eq	Level assessment	Cumulative Percentage
Transport - CO_2 Road transportation	96,683	0.23	0.23
Other sectors - CO_2 commercial, residential, agriculture gaseous fuels	57,924	0.14	0.36
Energy industries - CO_2 gaseous fuels	48,090	0.11	0.47
Energy industries - CO_2 solid fuels	37,299	0.09	0.56
Manufacturing industries and construction - CO_2 gaseous fuels	29,750	0.07	0.63
Energy industries - CO_2 liquid fuels	18,188	0.04	0.67
Other sectors - CO_2 commercial, residential, agriculture liquid fuels	14,965	0.03	0.71
Enteric Fermentation- CH_4	14,039	0.03	0.74
Solid waste disposal - CH_4	13,621	0.03	0.77
Product uses as substitutes for ozone depleting substances - HFCs Refrigeration and Air conditioning	12,252	0.03	0.80
Manufacturing industries and construction - CO_2 solid fuels	8,802	0.02	0.82
Manufacturing industries and construction - CO_2 liquid fuels	7,994	0.02	0.84
Mineral industry- CO_2 Cement production	7,680	0.02	0.86
Direct N_2O Emissions from Managed soils	7,150	0.02	0.88
Other sectors - CO_2 commercial, residential, agriculture other fossil fuels	4,920	0.01	0.89
Fugitive - CH_4 Oil and natural gas - Natural gas	4,417	0.01	0.90
Transport - CO_2 Waterborne navigation	3,824	0.01	0.91
Manure Management - CH_4	3,106	0.01	0.91
Wastewater treatment and discharge - CH_4	2,488	0.01	0.92
Other sectors - CH_4 commercial, residential, agriculture biomass	2,211	0.01	0.92
Transport - CO_2 Civil Aviation	2,155	0.01	0.93
Rice cultivations - CH_4	1,710	0.00	0.93
Indirect N_2O Emissions from Managed soils	1,707	0.00	0.94
Fugitive - CO_2 Oil and natural gas - Oil	1,706	0.00	0.94
Mineral industry- CO_2 Lime production	1,661	0.00	0.95
Product uses as substitutes for ozone depleting substances - HFCs Fire protection	1,593	0.00	0.95
Chemical industry- PFCs Fluorochemical production	1,493	0.00	0.95
Metal industry- CO_2 Iron and steel production	1,473	0.00	0.96
Wastewater treatment and discharge - N_2O	1,351	0.00	0.96
Manure Management - N_2O	1,281	0.00	0.96
Other sectors - N_2O commercial, residential, agriculture biomass	1,208	0.00	0.96
Non-Energy products from Fuels and Solvent Use - CO_2	980	0.00	0.97
Transport - N_2O Road transportation	847	0.00	0.97
Indirect N_2O Emissions from Manure Management	841	0.00	0.97
Other sectors - N_2O commercial, residential, agriculture liquid fuels	764	0.00	0.97
Mineral industry- CO_2 Other processes uses of carbonates	753	0.00	0.97
Transport - CO_2 Other transportation - pipelines	669	0.00	0.98
Product uses as substitutes for ozone depleting substances - HFCs Foam blowing agents	650	0.00	0.98
Chemical industry- CO_2 Ammonia production	643	0.00	0.98
Biological treatment of Solid waste - N_2O	530	0.00	0.98
Urea application - CO_2	527	0.00	0.98
Other non specified - CO_2 military mobile - liquid fuels	515	0.00	0.98
Mineral industry- CO_2 Glass production	512	0.00	0.98

Table A1.2 Results of the key category analysis without LULUCF. Approach 1 Trend assessment base year-2016

CATEGORIES	Contribution to trend (%)	Cumulative Percentage
Energy industries - CO_2 liquid fuels	0.20	0.20
Energy industries - CO_2 gaseous fuels	0.14	0.34
Other sectors - CO_2 commercial, residential, agriculture gaseous fuels	0.11	0.45
Manufacturing industries and construction - CO_2 liquid fuels	0.08	0.53
Transport - CO_2 Road transportation	0.08	0.62
Other sectors - CO_2 commercial, residential, agriculture liquid fuels	0.07	0.68
Product uses as substitutes for ozone depleting substances - HFCs Refrigeration and Air conditioning	0.05	0.73
Manufacturing industries and construction - CO_2 solid fuels	0.05	0.78
Energy industries - CO_2 solid fuels	0.02	0.80
Mineral industry- CO_2 Cement production	0.02	0.82
Other sectors - CO_2 commercial, residential, agriculture other fossil fuels	0.02	0.84
Chemical industry- N_2O Adipic acid production	0.01	0.86
Solid waste disposal - CH_4	0.01	0.87
Manufacturing industries and construction - CO_2 gaseous fuels	0.01	0.88
Fugitive - CH_4 Oil and natural gas - Natural gas	0.01	0.89
Metal industry- PFCs Aluminium production	0.01	0.90
Chemical industry- N_2O Nitric acid production	0.01	0.91
Product uses as substitutes for ozone depleting substances - HFCs Fire protection	0.01	0.91
Other sectors - CH_4 commercial, residential, agriculture biomass	0.01	0.92
Mineral industry- CO_2 Other processes uses of carbonates	0.01	0.93
Enteric Fermentation- CH_4	0.01	0.93
Metal industry- CO_2 Iron and steel production	0.00	0.93
Transport - CO_2 Civil Aviation	0.00	0.94
Chemical industry- CO_2 Ammonia production	0.00	0.94
Other sectors - N_2O commercial, residential, agriculture biomass	0.00	0.95
Other sectors - CO_2 commercial, residential, agriculture solid fuels	0.00	0.95
Chemical industry- PFCs Fluorochemical production	0.00	0.95
Transport - CO_2 Waterborne navigation	0.00	0.95
Product uses as substitutes for ozone depleting substances - HFCs Foam blowing agents	0.00	0.96
Transport - CH_4 Road transportation	0.00	0.96
Biological treatment of Solid waste - N_2O	0.00	0.96
Transport - CO_2 Railways	0.00	0.96
Non-Energy products from Fuels and Solvent Use - CO_2	0.00	0.96
Manufacturing industries and construction - N_2O liquid fuels	0.00	0.97
Manufacturing industries and construction - CO_2 other fuels	0.00	0.97
Other non specified - CO_2 military mobile - liquid fuels	0.00	0.97
Fugitive - CO_2 Oil and natural gas - venting and flaring	0.00	0.97
Chemical industry- HFCs Fluorochemical production	0.00	0.97
Transport - CO_2 Other transportation - pipelines	0.00	0.97
Metal industry- CO_2 Ferroalloys production	0.00	0.97
Incineration and open burning of waste - CO_2	0.00	0.98
Wastewater treatment and discharge - N_2O	0.00	0.98
Metal industry- CO_2 Aluminium production	0.00	0.98
Direct N_2O Emissions from Managed soils	0.00	0.98
Fugitive - CO_2 Oil and natural gas - Oil	0.00	0.98
Manure Management - N_2O	0.00	0.98
Fugitive - CO_2 Oil and natural gas - Other - flaring in refineries	0.00	0.98
Manufacturing industries and construction - CH_4 biomass	0.00	0.98
Other Product Manufacture and Use - N_2O	0.00	0.98
Metal industry- CO_2 Zinc production	0.00	0.98

Table A1.3 Results of the key category analysis with LULUCF. Approach 1 Level assessment, year 2016

CATEGORIES	2016 CO_2 eq	Level assessment	Cumulative Percentage
Transport - CO_2 Road transportation	96,683	0.20	0.20
Other sectors - CO_2 commercial, residential, agriculture gaseous fuels	57,924	0.12	0.32
Energy industries - CO_2 gaseous fuels	48,090	0.10	0.42
Energy industries - CO_2 solid fuels	37,299	0.08	0.50
Forest Land remaining Forest Land - CO_2	-30,251	0.06	0.56
Manufacturing industries and construction - CO_2 gaseous fuels	29,750	0.06	0.62
Energy industries - CO_2 liquid fuels	18,188	0.04	0.66
Other sectors - CO_2 commercial, residential, agriculture liquid fuels	14,965	0.03	0.69
Enteric Fermentation- CH_4	14,039	0.03	0.72
Solid waste disposal - CH_4	13,621	0.03	0.75
Product uses as substitutes for ozone depleting substances - HFCs Refrigeration and Air conditioning	12,252	0.03	0.77
Land Converted to Settlements - CO_2	9,014	0.02	0.79
Manufacturing industries and construction - CO_2 solid fuels	8,802	0.02	0.81
Manufacturing industries and construction - CO_2 liquid fuels	7,994	0.02	0.83
Mineral industry- CO_2 Cement production	7,680	0.02	0.84
Direct N2O Emissions from Managed soils	7,150	0.01	0.86
Land Converted to Grassland - CO_2	-5,996	0.01	0.87
Land Converted to Forest Land - CO_2	-5,829	0.01	0.88
Other sectors - CO_2 commercial, residential, agriculture other fossil fuels	4,920	0.01	0.89
Fugitive - CH_4 Oil and natural gas - Natural gas	4,417	0.01	0.90
Transport - CO_2 Waterborne navigation	3,824	0.01	0.91
Manure Management - CH_4	3,106	0.01	0.91
Wastewater treatment and discharge - CH_4	2,488	0.01	0.92
Other sectors - CH_4 commercial, residential, agriculture biomass	2,211	0.00	0.92
Transport - CO_2 Civil Aviation	2,155	0.00	0.93
Cropland Remaining Cropland - CO2	1,918	0.00	0.93
Rice cultivations - CH4	1,710	0.00	0.94
Indirect N2O Emissions from Managed soils	1,707	0.00	0.94
Fugitive - CO2 Oil and natural gas - Oil	1,706	0.00	0.94
Mineral industry- CO2 Lime production	1,661	0.00	0.95
Product uses as substitutes for ozone depleting substances - HFCs Fire protection	1,593	0.00	0.95
Chemical industry- PFCs Fluorochemical production	1,493	0.00	0.95
Metal industry- CO2 Iron and steel production	1,473	0.00	0.96
Wastewater treatment and discharge - N2O	1,351	0.00	0.96
Manure Management - N2O	1,281	0.00	0.96
Other sectors - N2O commercial, residential, agriculture biomass	1,208	0.00	0.96
Non-Energy products from Fuels and Solvent Use - CO2	980	0.00	0.97
Transport - N2O Road transportation	847	0.00	0.97
Indirect N2O Emissions from Manure Management	841	0.00	0.97
Other sectors - N2O commercial, residential, agriculture liquid fuels	764	0.00	0.97
Mineral industry- CO2 Other processes uses of carbonates	753	0.00	0.97
Land Converted to Settlements - N2O	678	0.00	0.97
Transport - CO2 Other transportation - pipelines	669	0.00	0.97
Product uses as substitutes for ozone depleting substances - HFCs Foam blowing agents	650	0.00	0.98
Grassland Remaining Grassland - CO2	-647	0.00	0.98
Chemical industry- CO2 Ammonia production	643	0.00	0.98
Land Converted to Cropland - CO2	542	0.00	0.98
Biological treatment of Solid waste - N2O	530	0.00	0.98
Urea application - CO2	527	0.00	0.98
Other non specified - CO2 military mobile - liquid fuels	515	0.00	0.98

Table A1.4 Results of the key category analysis with LULUCF. Approach 1 Trend assessment, base year-2016

CATEGORIES	Contribution to trend (%)	Cumulative Percentage
Energy industries - CO2 liquid fuels	0.16	0.16
Energy industries - CO2 gaseous fuels	0.13	0.29
Other sectors - CO2 commercial, residential, agriculture gaseous fuels	0.11	0.39
Transport - CO2 Road transportation	0.09	0.48
Manufacturing industries and construction - CO2 liquid fuels	0.07	0.55
Other sectors - CO2 commercial, residential, agriculture liquid fuels	0.05	0.60
Product uses as substitutes for ozone depleting substances - HFCs Refrigeration and Air conditioning	0.05	0.65
Forest Land remaining Forest Land - CO2	0.04	0.69
Manufacturing industries and construction - CO2 solid fuels	0.04	0.73
Energy industries - CO2 solid fuels	0.03	0.76
Manufacturing industries and construction - CO2 gaseous fuels	0.02	0.77
Grassland Remaining Grassland - CO2	0.02	0.79
Mineral industry- CO2 Cement production	0.02	0.81
Other sectors - CO2 commercial, residential, agriculture other fossil fuels	0.02	0.82
Land Converted to Grassland - CO2	0.02	0.84
Solid waste disposal - CH4	0.02	0.85
Land Converted to Settlements - CO2	0.01	0.87
Chemical industry- N2O Adipic acid production	0.01	0.88
Land Converted to Forest Land - CO2	0.01	0.89
Enteric Fermentation- CH4	0.01	0.90
Fugitive - CH4 Oil and natural gas - Natural gas	0.01	0.90
Product uses as substitutes for ozone depleting substances - HFCs Fire protection	0.01	0.91
Metal industry- PFCs Aluminium production	0.01	0.92
Chemical industry- N2O Nitric acid production	0.01	0.92
Other sectors - CH4 commercial, residential, agriculture biomass	0.01	0.93
Mineral industry- CO2 Other processes uses of carbonates	0.00	0.93
Transport - CO2 Civil Aviation	0.00	0.93
Metal industry- CO2 Iron and steel production	0.00	0.94
Chemical industry- CO2 Ammonia production	0.00	0.94
Harvest Wood Products - CO2	0.00	0.94
Other sectors - N2O commercial, residential, agriculture biomass	0.00	0.95
Chemical industry- PFCs Fluorochemical production	0.00	0.95
Direct N2O Emissions from Managed soils	0.00	0.95
Product uses as substitutes for ozone depleting substances - HFCs Foam blowing agents	0.00	0.95
Other sectors - CO2 commercial, residential, agriculture solid fuels	0.00	0.96
Cropland Remaining Cropland - CO2	0.00	0.96
Biological treatment of Solid waste - N2O	0.00	0.96
Transport - CH4 Road transportation	0.00	0.96
Manufacturing industries and construction - CO2 other fuels	0.00	0.96
Transport - CO2 Railways	0.00	0.96
Grassland Remaining Grassland - CH4	0.00	0.97
Transport - CO2 Waterborne navigation	0.00	0.97
Wastewater treatment and discharge - N2O	0.00	0.97
Manufacturing industries and construction - N2O liquid fuels	0.00	0.97
Transport - CO2 Other transportation - pipelines	0.00	0.97
Chemical industry- HFCs Fluorochemical production	0.00	0.97
Non-Energy products from Fuels and Solvent Use - CO2	0.00	0.97
Forest Land remaining Forest Land - CH4	0.00	0.98
Fugitive - CO2 Oil and natural gas - venting and flaring	0.00	0.98
Other non specified - CO2 military mobile - liquid fuels	0.00	0.98
Metal industry- CO2 Ferroalloys production	0.00	0.98

CATEGORIES	Contribution	Cumulative
Incineration and open burning of waste - CO2	0.00	0.98
Land Converted to Settlements - N2O	0.00	0.98
Metal industry- CO2 Aluminium production	0.00	0.98
Rice cultivations - CH4	0.00	0.98
Mineral industry- CO2 Lime production	0.00	0.98
Transport - N2O Road transportation	0.00	0.98
Manufacturing industries and construction - CH4 biomass	0.00	0.98

The application of Approach 1, excluding LULUCF categories, gives as a result 27 key categories accounting for the 95% of the total levels; when applying the trend analysis, excluding LULUCF categories, the number of key categories is equal to 27 (Tables A1.1, A1.2).
The Approach 1 level assessment, repeated for the full inventory including the LULUCF, results in 32 key categories (sources and sinks), and 33 key categories outcome from the trend analysis (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 2016 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 2016, excluding the LULUCF sector. Details on the method used for LULUCF are described in chapter 6. In Table A1.6, results by category, concerning only CO_2 emissions and removals, are reported whereas in Table A1.7, results include CO_2, CH_4, N_2O 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 2016

IPCC category	Gas	Emissions		Uncertainty			Contribution to variance	Sensitivity		Uncertainty in trend		
		Base year emissions	2016	AD	EF	Combined		Type A	Type B	introduced by EF uncertainty	introduced by AD uncertainty	in total national emissions
Energy industries - CO2 liquid fuels	CO2	81,085	18,188	3%	3%	0.042	0.000	0.094	0.035	0.003	0.001	0.00001
Energy industries - CO2 solid fuels	CO2	38,646	37,299	3%	3%	0.042	0.000	0.010	0.072	0.000	0.003	0.00001
Energy industries - CO2 gaseous fuels	CO2	16,573	48,090	3%	3%	0.042	0.000	0.066	0.093	0.002	0.004	0.00002
Energy industries - CO2 other fuels	CO2	143	209	3%	3%	0.042	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - N2O liquid fuels	N2O	296	140	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - N2O solid fuels	N2O	163	162	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - N2O gaseous fuels	N2O	9	29	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - N2O other fuels	N2O	1	1	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - N2O biomass	N2O	16	108	20%	50%	0.539	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - CH4 liquid fuels	CH4	74	12	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - CH4 solid fuels	CH4	132	24	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - CH4 gaseous fuels	CH4	11	30	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - CH4 other fuels	CH4	0	0	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - CH4 biomass	CH4	10	65	20%	50%	0.539	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - CO2 liquid fuels	CO2	34,677	7,994	3%	3%	0.042	0.000	0.040	0.015	0.001	0.001	0.00000
Manufacturing industries and construction - CO2 solid fuels	CO2	24,926	8,802	3%	3%	0.042	0.000	0.023	0.017	0.001	0.001	0.00000
Manufacturing industries and construction - CO2 gaseous fuels	CO2	32,110	29,750	3%	3%	0.042	0.000	0.006	0.057	0.000	0.002	0.00001
Manufacturing industries and construction - CO2 other fuels	CO2	0	409	3%	3%	0.042	0.000	0.001	0.001	0.000	0.000	0.00000
Manufacturing industries and construction - N2O liquid fuels	N2O	941	361	3%	50%	0.501	0.000	0.001	0.001	0.000	0.000	0.00000
Manufacturing industries and construction - N2O solid fuels	N2O	243	89	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - N2O gaseous fuels	N2O	164	155	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - N2O other fuels	N2O	0	23	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - N2O biomass	N2O	4	84	20%	50%	0.539	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - CH4 liquid fuels	CH4	45	11	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - CH4 solid fuels	CH4	107	60	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000

IPCC category	Gas	Emissions		Uncertainty				Sensitivity		Uncertainty in trend		
		Base year emissions	2016	AD	EF	Combined	Contribution to variance	Type A	Type B	introduced by EF uncertainty	introduced by AD uncertainty	in total national emissions
Manufacturing industries and construction - CH4 gaseous fuels	CH4	15	13	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - CH4 other fuels	CH4	0	0	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - CH4 biomass	CH4	3	193	20%	50%	0.539	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CO2 Road transportation	CO2	92,257	96,683	3%	3%	0.042	0.000	0.040	0.186	0.001	0.008	0.00006
Transport - N2O Road transportation	N2O	824	847	3%	40%	0.401	0.000	0.000	0.002	0.000	0.000	0.00000
Transport - CH4 Road transportation	CH4	870	199	3%	40%	0.401	0.000	0.001	0.000	0.000	0.000	0.00000
Transport - CO2 Waterborne navigation	CO2	5,470	3,824	3%	3%	0.042	0.000	0.001	0.007	0.000	0.000	0.00000
Transport - N2O Waterborne navigation	N2O	38	28	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CH4 Waterborne navigation	CH4	35	17	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CO2 Civil Aviation	CO2	1,493	2,155	3%	3%	0.042	0.000	0.002	0.004	0.000	0.000	0.00000
Transport - N2O Civil Aviation	N2O	12	18	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CH4 Civil Aviation	CH4	1	1	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CO2 Railways	CO2	613	47	3%	5%	0.058	0.000	0.001	0.000	0.000	0.000	0.00000
Transport - N2O Railways	N2O	72	6	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CH4 Railways	CH4	1	0	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CO2 Other transportation - pipelines	CO2	407	669	3%	3%	0.042	0.000	0.001	0.001	0.000	0.000	0.00000
Transport - N2O Other transportation - pipelines	N2O	7	10	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CH4 Other transportation - pipelines	CH4	0	1	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Other sectors - CO2 commercial, residential, agriculture liquid fuels	CO2	38,274	14,965	3%	3%	0.042	0.000	0.032	0.029	0.001	0.001	0.00000
Other sectors - CO2 commercial, residential, agriculture solid fuels	CO2	899	0	3%	3%	0.042	0.000	0.001	0.000	0.000	0.000	0.00000
Other sectors - CO2 commercial, residential, agriculture gaseous fuels	CO2	36,401	57,924	3%	3%	0.042	0.000	0.054	0.112	0.002	0.005	0.00003
Other sectors - CO2 commercial, residential, agriculture other fossil fuels	CO2	526	4,920	3%	3%	0.042	0.000	0.009	0.009	0.000	0.000	0.00000
Other sectors - N2O commercial, residential, agriculture liquid fuels	N2O	996	764	3%	50%	0.501	0.000	0.000	0.001	0.000	0.000	0.00000
Other sectors - N2O commercial, residential, agriculture solid fuels	N2O	4	0	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Other sectors - N2O commercial, residential, agriculture gaseous fuels	N2O	196	299	3%	50%	0.501	0.000	0.000	0.001	0.000	0.000	0.00000
Other sectors - N2O commercial, residential, agriculture other fossil fuels	N2O	15	137	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Other sectors - N2O commercial, residential,	N2O	532	1,208	3%	50%	0.501	0.000	0.001	0.002	0.001	0.000	0.00000

IPCC category	Gas	Emissions		Uncertainty				Sensitivity		Uncertainty in trend		
		Base year emissions	2016	AD	EF	Combined	Contribution to variance	Type A	Type B	introduced by EF uncertainty	introduced by AD uncertainty	in total national emissions
agriculture biomass												
Other sectors - CH4 commercial, residential, agriculture liquid fuels	CH4	94	21	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Other sectors - CH4 commercial, residential, agriculture solid fuels	CH4	10	0	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Other sectors - CH4 commercial, residential, agriculture gaseous fuels	CH4	41	63	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Other sectors - CH4 commercial, residential, agriculture other fossil fuels	CH4	1	7	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Other sectors - CH4 commercial, residential, agriculture biomass	CH4	997	2,211	3%	50%	0.501	0.000	0.003	0.004	0.001	0.000	0.00000
Other non specified - CO2 military mobile - liquid fuels	CO2	1,071	515	3%	5%	0.058	0.000	0.001	0.001	0.000	0.000	0.00000
Other non specified - N2O military mobile - liquid fuels	N2O	67	16	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Other non specified - CH4 military mobile - liquid fuels	CH4	4	2	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CO2 Solid fuels	CO2	0	0	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CH4 Solid fuels	CH4	132	42	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CO2 Oil and natural gas - Oil	CO2	2,368	1,706	3%	10%	0.104	0.000	0.000	0.003	0.000	0.000	0.00000
Fugitive - CH4 Oil and natural gas - Oil	CH4	295	211	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - N2O Oil and natural gas - Oil	N2O	0	0	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CO2 Oil and natural gas - Natural gas	CO2	9	6	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CH4 Oil and natural gas - Natural gas	CH4	8,235	4,417	3%	50%	0.501	0.000	0.005	0.009	0.002	0.000	0.00001
Fugitive - CO2 Oil and natural gas - venting and flaring	CO2	956	420	50%	10%	0.510	0.000	0.001	0.001	0.000	0.001	0.00000
Fugitive - N2O Oil and natural gas - venting and flaring	N2O	1	1	50%	50%	0.707	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CH4 Oil and natural gas - venting and flaring	CH4	178	48	50%	50%	0.707	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CO2 Oil and natural gas - Other - flaring in refineries	CO2	681	352	50%	10%	0.510	0.000	0.000	0.001	0.000	0.000	0.00000
Fugitive - N2O Oil and natural gas - Other - flaring in refineries	N2O	11	8	50%	50%	0.707	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CH4 Oil and natural gas - Other - flaring in refineries	CH4	12	9	50%	50%	0.707	0.000	0.000	0.000	0.000	0.000	0.00000
Mineral industry- CO2 Cement production	CO2	15,846	7,680	3%	10%	0.104	0.000	0.010	0.015	0.001	0.001	0.00000
Mineral industry- CO2 Lime production	CO2	1,877	1,661	3%	10%	0.104	0.000	0.000	0.003	0.000	0.000	0.00000

IPCC category	Gas	Emissions		Uncertainty				Sensitivity		Uncertainty in trend		
		Base year emissions	2016	AD	EF	Combined	Contribution to variance	Type A	Type B	introduced by EF uncertainty	introduced by AD uncertainty	in total national emissions
Mineral industry- CO2 Glass production	CO2	453	512	3%	10%	0.104	0.000	0.000	0.001	0.000	0.000	0.00000
Mineral industry- CO2 Other processes uses of carbonates	CO2	2,544	753	3%	10%	0.104	0.000	0.003	0.001	0.000	0.000	0.00000
Chemical industry- CO2 Ammonia production	CO2	1,892	643	3%	10%	0.104	0.000	0.002	0.001	0.000	0.000	0.00000
Chemical industry- N2O Nitric acid production	N2O	2,005	50	3%	10%	0.104	0.000	0.003	0.000	0.000	0.000	0.00000
Chemical industry - CO2 Adipic acid production	CO2	1	2	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Chemical industry- N2O Adipic acid production	N2O	4,402	66	3%	10%	0.104	0.000	0.007	0.000	0.001	0.000	0.00000
Chemical industry- Caprolactam, Glyoxal and Glyoxylic Acid production -N2O	N2O	11	0	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Chemical industry- CO2 Carbide production	CO2	26	5	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Chemical industry- CO2 Titanium dioxide production	CO2	53	36	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Chemical industry- CO2 Soda ash production	CO2	183	282	3%	10%	0.104	0.000	0.000	0.001	0.000	0.000	0.00000
Chemical industry - CO2 Petrochemical and carbon black production	CO2	422	497	3%	10%	0.104	0.000	0.000	0.001	0.000	0.000	0.00000
Chemical industry - CH4 Petrochemical and carbon black production	CH4	61	4	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Chemical industry- HFCs Fluorochemical production	HFCs	444	1	5%	50%	0.502	0.000	0.001	0.000	0.000	0.000	0.00000
Chemical industry- PFCs Fluorochemical production	PFCs	932	1,493	5%	50%	0.502	0.000	0.001	0.003	0.001	0.000	0.00000
Chemical industry- SF6 Fluorochemical production	SF6	114	0	5%	50%	0.502	0.000	0.000	0.000	0.000	0.000	0.00000
Metal industry- CO2 Iron and steel production	CO2	3,124	1,473	3%	10%	0.104	0.000	0.002	0.003	0.000	0.000	0.00000
Metal industry- CH4 Iron and steel production	CH4	68	43	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Metal industry- CO2 Ferroalloys production	CO2	395	0	3%	10%	0.104	0.000	0.001	0.000	0.000	0.000	0.00000
Metal industry- CO2 Aluminium production	CO2	359	0	3%	20%	0.202	0.000	0.001	0.000	0.000	0.000	0.00000
Metal industry- PFCs Aluminium production	PFCs	1,975	0	3%	20%	0.202	0.000	0.003	0.000	0.001	0.000	0.00000
Metal industry- HFCs Magnesium production	HFCs	0	10	3%	20%	0.202	0.000	0.000	0.000	0.000	0.000	0.00000
Metal industry- CO2 Zinc production	CO2	500	237	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Non-Energy products from Fuels and Solvent Use - CO2	CO2	1,710	980	30%	50%	0.583	0.000	0.001	0.002	0.000	0.001	0.00000
Electronics Industry - HFCs	HFCs	0	10	5%	20%	0.206	0.000	0.000	0.000	0.000	0.000	0.00000
Electronics Industry - PFCs	PFCs	0	136	5%	20%	0.206	0.000	0.000	0.000	0.000	0.000	0.00000
Electronics Industry - SF6	SF6	0	45	5%	20%	0.206	0.000	0.000	0.000	0.000	0.000	0.00000
Electronics Industry - NF3	NF3	77	28	5%	20%	0.206	0.000	0.000	0.000	0.000	0.000	0.00000
Product uses as substitutes for ozone depleting	HFCs	0	12,252	30%	50%	0.583	0.000	0.024	0.024	0.012	0.010	0.00024

IPCC category	Gas	Emissions		Uncertainty				Sensitivity		Uncertainty in trend		
		Base year emissions	2016	AD	EF	Combined	Contribution to variance	Type A	Type B	introduced by EF uncertainty	introduced by AD uncertainty	in total national emissions
substances - HFCs Refrigeration and Air conditioning												
Product uses as substitutes for ozone depleting substances - HFCs Foam blowing agents	HFCs	0	650	30%	50%	0.583	0.000	0.001	0.001	0.001	0.001	0.00000
Product uses as substitutes for ozone depleting substances - HFCs Fire protection	HFCs	0	1,593	30%	50%	0.583	0.000	0.003	0.003	0.002	0.001	0.00000
Product uses as substitutes for ozone depleting substances - HFCs Aerosols	HFCs	0	164	30%	50%	0.583	0.000	0.000	0.000	0.000	0.000	0.00000
Other Product Manufacture and Use - SF6	SF6	296	332	5%	20%	0.206	0.000	0.000	0.001	0.000	0.000	0.00000
Other Product Manufacture and Use - N2O	N2O	781	458	5%	10%	0.112	0.000	0.000	0.001	0.000	0.000	0.00000
Enteric Fermentation- CH4	CH4	15,497	14,039	3%	20%	0.202	0.000	0.002	0.027	0.000	0.001	0.00000
Manure Management - CH4	CH4	3,934	3,106	5%	20%	0.206	0.000	0.000	0.006	0.000	0.000	0.00000
Manure Management - N2O	N2O	1,829	1,281	5%	20%	0.206	0.000	0.000	0.002	0.000	0.000	0.00000
Field burning of agricultural residues - CH4	CH4	15	17	30%	50%	0.583	0.000	0.000	0.000	0.000	0.000	0.00000
Field burning of agricultural residues - N2O	N2O	4	4	30%	50%	0.583	0.000	0.000	0.000	0.000	0.000	0.00000
Liming - CO2	CO2	1	12	10%	20%	0.224	0.000	0.000	0.000	0.000	0.000	0.00000
Urea application - CO2	CO2	465	527	10%	20%	0.224	0.000	0.000	0.001	0.000	0.000	0.00000
Direct N2O Emissions from Managed soils	N2O	8,331	7,150	20%	50%	0.539	0.000	0.001	0.014	0.000	0.004	0.00002
Indirect N2O Emissions from Managed soils	N2O	2,066	1,707	20%	50%	0.539	0.000	0.000	0.003	0.000	0.001	0.00000
Indirect N2O Emissions from Manure Management	N2O	1,061	841	5%	50%	0.502	0.000	0.000	0.002	0.000	0.000	0.00000
Rice cultivations - CH4	CH4	1,876	1,710	5%	10%	0.112	0.000	0.000	0.003	0.000	0.000	0.00000
Solid waste disposal - CH4	CH4	12,206	13,621	10%	20%	0.224	0.000	0.007	0.026	0.001	0.004	0.00002
Biological treatment of Solid waste - CH4	CH4	5	123	20%	100%	1.020	0.000	0.000	0.000	0.000	0.000	0.00000
Biological treatment of Solid waste - N2O	N2O	20	530	20%	100%	1.020	0.000	0.001	0.001	0.001	0.000	0.00000
Incineration and open burning of waste - CO2	CO2	507	95	10%	20%	0.224	0.000	0.001	0.000	0.000	0.000	0.00000
Incineration and open burning of waste - CH4	CH4	50	60	10%	20%	0.224	0.000	0.000	0.000	0.000	0.000	0.00000
Incineration and open burning of waste - N2O	N2O	37	21	10%	20%	0.224	0.000	0.000	0.000	0.000	0.000	0.00000
Wastewater treatment and discharge - CH4	CH4	3,222	2,488	20%	100%	1.020	0.000	0.000	0.005	0.000	0.001	0.00000
Wastewater treatment and discharge - N2O	N2O	1,266	1,351	20%	100%	1.020	0.000	0.001	0.003	0.001	0.001	0.00000
TOTAL		**518,440**	**427,862**				**0.001**					**0.000**
						Percertage uncertainty in total inventory	**2.7%**				**Trend uncertainty**	**2.1%**

Table A1.6 Results of the uncertainty analysis for the LULUCF sector – CO_2 (Approach 1)

IPCC	Gas	Emissions		Uncertainty			Contribution to variance
		1990	*2016*	*AD*	*EF*	*Combined*	
Categoy		*Gg CO_2 eq*				%	
A. Forest Land	CO_2	-17,635	-36,081	*0.18*	*0.17*	0.25	0.085
B. Cropland	CO_2	2,172	2,460	*0.75*	*0.75*	1.06	0.007
C. Grassland	CO_2	3,993	-6,644	*0.75*	*0.75*	1.06	0.051
D. Wetlands	CO_2	NE,NO	NO,NE			0	0.000
E. Settlements	CO_2	6,640	9,014	*0.75*	*0.75*	1.06	0.095
F. Other Land	CO_2	NO	NO			0	0.000
G. Harvested wood products	CO_2	-520	172	*0.25*	*0.50*	1	0.000
H. Other	CO_2	NO	NO			0	0.000
TOTAL		**-5,349**	**-31,078**				**0.238**
						Percertage uncertainty	**49%**

[a] the combined uncertainty has been calculated as explained in Chapter 6, 62.3 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 – CO_2, CH_4, N_2O (Approach 1)

IPCC	Gas	Emissions		Uncertainty			Contribution to variance
Categoy		*1990*	*2016*	*AD*	*EF*	*Combined*	
		Gg CO_2 eq				%	
A. Forest Land	CO_2	-16,840	-35,802	*0.18*	*0.17*	0.25	0.090
B. Cropland	CO_2	2,225	2,489	*0.75*	*0.75*	1.06	0.008
C. Grassland	CO_2	4,936	-6,484	*0.75*	*0.75*	1.06	0.053
D. Wetlands	CO_2	NO	NO			0	0.000
E. Settlements	CO_2	7,145	9,692	*0.75*	*0.75*	1.06	0.118
F. Other Land	CO_2	NO	NO			0	0.000
G. Harvested wood products	CO_2	-520	172	*0.25*	*0.50*	1	0.000
H. Other	CO_2	NO	NO			0	0.000
TOTAL		**-3,043**	**-29,927**				**0.268**
						Percertage uncertainty	**52%**

Table A1.8 Results of the uncertainty analysis including LULUCF (Approach 1). Year 2016

		Emissions		Uncertainty				Sensitivity		Uncertainty in trend		
IPCC category	**Gas**	**Base year**	**2016**	**AD**	**EF**	**Combined**	**Contribution to variance**	**Type A**	**Type B**	**introduced by EF uncertainty**	**introduced by AD uncertainty**	**in total national emissions**
Energy industries - CO2 liquid fuels	CO2	81,085	18,188	3%	3%	0.042	0.000	0.086	0.035	0.003	0.001	0.00001
Energy industries - CO2 solid fuels	CO2	38,646	37,299	3%	3%	0.042	0.000	0.014	0.072	0.000	0.003	0.00001
Energy industries - CO2 gaseous fuels	CO2	16,573	48,090	3%	3%	0.042	0.000	0.068	0.093	0.002	0.004	0.00002
Energy industries - CO2 other fuels	CO2	143	209	3%	3%	0.042	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - N2O liquid fuels	N2O	296	140	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - N2O solid fuels	N2O	163	162	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - N2O gaseous fuels	N2O	9	29	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - N2O other fuels	N2O	1	1	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - N2O biomass	N2O	16	108	20%	50%	0.539	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - CH4 liquid fuels	CH4	74	12	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - CH4 solid fuels	CH4	132	24	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - CH4 gaseous fuels	CH4	11	30	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - CH4 other fuels	CH4	0	0	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Energy industries - CH4 biomass	CH4	10	65	20%	50%	0.539	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - CO2 liquid fuels	CO2	34,677	7,994	3%	3%	0.042	0.000	0.036	0.016	0.001	0.001	0.00000
Manufacturing industries and construction - CO2 solid fuels	CO2	24,926	8,802	3%	3%	0.042	0.000	0.020	0.017	0.001	0.001	0.00000
Manufacturing industries and construction - CO2 gaseous fuels	CO2	32,110	29,750	3%	3%	0.042	0.000	0.010	0.058	0.000	0.002	0.00001
Manufacturing industries and construction - CO2 other fuels	CO2	0	409	3%	3%	0.042	0.000	0.001	0.001	0.000	0.000	0.00000
Manufacturing industries and construction - N2O liquid fuels	N2O	941	361	3%	50%	0.501	0.000	0.001	0.001	0.000	0.000	0.00000
Manufacturing industries and construction - N2O solid fuels	N2O	243	89	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - N2O gaseous fuels	N2O	164	155	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - N2O other fuels	N2O	0	23	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - N2O biomass	N2O	4	84	20%	50%	0.539	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - CH4 liquid fuels	CH4	45	11	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - CH4 solid fuels	CH4	107	60	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - CH4 gaseous fuels	CH4	15	13	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - CH4 other fuels	CH4	0	0	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Manufacturing industries and construction - CH4 biomass	CH4	3	193	20%	50%	0.539	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CO2 Road transportation	CO2	92,257	96,683	3%	3%	0.042	0.000	0.049	0.188	0.001	0.008	0.00007
Transport - N2O Road transportation	N2O	824	847	3%	40%	0.401	0.000	0.000	0.002	0.000	0.000	0.00000

IPCC category	Gas	Emissions		Uncertainty			Contribution to variance	Sensitivity		Uncertainty in trend		
		Base year	2016	AD	EF	Combined		Type A	Type B	introduced by EF uncertainty	introduced by AD uncertainty	in total national emissions
Transport - CH4 Road transportation	CH4	870	199	3%	40%	0.401	0.000	0.001	0.000	0.000	0.000	0.00000
Transport - CO2 Waterborne navigation	CO2	5,470	3,824	3%	3%	0.042	0.000	0.001	0.007	0.000	0.000	0.00000
Transport - N2O Waterborne navigation	N2O	38	28	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CH4 Waterborne navigation	CH4	35	17	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CO2 Civil Aviation	CO2	1,493	2,155	3%	3%	0.042	0.000	0.002	0.004	0.000	0.000	0.00000
Transport - N2O Civil Aviation	N2O	12	18	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CH4 Civil Aviation	CH4	1	1	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CO2 Railways	CO2	613	47	3%	5%	0.058	0.000	0.001	0.000	0.000	0.000	0.00000
Transport - N2O Railways	N2O	72	6	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CH4 Railways	CH4	1	0	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CO2 Other transportation - pipelines	CO2	407	669	3%	3%	0.042	0.000	0.001	0.001	0.000	0.000	0.00000
Transport - N2O Other transportation - pipelines	N2O	7	10	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Transport - CH4 Other transportation - pipelines	CH4	0	1	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Other sectors - CO2 commercial, residential, agriculture liquid fuels	CO2	38,274	14,965	3%	3%	0.042	0.000	0.028	0.029	0.001	0.001	0.00000
Other sectors - CO2 commercial, residential, agriculture solid fuels	CO2	899	0	3%	3%	0.042	0.000	0.001	0.000	0.000	0.000	0.00000
Other sectors - CO2 commercial, residential, agriculture gaseous fuels	CO2	36,401	57,924	3%	3%	0.042	0.000	0.058	0.112	0.002	0.005	0.00003
Other sectors - CO2 commercial, residential, agriculture other fossil fuels	CO2	526	4,920	3%	3%	0.042	0.000	0.009	0.010	0.000	0.000	0.00000
Other sectors - N2O commercial, residential, agriculture liquid fuels	N2O	996	764	3%	50%	0.501	0.000	0.000	0.001	0.000	0.000	0.00000
Other sectors - N2O commercial, residential, agriculture solid fuels	N2O	4	0	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Other sectors - N2O commercial, residential, agriculture gaseous fuels	N2O	196	299	3%	50%	0.501	0.000	0.000	0.001	0.000	0.000	0.00000
Other sectors - N2O commercial, residential, agriculture other fossil fuels	N2O	15	137	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Other sectors - N2O commercial, residential, agriculture biomass	N2O	532	1,208	3%	50%	0.501	0.000	0.002	0.002	0.001	0.000	0.00000
Other sectors - CH4 commercial, residential, agriculture liquid fuels	CH4	94	21	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Other sectors - CH4 commercial, residential, agriculture solid fuels	CH4	10	0	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Other sectors - CH4 commercial, residential, agriculture gaseous fuels	CH4	41	63	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Other sectors - CH4 commercial, residential, agriculture other fossil fuels	CH4	1	7	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000

IPCC category	Gas	Emissions		Uncertainty			Contribution to variance	Sensitivity		Uncertainty in trend		
		Base year	2016	AD	EF	Combined		Type A	Type B	introduced by EF uncertainty	introduced by AD uncertainty	in total national emissions
Other sectors - CH4 commercial, residential, agriculture biomass	CH4	997	2,211	3%	50%	0.501	0.000	0.003	0.004	0.001	0.000	0.00000
Other non specified - CO2 military mobile - liquid fuels	CO2	1,071	515	3%	5%	0.058	0.000	0.001	0.001	0.000	0.000	0.00000
Other non specified - N2O military mobile - liquid fuels	N2O	67	16	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Other non specified - CH4 military mobile - liquid fuels	CH4	4	2	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CO2 Solid fuels	CO2	0	0	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CH4 Solid fuels	CH4	132	42	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CO2 Oil and natural gas - Oil	CO2	2,368	1,706	3%	10%	0.104	0.000	0.000	0.003	0.000	0.000	0.00000
Fugitive - CH4 Oil and natural gas - Oil	CH4	295	211	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - N2O Oil and natural gas - Oil	N2O	0	0	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CO2 Oil and natural gas - Natural gas	CO2	9	6	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CH4 Oil and natural gas - Natural gas	CH4	8,235	4,417	3%	50%	0.501	0.000	0.004	0.009	0.002	0.000	0.00000
Fugitive - CO2 Oil and natural gas - venting and flaring	CO2	956	420	50%	10%	0.510	0.000	0.001	0.001	0.000	0.001	0.00000
Fugitive - N2O Oil and natural gas - venting and flaring	N2O	1	1	50%	50%	0.707	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CH4 Oil and natural gas - venting and flaring	CH4	178	48	50%	50%	0.707	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CO2 Oil and natural gas - Other - flaring in refineries	CO2	681	352	50%	10%	0.510	0.000	0.000	0.001	0.000	0.000	0.00000
Fugitive - N2O Oil and natural gas - Other - flaring in refineries	N2O	11	8	50%	50%	0.707	0.000	0.000	0.000	0.000	0.000	0.00000
Fugitive - CH4 Oil and natural gas - Other - flaring in refineries	CH4	12	9	50%	50%	0.707	0.000	0.000	0.000	0.000	0.000	0.00000
Mineral industry- CO2 Cement production	CO2	15,846	7,680	3%	10%	0.104	0.000	0.009	0.015	0.001	0.001	0.00000
Mineral industry- CO2 Lime production	CO2	1,877	1,661	3%	10%	0.104	0.000	0.000	0.003	0.000	0.000	0.00000
Mineral industry- CO2 Glass production	CO2	453	512	3%	10%	0.104	0.000	0.000	0.001	0.000	0.000	0.00000
Mineral industry- CO2 Other processes uses of carbonates	CO2	2,544	753	3%	10%	0.104	0.000	0.002	0.001	0.000	0.000	0.00000
Chemical industry- CO2 Ammonia production	CO2	1,892	643	3%	10%	0.104	0.000	0.002	0.001	0.000	0.000	0.00000
Chemical industry- N2O Nitric acid production	N2O	2,005	50	3%	10%	0.104	0.000	0.003	0.000	0.000	0.000	0.00000
Chemical industry - CO2 Adipic acid production	CO2	1	2	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Chemical industry- N2O Adipic acid production	N2O	4,402	66	3%	10%	0.104	0.000	0.006	0.000	0.001	0.000	0.00000
Chemical industry- Caprolactam, Glyoxal and Glyoxylic Acid production -N2O	N2O	11	0	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Chemical industry- CO2 Carbide production	CO2	26	5	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Chemical industry- CO2 Titanium dioxide production	CO2	53	36	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Chemical industry- CO2 Soda ash production	CO2	183	282	3%	10%	0.104	0.000	0.000	0.001	0.000	0.000	0.00000
Chemical industry - CO2 Petrochemical and carbon black production	CO2	422	497	3%	10%	0.104	0.000	0.000	0.001	0.000	0.000	0.00000
Chemical industry - N2O Petrochemical and carbon black	N2O	61	4	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000

IPCC category	Gas	Emissions		Uncertainty			Contribution to variance	Sensitivity		Uncertainty in trend		
		Base year	2016	AD	EF	Combined		Type A	Type B	introduced by EF uncertainty	introduced by AD uncertainty	in total national emissions
production												
Chemical industry- HFCs Fluorochemical production	HFCs	444	1	5%	50%	0.502	0.000	0.001	0.000	0.000	0.000	0.00000
Chemical industry- PFCs Fluorochemical production	PFCs	932	1,493	5%	50%	0.502	0.000	0.002	0.003	0.001	0.000	0.00000
Chemical industry- SF6 Fluorochemical production	SF6	114	0	5%	50%	0.502	0.000	0.000	0.000	0.000	0.000	0.00000
Metal industry- CO2 Iron and steel production	CO2	3,124	1,473	3%	10%	0.104	0.000	0.002	0.003	0.000	0.000	0.00000
Metal industry- CH4 Iron and steel production	CH4	68	43	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Metal industry- CO2 Ferroalloys production	CO2	395	0	3%	10%	0.104	0.000	0.001	0.000	0.000	0.000	0.00000
Metal industry- CO2 Aluminium production	CO2	359	0	3%	20%	0.202	0.000	0.001	0.000	0.000	0.000	0.00000
Metal industry- PFCs Aluminium production	PFCs	1,975	0	3%	20%	0.202	0.000	0.003	0.000	0.001	0.000	0.00000
Metal industry- HFCs Magnesium production	HFCs	0	10	3%	20%	0.202	0.000	0.000	0.000	0.000	0.000	0.00000
Metal industry- CO2 Zinc production	CO2	500	237	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.00000
Non-Energy products from Fuels and Solvent Use - CO2	CO2	1,710	980	30%	50%	0.583	0.000	0.001	0.002	0.000	0.001	0.00000
Electronics Industry - HFCs	HFCs	0	10	5%	20%	0.206	0.000	0.000	0.000	0.000	0.000	0.00000
Electronics Industry - PFCs	PFCs	0	136	5%	20%	0.206	0.000	0.000	0.000	0.000	0.000	0.00000
Electronics Industry - SF6	SF6	0	45	5%	20%	0.206	0.000	0.000	0.000	0.000	0.000	0.00000
Electronics Industry - NF3	NF3	77	28	5%	20%	0.206	0.000	0.000	0.000	0.000	0.000	0.00000
Product uses as substitutes for ozone depleting substances - HFCs Refrigeration and Air conditioning	HFCs	0	12,252	30%	50%	0.583	0.000	0.024	0.024	0.012	0.010	0.00024
Product uses as substitutes for ozone depleting substances - HFCs Foam blowing agents	HFCs	0	650	30%	50%	0.583	0.000	0.001	0.001	0.001	0.001	0.00000
Product uses as substitutes for ozone depleting substances - HFCs Fire protection	HFCs	0	1,593	30%	50%	0.583	0.000	0.003	0.003	0.002	0.001	0.00000
Product uses as substitutes for ozone depleting substances - HFCs Aerosols	HFCs	0	164	30%	50%	0.583	0.000	0.000	0.000	0.000	0.000	0.00000
Other Product Manufacture and Use - SF6	SF6	296	332	5%	20%	0.206	0.000	0.000	0.001	0.000	0.000	0.00000
Other Product Manufacture and Use - N2O	N2O	781	458	5%	10%	0.112	0.000	0.000	0.001	0.000	0.000	0.00000
Enteric Fermentation- CH4	CH4	15,497	14,039	3%	20%	0.202	0.000	0.004	0.027	0.001	0.001	0.00000
Manure Management - CH4	CH4	3,934	3,106	5%	20%	0.206	0.000	0.000	0.006	0.000	0.000	0.00000
Manure Management - N2O	N2O	1,829	1,281	5%	20%	0.206	0.000	0.000	0.002	0.000	0.000	0.00000
Field burning of agricultural residues - CH4	CH4	15	17	30%	50%	0.583	0.000	0.000	0.000	0.000	0.000	0.00000
Field burning of agricultural residues - N2O	N2O	4	4	30%	50%	0.583	0.000	0.000	0.000	0.000	0.000	0.00000
Liming - CO2	CO2	1	12	10%	20%	0.224	0.000	0.000	0.000	0.000	0.000	0.00000
Urea application - CO2	CO2	465	527	10%	20%	0.224	0.000	0.000	0.001	0.000	0.000	0.00000
Direct N2O Emissions from Managed soils	N2O	8,331	7,150	20%	50%	0.539	0.000	0.001	0.014	0.001	0.004	0.00002
Indirect N2O Emissions from Managed soils	N2O	2,066	1,707	20%	50%	0.539	0.000	0.000	0.003	0.000	0.001	0.00000
Indirect N2O Emissions from Manure Management	N2O	1,061	841	5%	50%	0.502	0.000	0.000	0.002	0.000	0.000	0.00000
Rice cultivations - CH4	CH4	1,876	1,710	5%	10%	0.112	0.000	0.001	0.003	0.000	0.000	0.00000

IPCC category	Gas	Emissions		Uncertainty				Sensitivity		Uncertainty in trend		
		Base year	2016	AD	EF	Combined	Contribution to variance	Type A	Type B	introduced by EF uncertainty	introduced by AD uncertainty	in total national emissions
Solid waste disposal - CH4	CH4	12,206	13,621	10%	20%	0.224	0.000	0.008	0.026	0.002	0.004	0.00002
Biological treatment of Solid waste - CH4	CH4	5	123	20%	100%	1.020	0.000	0.000	0.000	0.000	0.000	0.00000
Biological treatment of Solid waste - N2O	N2O	20	530	20%	100%	1.020	0.000	0.001	0.001	0.001	0.000	0.00000
Incineration and open burning of waste - CO2	CO2	507	95	10%	20%	0.224	0.000	0.001	0.000	0.000	0.000	0.00000
Incineration and open burning of waste - CH4	CH4	50	60	10%	20%	0.224	0.000	0.000	0.000	0.000	0.000	0.00000
Incineration and open burning of waste - N2O	N2O	37	21	10%	20%	0.224	0.000	0.000	0.000	0.000	0.000	0.00000
Wastewater treatment and discharge - CH4	CH4	3,222	2,488	20%	100%	1.020	0.000	0.000	0.005	0.000	0.001	0.00000
Wastewater treatment and discharge - N2O	N2O	1,266	1,351	20%	100%	1.020	0.000	0.001	0.003	0.001	0.001	0.00000
Forest Land remaining Forest Land - CO2	CO2	-15,002	-30,251	18%	17%	0.248	0.000	0.036	0.059	0.006	0.015	0.00026
Forest Land remaining Forest Land - CH4	CH4	720	238	18%	17%	0.248	0.000	0.001	0.000	0.000	0.000	0.00000
Forest Land remaining Forest Land - N2O	N2O	3	1	18%	17%	0.248	0.000	0.000	0.000	0.000	0.000	0.00000
Land Converted to Forest Land - CO2	CO2	-2,633	-5,829	75%	75%	1.061	0.000	0.007	0.011	0.006	0.012	0.00017
Land Converted to Forest Land - CH4	CH4	72	40	75%	75%	1.061	0.000	0.000	0.000	0.000	0.000	0.00000
Land Converted to Forest Land - N2O	N2O	0	0	75%	75%	1.061	0.000	0.000	0.000	0.000	0.000	0.00000
Cropland Remaining Cropland - CO2	CO2	1,638	1,918	75%	75%	1.061	0.000	0.001	0.004	0.001	0.004	0.00002
Cropland Remaining Cropland - CH4	CH4	5	2	75%	75%	1.061	0.000	0.000	0.000	0.000	0.000	0.00000
Cropland Remaining Cropland - N2O	N2O	2	1	75%	75%	1.061	0.000	0.000	0.000	0.000	0.000	0.00000
Land Converted to Cropland - CO2	CO2	534	542	75%	75%	1.061	0.000	0.000	0.001	0.000	0.001	0.00000
Land Converted to Cropland - N2O	N2O	45	27	75%	75%	1.061	0.000	0.000	0.000	0.000	0.000	0.00000
Grassland Remaining Grassland - CO2	CO2	5,268	-647	75%	75%	1.061	0.000	0.009	0.001	0.007	0.001	0.00005
Grassland Remaining Grassland - CH4	CH4	686	116	75%	75%	1.061	0.000	0.001	0.000	0.001	0.000	0.00000
Grassland Remaining Grassland - N2O	N2O	257	43	75%	75%	1.061	0.000	0.000	0.000	0.000	0.000	0.00000
Land Converted to Grassland - CO2	CO2	-1,275	-5,996	75%	75%	1.061	0.000	0.010	0.012	0.007	0.012	0.00021
Land Converted to Settlements - CO2	CO2	6,640	9,014	75%	75%	1.061	0.001	0.008	0.017	0.006	0.019	0.00038
Land Converted to Settlements - N2O	N2O	505	678	75%	75%	1.061	0.000	0.001	0.001	0.000	0.001	0.00000
Harvest Wood Products - CO2	CO2	-520	172	25%	50%	0.559	0.000	0.001	0.000	0.001	0.000	0.00000
Indirect N2O from Managed soils - LULUCF	N2O	10	6	75%	75%	1.061	0.000	0.000	0.000	0.000	0.000	0.00000
TOTAL		**515,397**	**397,935**				**0.002**					**0.002**
						Percertage uncertainty in total inventory	**4.8%**				**Trend uncertainty**	**3.9%**

Emission sources of the Italian inventory are disaggregated into a detailed level, 127 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 146 categories. Uncertainties are therefore estimated for these categories. To estimate uncertainty for both activity data and emission factors, information provided in the IPCC 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 2.1%; if considering the LULUCF sector the overall uncertainty increases to 2.9%.
In 2016, the results of Approach 1 suggest an uncertainty of 2.7% in the combined GWP total emissions. The analysis also estimates an uncertainty of 2.1% in the trend.
For the LULUCF sector, the uncertainty value resulting from Approach 1 is 52% in the combined GWP total emissions for the year 2016, whereas a value equal to 49% is resulting from the Approach 1 uncertainty analysis, applied to LULUCF CO_2 emissions only (see Tables A1.6 and A1.7).
Including the LULUCF sector in the total uncertainty assessment, Approach 1 shows an uncertainty of 4.8% in the combined GWP total emissions for the year 2015, whereas the uncertainty in the trend is equal to 3.9%. 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:

$$\textit{Level Assessment, with Uncertainty} = \textit{Approach 1 Level Assessment} \cdot \textit{Relative Category Uncertainty}$$

$$\textit{Trend Assessment, with Uncertainty} = \textit{Approach 1 Trend Assessment} \cdot \textit{Relative Category Uncertainty}$$

Approach 2 has been applied both to the base and the current year submission. In this section, detailed results are reported for the 2016 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 2016, while in Table A1.10 results, including LULUCF categories, are shown.
The application of Approach 2 to the base year gives as a result 31 key categories accounting for the 90% of the total levels uncertainty. Including the LULUCF categories, 35 key categories result accounting for 90% of the total uncertainty levels.
For the year 2016, 27 key categories accounting for the 90% of the total levels uncertainty were identified; when applying the trend analysis the key categories increased to 31.

The application of Approach 2 to the inventory, including the LULUCF categories, results in 29 key categories which account for the 90% of the total levels uncertainty; for the trend analysis, with LULUCF, the number of key categories is 30.

Table A1.9 Results of the key category analysis without LULUCF. Approach 2 Level assessment, year 2016

CATEGORIES	Share	Uncertainty	L*U	Level assessment with uncertainty	Cumulative Percentage
Product uses as substitutes for ozone depleting substances - HFCs Refrigeration and Air conditioning	0.03	0.5831	0.0167	0.1454	0.15
Transport - CO2 Road transportation	0.23	0.0424	0.0096	0.0835	0.23
Direct N2O Emissions from Managed soils	0.02	0.5385	0.0090	0.0784	0.31
Solid waste disposal - CH4	0.03	0.2236	0.0071	0.0620	0.37
Enteric Fermentation- CH4	0.03	0.2022	0.0066	0.0578	0.43
Wastewater treatment and discharge - CH4	0.01	1.0198	0.0059	0.0517	0.48
Other sectors - CO2 commercial, residential, agriculture gaseous fuels	0.14	0.0424	0.0057	0.0500	0.53
Fugitive - CH4 Oil and natural gas - Natural gas	0.01	0.5009	0.0052	0.0450	0.57
Energy industries - CO2 gaseous fuels	0.11	0.0424	0.0048	0.0415	0.62
Energy industries - CO2 solid fuels	0.09	0.0424	0.0037	0.0322	0.65
Wastewater treatment and discharge - N2O	0.00	1.0198	0.0032	0.0281	0.68
Manufacturing industries and construction - CO2 gaseous fuels	0.07	0.0424	0.0030	0.0257	0.70
Other sectors - CH4 commercial, residential, agriculture biomass	0.01	0.5009	0.0026	0.0226	0.72
Product uses as substitutes for ozone depleting substances - HFCs Fire protection	0.00	0.5831	0.0022	0.0189	0.74
Indirect N2O Emissions from Managed soils	0.00	0.5385	0.0021	0.0187	0.76
Mineral industry- CO2 Cement production	0.02	0.1044	0.0019	0.0163	0.78
Energy industries - CO2 liquid fuels	0.04	0.0424	0.0018	0.0157	0.79
Chemical industry- PFCs Fluorochemical production	0.00	0.5025	0.0018	0.0153	0.81
Manure Management - CH4	0.01	0.2062	0.0015	0.0130	0.82
Other sectors - CO2 commercial, residential, agriculture liquid fuels	0.03	0.0424	0.0015	0.0129	0.83
Other sectors - N2O commercial, residential, agriculture biomass	0.00	0.5009	0.0014	0.0123	0.85
Non-Energy products from Fuels and Solvent Use - CO2	0.00	0.5831	0.0013	0.0116	0.86
Biological treatment of Solid waste - N2O	0.00	1.0198	0.0013	0.0110	0.87
Indirect N2O Emissions from Manure Management	0.00	0.5025	0.0010	0.0086	0.88
Other sectors - N2O commercial, residential, agriculture liquid fuels	0.00	0.5009	0.0009	0.0078	0.89
Product uses as substitutes for ozone depleting substances - HFCs Foam blowing agents	0.00	0.5831	0.0009	0.0077	0.8939
Manufacturing industries and construction - CO2 solid fuels	0.02	0.0424	0.0009	0.0076	0.9015
Transport - N2O Road transportation	0.00	0.4011	0.0008	0.0069	0.9084
Manufacturing industries and construction - CO2 liquid fuels	0.02	0.0424	0.0008	0.0069	0.9154
Manure Management - N2O	0.00	0.2062	0.0006	0.0054	0.9207
Fugitive - CO2 Oil and natural gas - venting and flaring	0.00	0.5099	0.0005	0.0044	0.93
Other sectors - CO2 commercial, residential, agriculture other fossil fuels	0.01	0.0424	0.0005	0.0042	0.93
Rice cultivations - CH4	0.00	0.1118	0.0004	0.0039	0.93
Manufacturing industries and construction - N2O liquid fuels	0.00	0.5009	0.0004	0.0037	0.94
Fugitive - CO2 Oil and natural gas - Other - flaring in refineries	0.00	0.5099	0.0004	0.0037	0.94
Fugitive - CO2 Oil and natural gas - Oil	0.00	0.1044	0.0004	0.0036	0.94
Mineral industry- CO2 Lime production	0.00	0.1044	0.0004	0.0035	0.95
Transport - CO2 Waterborne navigation	0.01	0.0424	0.0004	0.0033	0.95
Metal industry- CO2 Iron and steel production	0.00	0.1044	0.0004	0.0031	0.95

Table A1.10 Results of the key category analysis without LULUCF. Approach 2 Trend assessment, base year-2016

CATEGORIES	Trend assessment with uncertainty	Uncertainty	T*U	Relative trend assessment with uncertainty	Cumulative Percentage
Product uses as substitutes for ozone depleting substances - HFCs Refrigeration and Air conditioning	0.02	0.5831	0.0138	0.271	0.27
Energy industries - CO2 liquid fuels	0.09	0.0424	0.0040	0.078	0.35
Energy industries - CO2 gaseous fuels	0.07	0.0424	0.0028	0.055	0.40
Fugitive - CH4 Oil and natural gas - Natural gas	0.00	0.5009	0.0023	0.045	0.45
Other sectors - CO2 commercial, residential, agriculture gaseous fuels	0.05	0.0424	0.0023	0.045	0.49
Product uses as substitutes for ozone depleting substances - HFCs Fire protection	0.00	0.5831	0.0018	0.035	0.53
Manufacturing industries and construction - CO2 liquid fuels	0.04	0.0424	0.0017	0.033	0.56
Transport - CO2 Road transportation	0.04	0.0424	0.0017	0.033	0.60
Solid waste disposal - CH4	0.01	0.2236	0.0015	0.030	0.63
Other sectors - CO2 commercial, residential, agriculture liquid fuels	0.03	0.0424	0.0014	0.027	0.65
Other sectors - CH4 commercial, residential, agriculture biomass	0.00	0.5009	0.0013	0.026	0.68
Mineral industry- CO2 Cement production	0.01	0.1044	0.0011	0.021	0.70
Biological treatment of Solid waste - N2O	0.00	1.0198	0.0010	0.020	0.72
Manufacturing industries and construction - CO2 solid fuels	0.02	0.0424	0.0010	0.019	0.74
Other sectors - N2O commercial, residential, agriculture biomass	0.00	0.5009	0.0007	0.015	0.75
Product uses as substitutes for ozone depleting substances - HFCs Foam blowing agents	0.00	0.5831	0.0007	0.014	0.77
Chemical industry- N2O Adipic acid production	0.01	0.1044	0.0007	0.014	0.78
Chemical industry- PFCs Fluorochemical production	0.00	0.5025	0.0007	0.014	0.80
Metal industry- PFCs Aluminium production	0.00	0.2022	0.0006	0.013	0.81
Wastewater treatment and discharge - N2O	0.00	1.0198	0.0006	0.012	0.82
Enteric Fermentation- CH4	0.00	0.2022	0.0005	0.010	0.83
Non-Energy products from Fuels and Solvent Use - CO2	0.00	0.5831	0.0005	0.010	0.84
Energy industries - CO2 solid fuels	0.01	0.0424	0.0004	0.009	0.85
Manufacturing industries and construction - N2O liquid fuels	0.00	0.5009	0.0004	0.008	0.86
Transport - CH4 Road transportation	0.00	0.4011	0.0004	0.008	0.86
Other sectors - CO2 commercial, residential, agriculture other fossil fuels	0.01	0.0424	0.0004	0.007	0.87
Fugitive - CO2 Oil and natural gas - venting and flaring	0.00	0.5099	0.0004	0.007	0.88
Chemical industry- HFCs Fluorochemical production	0.00	0.5025	0.0004	0.007	0.89
Wastewater treatment and discharge - CH4	0.00	1.0198	0.0003	0.007	0.89
Chemical industry- N2O Nitric acid production	0.00	0.1044	0.0003	0.006	0.90
Direct N2O Emissions from Managed soils	0.00	0.5385	0.0003	0.006	0.9047
Mineral industry- CO2 Other processes uses of carbonates	0.00	0.1044	0.0003	0.005	0.91
Manufacturing industries and construction - CO2 gaseous fuels	0.01	0.0424	0.0003	0.005	0.92
Biological treatment of Solid waste - CH4	0.00	1.0198	0.0002	0.005	0.92
Metal industry- CO2 Iron and steel production	0.00	0.1044	0.0002	0.004	0.92
Fugitive - CO2 Oil and natural gas - Other - flaring in refineries	0.00	0.5099	0.0002	0.004	0.93
Manufacturing industries and construction - CH4 biomass	0.00	0.5385	0.0002	0.004	0.93
Chemical industry- CO2 Ammonia production	0.00	0.1044	0.0002	0.004	0.94
Product uses as substitutes for ozone depleting substances - HFCs Aerosols	0.00	0.5831	0.0002	0.004	0.94
Incineration and open burning of waste - CO2	0.00	0.2236	0.0001	0.003	0.94
Fugitive - CH4 Oil and natural gas - venting and flaring	0.00	0.7071	0.0001	0.003	0.94

CATEGORIES	Trend assessment with uncertainty	Uncertainty	T*U	Relative trend assessment with uncertainty	Cumulative Percentage
Other sectors - N2O commercial, residential, agriculture gaseous fuels	0.00	0.5009	0.0001	0.003	0.95
Transport - N2O Road transportation	0.00	0.4011	0.0001	0.003	0.95
Other sectors - N2O commercial, residential, agriculture other fossil fuels	0.00	0.5009	0.0001	0.002	0.95
Metal industry- CO2 Aluminium production	0.00	0.2022	0.0001	0.002	0.95

Table A1.11 Results of the key category analysis with LULUCF. Approach 2 Level assessment, year 2016

CATEGORIES	Share	Uncertainty	L*U	Level assessment with uncertainty	Cumulative Percentage
Land Converted to Settlements - CO2	0.02	1.0607	0.0198	0.1150	0.12
Forest Land remaining Forest Land - CO2	0.06	0.2476	0.0155	0.0901	0.21
Product uses as substitutes for ozone depleting substances - HFCs Refrigeration and Air conditioning	0.03	0.5831	0.0148	0.0859	0.29
Land Converted to Grassland - CO2	0.01	1.0607	0.0132	0.0765	0.37
Land Converted to Forest Land - CO2	0.01	1.0607	0.0128	0.0744	0.44
Transport - CO2 Road transportation	0.20	0.0424	0.0085	0.0493	0.49
Direct N2O Emissions from Managed soils	0.01	0.5385	0.0080	0.0463	0.54
Solid waste disposal - CH4	0.03	0.2236	0.0063	0.0366	0.57
Enteric Fermentation- CH4	0.03	0.2022	0.0059	0.0342	0.61
Wastewater treatment and discharge - CH4	0.01	1.0198	0.0052	0.0305	0.64
Other sectors - CO2 commercial, residential, agriculture gaseous fuels	0.12	0.0424	0.0051	0.0296	0.67
Fugitive - CH4 Oil and natural gas - Natural gas	0.01	0.5009	0.0046	0.0266	0.70
Energy industries - CO2 gaseous fuels	0.10	0.0424	0.0042	0.0245	0.72
Cropland Remaining Cropland - CO2	0.00	1.0607	0.0042	0.0245	0.74
Energy industries - CO2 solid fuels	0.08	0.0424	0.0033	0.0190	0.76
Wastewater treatment and discharge - N2O	0.00	1.0198	0.0029	0.0166	0.78
Manufacturing industries and construction - CO2 gaseous fuels	0.06	0.0424	0.0026	0.0152	0.79
Other sectors - CH4 commercial, residential, agriculture biomass	0.00	0.5009	0.0023	0.0133	0.81
Product uses as substitutes for ozone depleting substances - HFCs Fire protection	0.00	0.5831	0.0019	0.0112	0.82
Indirect N2O Emissions from Managed soils	0.00	0.5385	0.0019	0.0111	0.83
Mineral industry- CO2 Cement production	0.02	0.1044	0.0017	0.0096	0.84
Energy industries - CO2 liquid fuels	0.04	0.0424	0.0016	0.0093	0.85
Chemical industry- PFCs Fluorochemical production	0.00	0.5025	0.0016	0.0090	0.86
Land Converted to Settlements - N2O	0.00	1.0607	0.0015	0.0086	0.87
Grassland Remaining Grassland - CO2	0.00	1.0607	0.0014	0.0083	0.88
Manure Management - CH4	0.01	0.2062	0.0013	0.0077	0.883
Other sectors - CO2 commercial, residential, agriculture liquid fuels	0.03	0.0424	0.0013	0.0076	0.8906
Other sectors - N2O commercial, residential, agriculture biomass	0.00	0.5009	0.0013	0.0073	0.8979
Land Converted to Cropland - CO2	0.00	1.0607	0.0012	0.0069	0.9048
Non-Energy products from Fuels and Solvent Use - CO2	0.00	0.5831	0.0012	0.0069	0.91
Biological treatment of Solid waste - N2O	0.00	1.0198	0.0011	0.0065	0.92
Indirect N2O Emissions from Manure Management	0.00	0.5025	0.0009	0.0051	0.92
Other sectors - N2O commercial, residential, agriculture liquid fuels	0.00	0.5009	0.0008	0.0046	0.93
Product uses as substitutes for ozone depleting substances - HFCs Foam blowing agents	0.00	0.5831	0.0008	0.0046	0.93

CATEGORIES	Share	Uncertainty	L*U	Level assessment with uncertainty	Cumulative Percentage
Manufacturing industries and construction - CO2 solid fuels	0.02	0.0424	0.0008	0.0045	0.94
Transport - N2O Road transportation	0.00	0.4011	0.0007	0.0041	0.94
Manufacturing industries and construction - CO2 liquid fuels	0.02	0.0424	0.0007	0.0041	0.95
Manure Management - N2O	0.00	0.2062	0.0005	0.0032	0.95
Fugitive - CO2 Oil and natural gas - venting and flaring	0.00	0.5099	0.0004	0.0026	0.95
Other sectors - CO2 commercial, residential, agriculture other fossil fuels	0.01	0.0424	0.0004	0.0025	0.95

Table A1.12 Results of the key category analysis with LULUCF. Approach 2 Trend assessment, base year- 2016

CATEGORIES	Trend assessment	Uncertainty	T*U	Relative trend assessment with uncertainty	Cumulative Percentage
Product uses as substitutes for ozone depleting substances - HFCs Refrigeration and Air conditioning	0.02	0.5831	0.0139	0.16	0.16
Grassland Remaining Grassland - CO2	0.01	1.0607	0.0090	0.10	0.26
Land Converted to Grassland - CO2	0.01	1.0607	0.0085	0.10	0.36
Land Converted to Settlements - CO2	0.01	1.0607	0.0074	0.08	0.44
Forest Land remaining Forest Land - CO2	0.02	0.2476	0.0053	0.06	0.50
Land Converted to Forest Land - CO2	0.00	1.0607	0.0050	0.06	0.56
Energy industries - CO2 liquid fuels	0.08	0.0424	0.0034	0.04	0.60
Energy industries - CO2 gaseous fuels	0.06	0.0424	0.0027	0.03	0.63
Other sectors - CO2 commercial, residential, agriculture gaseous fuels	0.05	0.0424	0.0023	0.03	0.65
Transport - CO2 Road transportation	0.05	0.0424	0.0019	0.02	0.67
Product uses as substitutes for ozone depleting substances - HFCs Fire protection	0.00	0.5831	0.0018	0.02	0.69
Fugitive - CH4 Oil and natural gas - Natural gas	0.00	0.5009	0.0018	0.02	0.71
Solid waste disposal - CH4	0.01	0.2236	0.0017	0.02	0.73
Manufacturing industries and construction - CO2 liquid fuels	0.03	0.0424	0.0014	0.02	0.75
Other sectors - CH4 commercial, residential, agriculture biomass	0.00	0.5009	0.0013	0.01	0.77
Cropland Remaining Cropland - CO2	0.00	1.0607	0.0012	0.01	0.78
Other sectors - CO2 commercial, residential, agriculture liquid fuels	0.03	0.0424	0.0011	0.01	0.79
Biological treatment of Solid waste - N2O	0.00	1.0198	0.0009	0.01	0.80
Mineral industry- CO2 Cement production	0.01	0.1044	0.0009	0.01	0.81
Harvest Wood Products - CO2	0.00	0.5590	0.0008	0.01	0.82
Manufacturing industries and construction - CO2 solid fuels	0.02	0.0424	0.0008	0.01	0.83
Grassland Remaining Grassland - CH4	0.00	1.0607	0.0008	0.01	0.84
Enteric Fermentation- CH4	0.00	0.2022	0.0008	0.01	0.85
Product uses as substitutes for ozone depleting substances - HFCs Foam blowing agents	0.00	0.5831	0.0007	0.01	0.86
Other sectors - N2O commercial, residential, agriculture biomass	0.00	0.5009	0.0007	0.01	0.86
Chemical industry- PFCs Fluorochemical production	0.00	0.5025	0.0007	0.01	0.87
Direct N2O Emissions from Managed soils	0.00	0.5385	0.0007	0.01	0.88
Wastewater treatment and discharge - N2O	0.00	1.0198	0.0007	0.01	0.89
Chemical industry- N2O Adipic acid production	0.01	0.1044	0.0006	0.01	0.896
Energy industries - CO2 solid fuels	0.01	0.0424	0.0006	0.01	0.902
Metal industry- PFCs Aluminium production	0.00	0.2022	0.0006	0.01	0.908
Land Converted to Settlements - N2O	0.00	1.0607	0.0005	0.01	0.91
Manufacturing industries and construction - CO2 gaseous fuels	0.01	0.0424	0.0004	0.00	0.92

CATEGORIES	Trend assessment	Uncertainty	T*U	Relative trend assessment with uncertainty	Cumulative Percentage
Non-Energy products from Fuels and Solvent Use - CO2	0.00	0.5831	0.0004	0.00	0.92
Other sectors - CO2 commercial, residential, agriculture other fossil fuels	0.01	0.0424	0.0003	0.00	0.93
Transport - CH4 Road transportation	0.00	0.4011	0.0003	0.00	0.93
Manufacturing industries and construction - N2O liquid fuels	0.00	0.5009	0.0003	0.00	0.93
Chemical industry- HFCs Fluorochemical production	0.00	0.5025	0.0003	0.00	0.94
Grassland Remaining Grassland - N2O	0.00	1.0607	0.0003	0.00	0.94
Fugitive - CO2 Oil and natural gas - venting and flaring	0.00	0.5099	0.0003	0.00	0.94
Chemical industry- N2O Nitric acid production	0.00	0.1044	0.0003	0.00	0.95
Land Converted to Cropland - CO2	0.00	1.0607	0.0002	0.00	0.95
Mineral industry- CO2 Other processes uses of carbonates	0.00	0.1044	0.0002	0.00	0.95

Table A1.13 Results of the key category analysis without LULUCF. Approach 2 Level assessment, base year

CATEGORIES	Share	Uncertainty	L*U	Level assessment with uncertainty	Cumulative Percentage
Direct N2O Emissions from Managed soils	0.02	0.5385	0.0087	0.0891	0.09
Fugitive - CH4 Oil and natural gas - Natural gas	0.02	0.5009	0.0080	0.0819	0.17
Transport - CO2 Road transportation	0.18	0.0424	0.0075	0.0777	0.25
Energy industries - CO2 liquid fuels	0.16	0.0424	0.0066	0.0683	0.32
Wastewater treatment and discharge - CH4	0.01	1.0198	0.0063	0.0652	0.38
Enteric Fermentation- CH4	0.03	0.2022	0.0060	0.0622	0.44
Solid waste disposal - CH4	0.02	0.2236	0.0053	0.0542	0.50
Mineral industry- CO2 Cement production	0.03	0.1044	0.0032	0.0328	0.53
Energy industries - CO2 solid fuels	0.07	0.0424	0.0032	0.0326	0.56
Other sectors - CO2 commercial, residential, agriculture liquid fuels	0.07	0.0424	0.0031	0.0322	0.60
Other sectors - CO2 commercial, residential, agriculture gaseous fuels	0.07	0.0424	0.0030	0.0307	0.63
Manufacturing industries and construction - CO2 liquid fuels	0.07	0.0424	0.0028	0.0292	0.66
Manufacturing industries and construction - CO2 gaseous fuels	0.06	0.0424	0.0026	0.0270	0.68
Wastewater treatment and discharge - N2O	0.00	1.0198	0.0025	0.0256	0.71
Indirect N2O Emissions from Managed soils	0.00	0.5385	0.0021	0.0221	0.73
Manufacturing industries and construction - CO2 solid fuels	0.05	0.0424	0.0020	0.0210	0.75
Non-Energy products from Fuels and Solvent Use - CO2	0.00	0.5831	0.0019	0.0198	0.77
Manure Management - CH4	0.01	0.2062	0.0016	0.0161	0.79
Energy industries - CO2 gaseous fuels	0.03	0.0424	0.0014	0.0140	0.80
Indirect N2O Emissions from Manure Management	0.00	0.5025	0.0010	0.0106	0.81
Other sectors - CH4 commercial, residential, agriculture biomass	0.00	0.5009	0.0010	0.0099	0.82
Other sectors - N2O commercial, residential, agriculture liquid fuels	0.00	0.5009	0.0010	0.0099	0.83
Fugitive - CO2 Oil and natural gas - venting and flaring	0.00	0.5099	0.0009	0.0097	0.84
Manufacturing industries and construction - N2O liquid fuels	0.00	0.5009	0.0009	0.0094	0.85
Chemical industry- PFCs Fluorochemical production	0.00	0.5025	0.0009	0.0093	0.86
Chemical industry- N2O Adipic acid production	0.01	0.1044	0.0009	0.0091	0.87
Metal industry- PFCs Aluminium production	0.00	0.2022	0.0008	0.0079	0.88
Manure Management - N2O	0.00	0.2062	0.0007	0.0075	0.88
Transport - CH4 Road transportation	0.00	0.4011	0.0007	0.0069	0.892

CATEGORIES	Share	Uncertainty	L*U	Level assessment with uncertainty	Cumulative Percentage
Fugitive - CO2 Oil and natural gas - Other - flaring in refineries	0.00	0.5099	0.0007	0.0069	0.8988
Transport - N2O Road transportation	0.00	0.4011	0.0006	0.0066	0.905
Metal industry- CO2 Iron and steel production	0.01	0.1044	0.0006	0.0065	0.91
Other sectors - N2O commercial, residential, agriculture biomass	0.00	0.5009	0.0005	0.0053	0.92
Mineral industry- CO2 Other processes uses of carbonates	0.00	0.1044	0.0005	0.0053	0.92
Fugitive - CO2 Oil and natural gas - Oil	0.00	0.1044	0.0005	0.0049	0.93
Transport - CO2 Waterborne navigation	0.01	0.0424	0.0004	0.0046	0.93
Chemical industry- HFCs Fluorochemical production	0.00	0.5025	0.0004	0.0044	0.94
Rice cultivations - CH4	0.00	0.1118	0.0004	0.0042	0.94
Chemical industry- N2O Nitric acid production	0.00	0.1044	0.0004	0.0042	0.94
Chemical industry- CO2 Ammonia production	0.00	0.1044	0.0004	0.0039	0.95
Mineral industry- CO2 Lime production	0.00	0.1044	0.0004	0.0039	0.95

Table A1.14 Results of the key category analysis with LULUCF. Approach 2 Level assessment, base year

CATEGORIES	Share	Uncertainty	L*U	Level assessment with uncertainty	Cumulative Percentage
Land Converted to Settlements - CO2	0.01	1.0607	0.0127	0.0936	0.09
Grassland Remaining Grassland - CO2	0.01	1.0607	0.0101	0.0742	0.17
Direct N2O Emissions from Managed soils	0.02	0.5385	0.0081	0.0596	0.23
Fugitive - CH4 Oil and natural gas - Natural gas	0.01	0.5009	0.0074	0.0548	0.28
Transport - CO2 Road transportation	0.17	0.0424	0.0071	0.0520	0.33
Forest Land remaining Forest Land - CO2	0.03	0.2476	0.0067	0.0494	0.38
Energy industries - CO2 liquid fuels	0.15	0.0424	0.0062	0.0457	0.43
Wastewater treatment and discharge - CH4	0.01	1.0198	0.0059	0.0437	0.47
Enteric Fermentation- CH4	0.03	0.2022	0.0057	0.0416	0.51
Land Converted to Forest Land - CO2	0.00	1.0607	0.0050	0.0371	0.55
Solid waste disposal - CH4	0.02	0.2236	0.0049	0.0363	0.59
Cropland Remaining Cropland - CO2	0.00	1.0607	0.0031	0.0231	0.61
Mineral industry- CO2 Cement production	0.03	0.1044	0.0030	0.0220	0.63
Energy industries - CO2 solid fuels	0.07	0.0424	0.0030	0.0218	0.65
Other sectors - CO2 commercial, residential, agriculture liquid fuels	0.07	0.0424	0.0029	0.0216	0.68
Other sectors - CO2 commercial, residential, agriculture gaseous fuels	0.07	0.0424	0.0028	0.0205	0.70
Manufacturing industries and construction - CO2 liquid fuels	0.06	0.0424	0.0027	0.0195	0.72
Manufacturing industries and construction - CO2 gaseous fuels	0.06	0.0424	0.0025	0.0181	0.73
Land Converted to Grassland - CO2	0.00	1.0607	0.0024	0.0180	0.75
Wastewater treatment and discharge - N2O	0.00	1.0198	0.0023	0.0172	0.77
Indirect N2O Emissions from Managed soils	0.00	0.5385	0.0020	0.0148	0.78
Manufacturing industries and construction - CO2 solid fuels	0.04	0.0424	0.0019	0.0141	0.80
Non-Energy products from Fuels and Solvent Use - CO2	0.00	0.5831	0.0018	0.0132	0.81
Manure Management - CH4	0.01	0.2062	0.0015	0.0108	0.82
Grassland Remaining Grassland - CH4	0.00	1.0607	0.0013	0.0097	0.83
Energy industries - CO2 gaseous fuels	0.03	0.0424	0.0013	0.0093	0.84
Land Converted to Cropland - CO2	0.00	1.0607	0.0010	0.0075	0.85
Land Converted to Settlements - N2O	0.00	1.0607	0.0010	0.0071	0.86
Indirect N2O Emissions from Manure Management	0.00	0.5025	0.0010	0.0071	0.86
Other sectors - CH4 commercial, residential, agriculture	0.00	0.5009	0.0009	0.0066	0.87

CATEGORIES	Share	Uncertainty	L*U	Level assessment with uncertainty	Cumulative Percentage
biomass					
Other sectors - N2O commercial, residential, agriculture liquid fuels	0.00	0.5009	0.0009	0.0066	0.88
Fugitive - CO2 Oil and natural gas - venting and flaring	0.00	0.5099	0.0009	0.0065	0.88
Manufacturing industries and construction - N2O liquid fuels	0.00	0.5009	0.0009	0.0063	0.89
Chemical industry- PFCs Fluorochemical production	0.00	0.5025	0.0008	0.0062	0.895
Chemical industry- N2O Adipic acid production	0.01	0.1044	0.0008	0.0061	0.902
Metal industry- PFCs Aluminium production	0.00	0.2022	0.0007	0.0053	0.91
Manure Management - N2O	0.00	0.2062	0.0007	0.0050	0.91
Transport - CH4 Road transportation	0.00	0.4011	0.0006	0.0046	0.92
Fugitive - CO2 Oil and natural gas - Other - flaring in refineries	0.00	0.5099	0.0006	0.0046	0.92
Transport - N2O Road transportation	0.00	0.4011	0.0006	0.0044	0.93
Metal industry- CO2 Iron and steel production	0.01	0.1044	0.0006	0.0043	0.93
Harvest Wood Products - CO2	0.00	0.5590	0.0005	0.0039	0.93
Grassland Remaining Grassland - N2O	0.00	1.0607	0.0005	0.0036	0.94
Other sectors - N2O commercial, residential, agriculture biomass	0.00	0.5009	0.0005	0.0035	0.94
Mineral industry- CO2 Other processes uses of carbonates	0.00	0.1044	0.0005	0.0035	0.94
Fugitive - CO2 Oil and natural gas - Oil	0.00	0.1044	0.0004	0.0033	0.95
Transport - CO2 Waterborne navigation	0.01	0.0424	0.0004	0.0031	0.95
Chemical industry- HFCs Fluorochemical production	0.00	0.5025	0.0004	0.0030	0.95

A1.5 Uncertainty assessment (IPCC Approach 2)

Montecarlo analysis was applied in the last submissions to estimate uncertainty of some of the key categories of the Italian inventory. The description of the key categories to which the analysis was applied and the reference year are 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

Sector	***Categories***	***Key***	**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_2O 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_2O Agriculture soils	L, T	101.9	21.34
Agriculture*	Indirect N_2O from Nitrogen used in agriculture	L, T	101.9	21.67
Agriculture*	N_2O 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 the 2012 submission. The other categories have been assessed in the 2011 submission. The results of the key category analysis is therefore to be attributed to the respective annual submission**

A summary of the results is described in the following by category.
Additional information on the choice of underlying distributions of each AD, parameter and EF related to an emission estimate, and relevant statistical parameters describing each distribution are documented in an internal report.

Energy: CO_2 from stationary combustion liquid fuels

Montecarlo analysis has been carried out for CO_2 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 CO_2 emissions from stationary combustion of liquid fuels, year 2009

	Value
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.

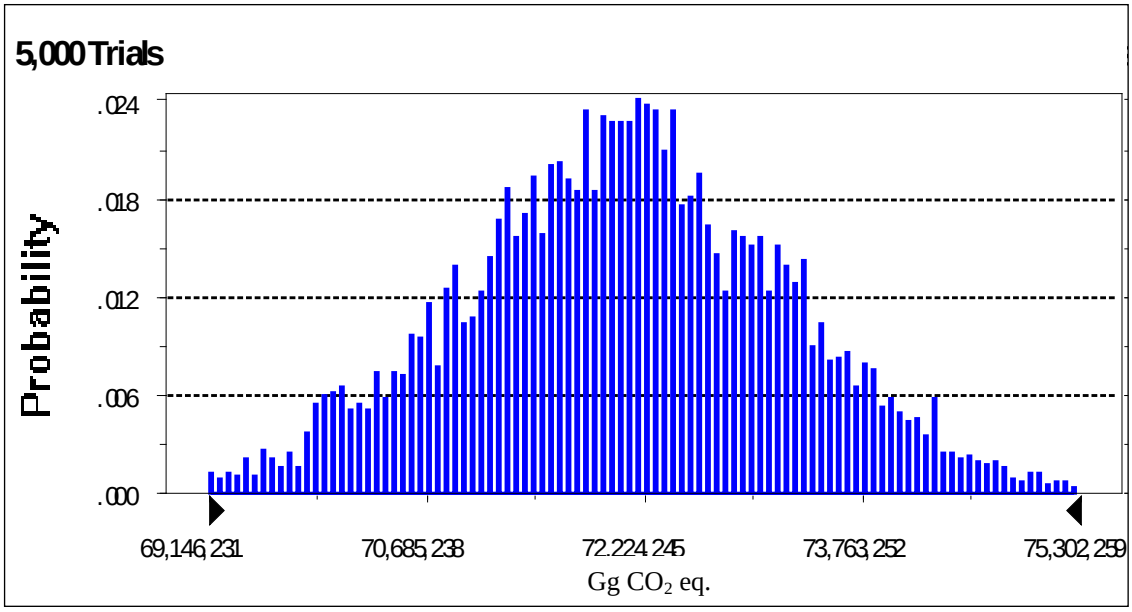


Figure A1.1 Probability density function resulting from Montecarlo analysis for CO_2 emissions from stationary combustion of liquid fuels, year 2009

Energy: CO_2 from stationary combustion solid fuels

Montecarlo analysis has been carried out for the CO_2 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 CO_2 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.

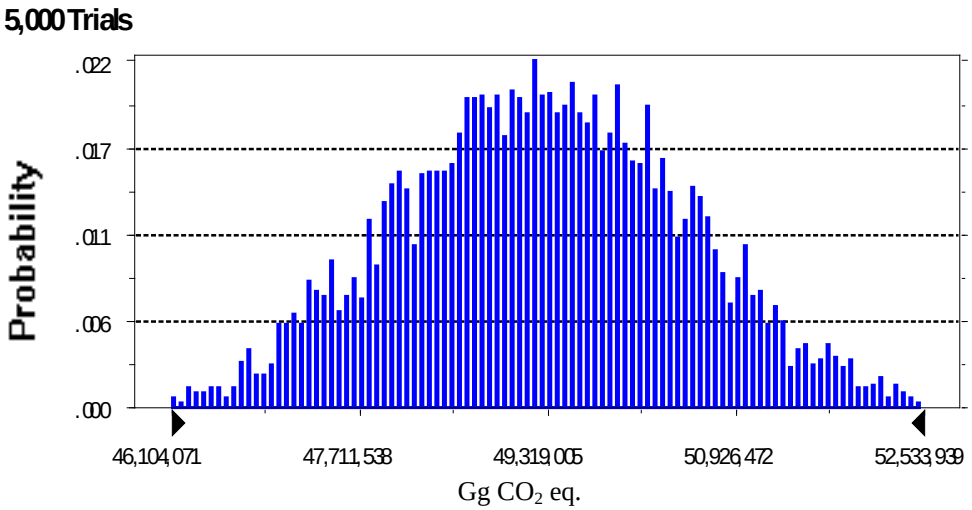


Figure A1.2 Probability density function resulting from Montecarlo analysis for CO_2 emissions from stationary combustion of solid fuels, year 2009

Energy: CO_2 from stationary combustion gaseous fuels

Montecarlo analysis has been carried out for the CO_2 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 CO_2 emissions from stationary combustion of gaseous fuels, year 2009

	Value
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.

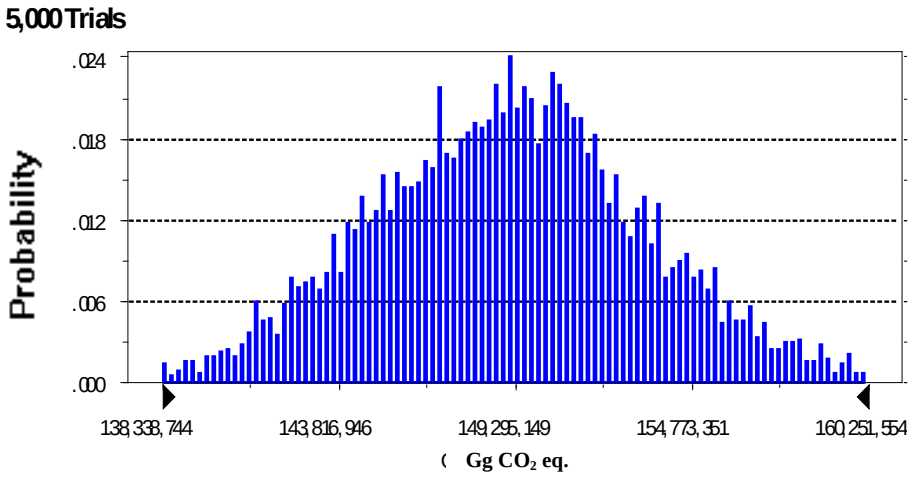


Figure A1.3 Probability density function resulting from Montecarlo analysis for CO_2 emissions from stationary combustion of gaseous fuels, year 2009

Energy: CO_2, CH_4 and N_2O Mobile combustion: Road Vehicles

Uncertainty of road transport emissions, at national level, has been assessed in the framework of study[82] "Uncertainty estimates and guidance for road transport emission calculations" performed by EMISIA[83] 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_2O
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 CO_2, CH_4 and N_2O emissions from mobile combustion, resulting from the Montecarlo assessment is shown in Figure A1.4.

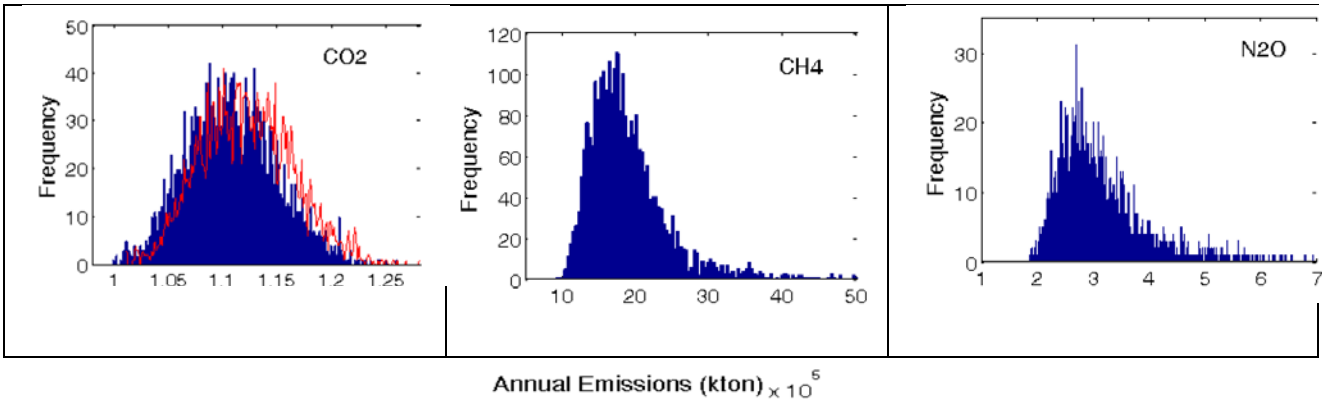


Figure A1.4 Probability density function resulting from Montecarlo analysis for CO_2, CH_4 and N_2O emissions from Mobile combustion: Road Vehicles, year 2005 (Kouridis et al., 2010)

Industrial Processes: CO_2 from Cement production

Montecarlo analysis has been carried out for the CO_2 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 CO_2 emissions from cement production, year 2009

	Value
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**

[82] 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

[83] EMISIA: www.emisia.com

The probability density function resulting from the Montecarlo assessment is shown in Figure A1.5.

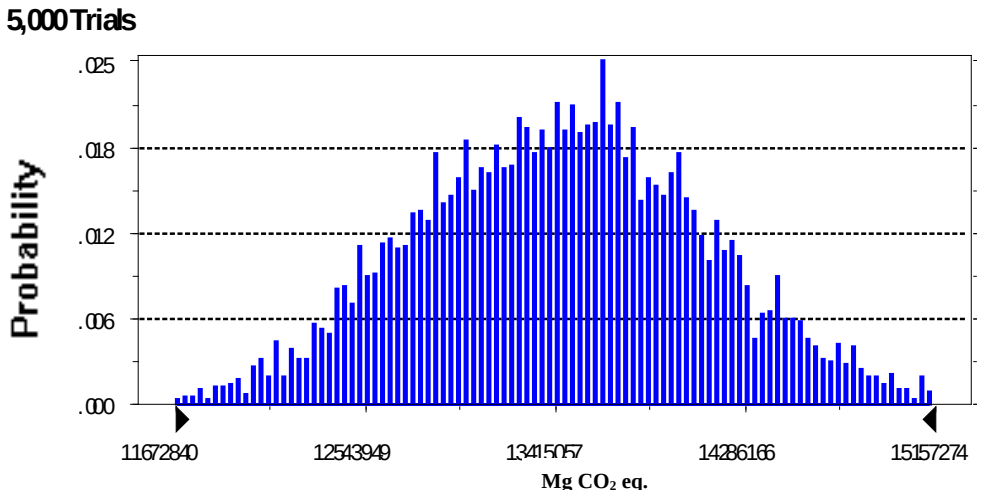


Figure A1.5 Probability density function resulting from Montecarlo analysis for CO_2 emissions from cement production, year 2009

Energy: CH_4 Fugitive emissions from Oil and Gas Operations

Montecarlo analysis has been carried out for CH_4 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 CH_4 from fugitive emissions, year 2009

	Value
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.

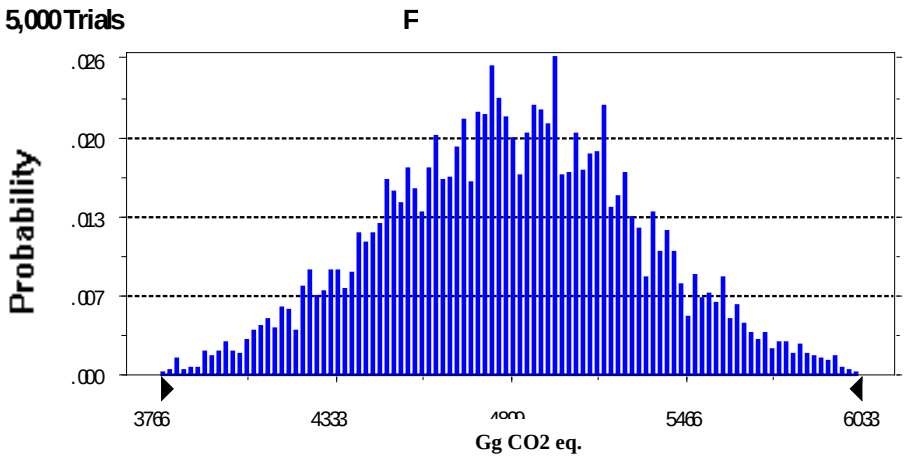


Figure A1.6 Probability density function resulting from Montecarlo analysis for CH_4 from fugitive emissions, year 2009

Agriculture: CH_4 Enteric Fermentation in Domestic Livestock

Montecarlo analysis has been carried out for the CH_4 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 CH_4 emissions from enteric fermentation, year 2009

	Value
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.

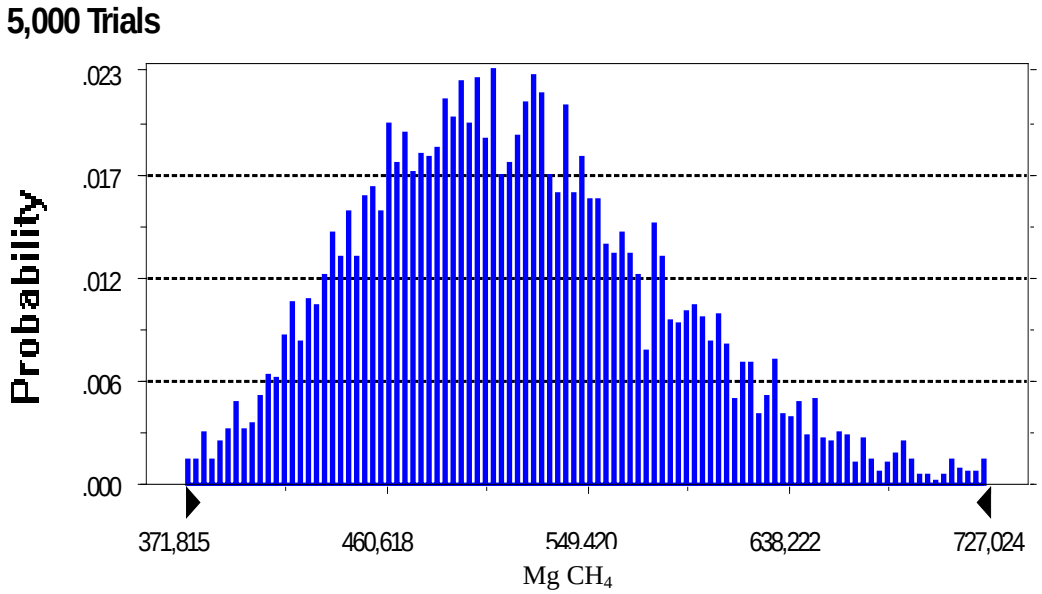


Figure A1.7 Probability density function resulting from Montecarlo analysis for CH_4 emissions from enteric fermentation, year 2009

Agriculture: Direct N_2O Agriculture soils

Montecarlo analysis has been carried out for the Direct N_2O 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 N_2O Agriculture soils emissions, year 2010

	Value
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.

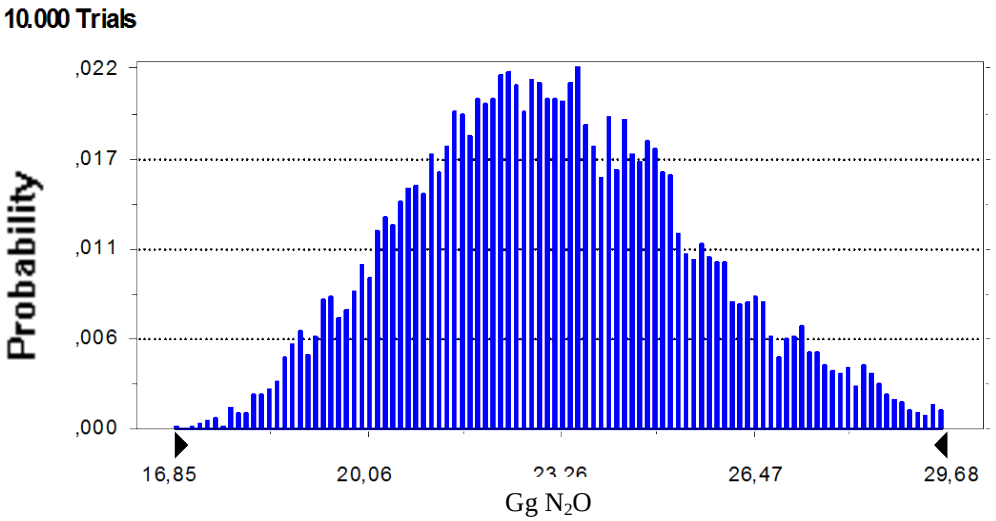


Figure A1.8 Probability density function resulting from Montecarlo analysis for Direct N_2O Agriculture soils emissions, year 2010

Agriculture: Indirect N_2O from Nitrogen used in agriculture

Montecarlo analysis has been carried out for the indirect N_2O 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 N_2O emissions from nitrogen used in agriculture, year 2010

	Value
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.

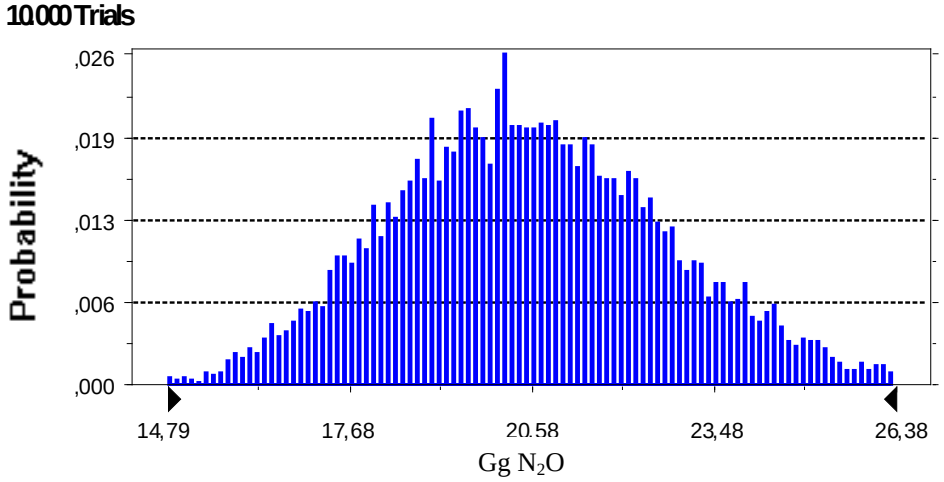


Figure A1.9 Probability density function resulting from Montecarlo analysis for indirect N_2O emissions from nitrogen used in agriculture, year 2010

Agriculture: N_2O manure management

Montecarlo analysis has been carried out for N_2O 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 N_2O emissions from Manure management, year 2010

	Value
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.

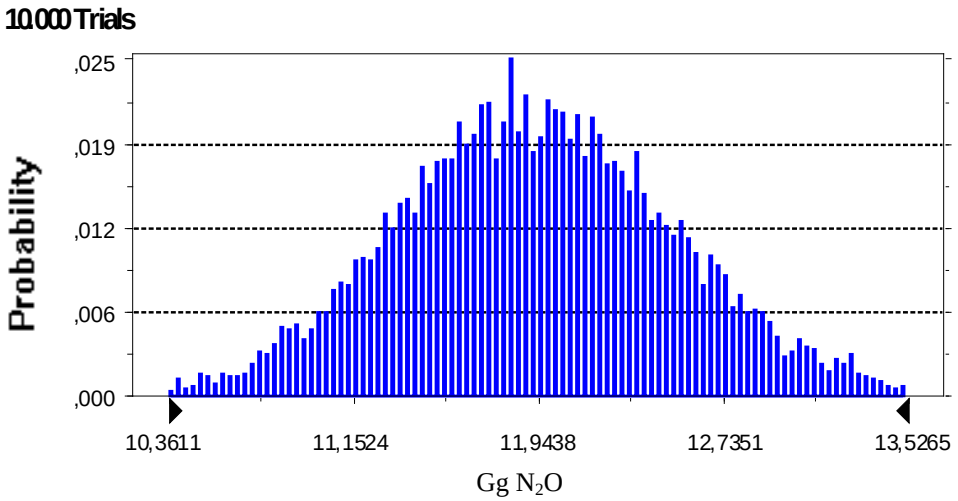


Figure A1.10 Probability density function resulting from Montecarlo analysis for N_2O emissions from Manure management, year 2010

Agriculture: CH_4 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 CH_4 emissions from enteric fermentation, year 2010

	Value
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.

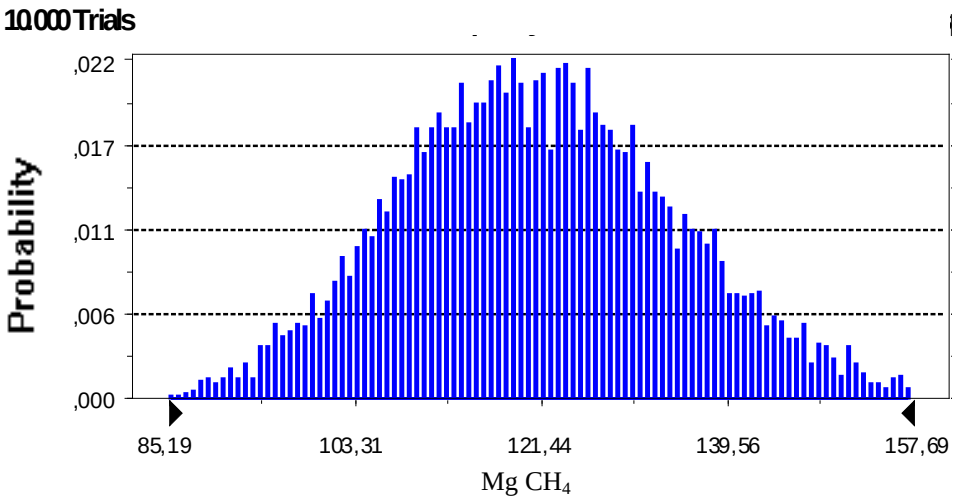


Figure A1.11 Probability density function resulting from Montecarlo analysis for CH_4 emissions from enteric fermentation, year 2010

LULUCF: CO_2 Forest Land remaining Forest Land

Montecarlo analysis has been carried out for the **CO_2** 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 CO_2 emissions and removals from Forest Land remaining Forest Land, year 2009

	Value					
	aboveground	*belowground*	*litter*	*deadwood*	*soils*	**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

	aboveground	*belowground*	*litter*	*deadwood*	*soils*	*total*
Stands	40.78	39.93	88.16	39.32	44.65	**41.91**
Coppie	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.

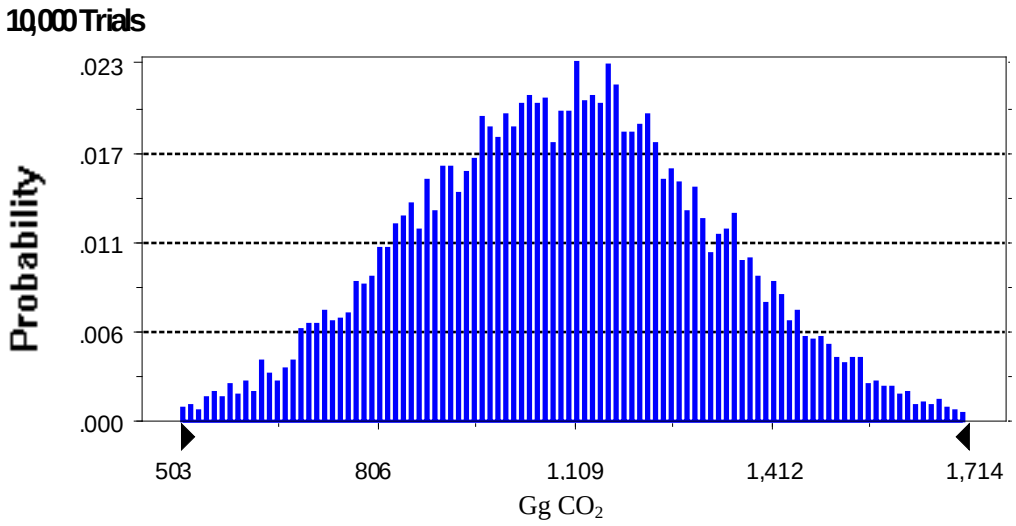


Figure A1.12 Probability density function resulting from Montecarlo analysis for the CO_2 emissions and removals from Forest Land remaining Forest Land category, year 2009

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

	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: CO_2 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					
	aboveground	*belowground*	*litter*	*deadwood*	*soils*	**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.

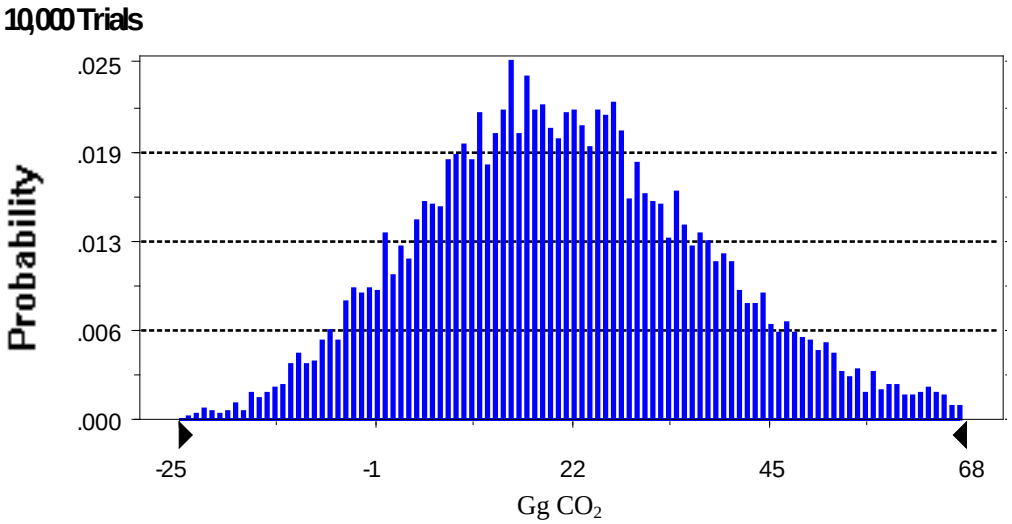


Figure A1.13 Probability density function resulting from Montecarlo analysis for the Land converting to Forest Land, year 2009

LULUCF: CO_2 Cropland remaining Cropland

For CO_2 emissions and removals from Cropland remaining Cropland, Approach 2 has been carried out taking into account the reporting subcategories (*woody crops*, *plantations*, *CO_2 emissions from organic soils*, *CO_2 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 CO_2 emissions and removals from Cropland remaining Cropland, year 2009

	Value				
	woody crops	*plantations*	*CO_2 emissions from organic soils*	*CO_2 emissions from lime application*	**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.

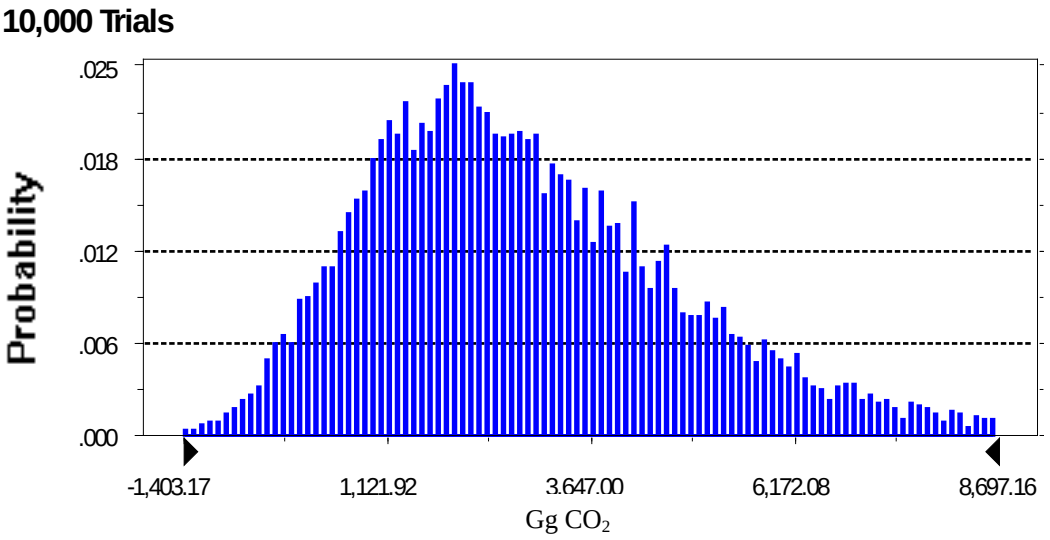


Figure A1.14 Probability density function resulting from Montecarlo analysis for the CO_2 emissions and removals from Cropland remaining Cropland, year 2009

LULUCF: CO_2 Land converting to Cropland

For CO_2 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 CO_2 emissions and removals from *Land converting to Cropland*, year 2009

	Value		
	Living biomass	*Soils*	**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.

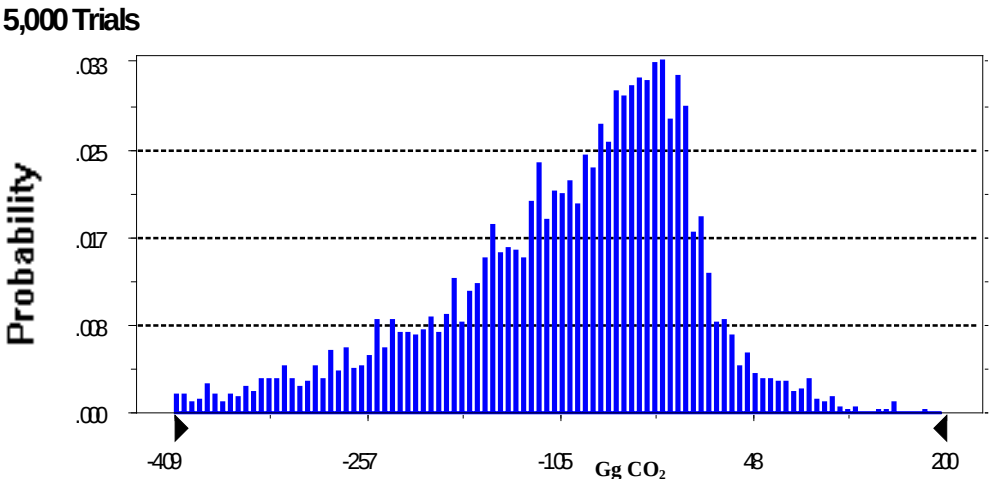


Figure A1.15 Probability density function resulting from Montecarlo analysis for CO_2 emissions and removals from Land converting to Cropland, year 2009

LULUCF: CO_2 Grassland remaining Grassland

For CO_2 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 CO_2 emissions and removals from Grassland remaining Grassland, year 2009

	Value					
	aboveground	*belowground*	*litter*	*deadwood*	*soils*	**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.

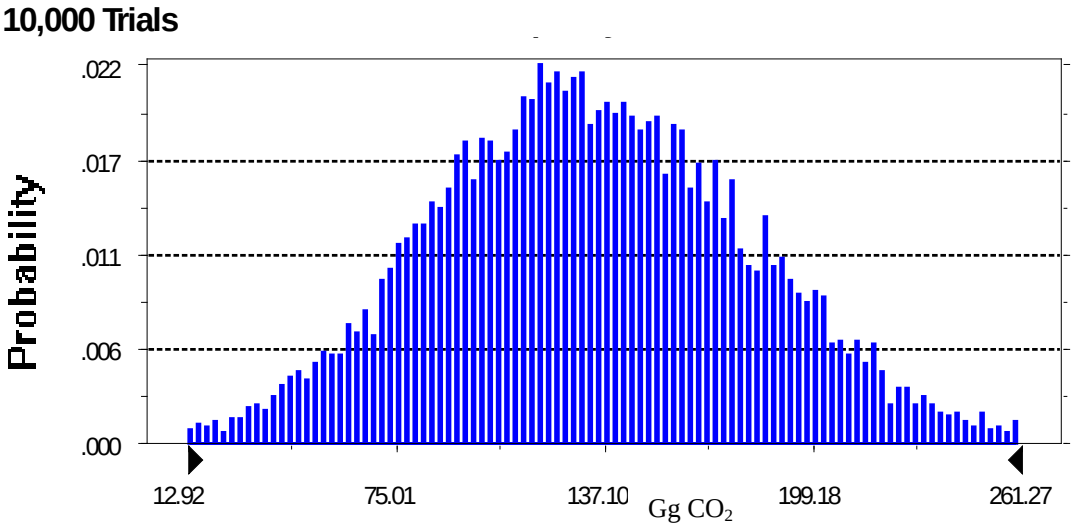


Figure A1.16 Probability density function resulting from Montecarlo analysis for CO_2 emissions and removals from Grassland remaining Grassland, year 2009

LULUCF: CO_2 Land converting to Grassland

For CO_2 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 CO_2 emissions and removals from Land converting to Grassland, year 2009

	Value		
	Living biomass	*Soils*	**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.

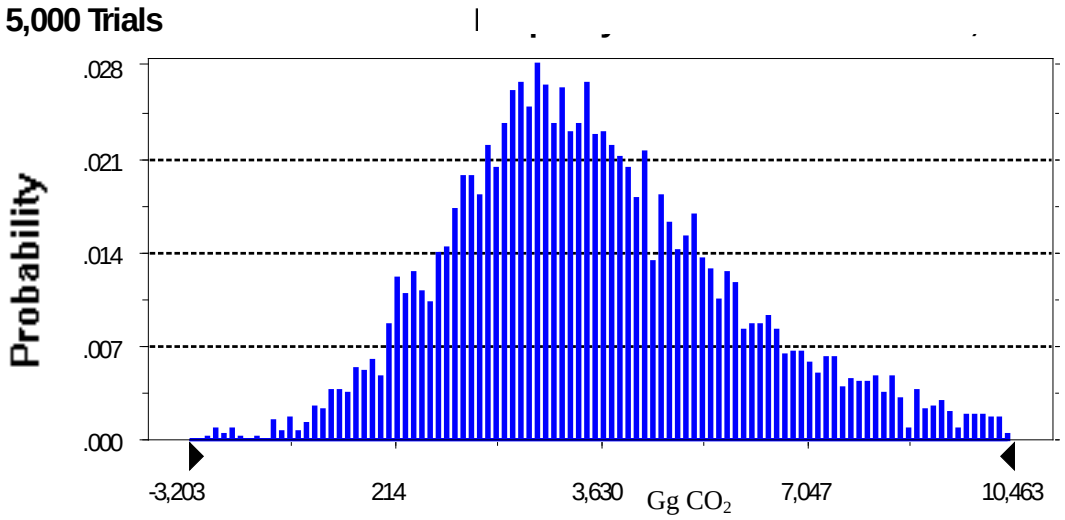


Figure A1.17 Probability density function resulting from Montecarlo analysis for the CO_2 emissions and removals from Land converting to Grassland, year 2009

LULUCF: CO_2 Land converting to Settlements

For CO_2 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 CO_2 emissions from Land converting to Settlements, year 2009

	Value				
	Annual crops to SL	*woody crops to SL*	*Grassland to SL*	*Forest land to SL*	**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

	living biomass %	**dead organic matter %**	**Soils %**	**Total %**
annual crops to SL	*-300.9; 75.5*	-	*-267.1; 72.0*	*-262.1;72.0*
woody crops to SL	*-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.

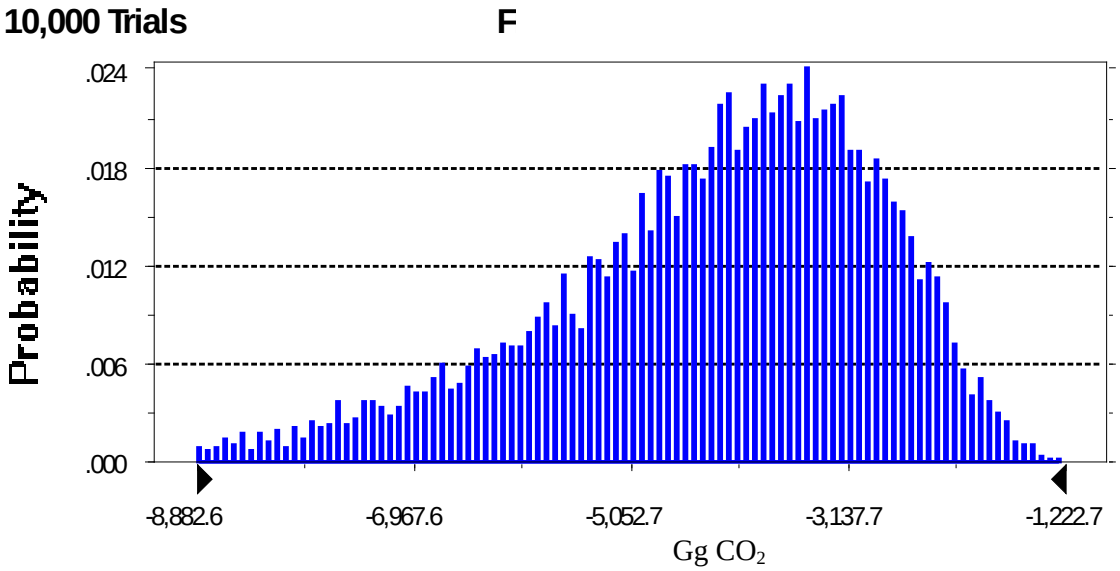


Figure A1.18 Probability density function resulting from Montecarlo analysis for the CO_2 emissions from Land converting to Settlements, year 2009

Waste: CH_4 from Solid waste Disposal Sites

Montecarlo analysis has been carried out for the CH_4 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

	Value
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.

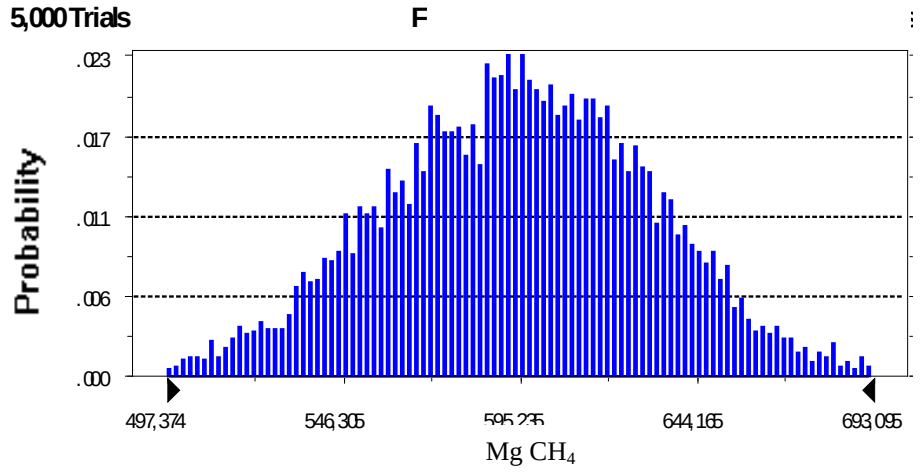


Figure A1.19 Probability density function resulting from Montecarlo analysis for the Solid waste disposal on land category, year 2009

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, several years), 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 Mm^3

	1990	1995	2000	2005	2010	2013	2014	2015	2016
national coal	58	-	Solids	Solids	Solids	Solids	Solids	Solids	Solids
imported coal	10,724	8,216	9,633	16,253	14,998	16,714	16,099	16,245	13,301
lignite	1,501	380							
Natural gas, m^3	9,731	11,277	22,334	30,544	29,630	20,371	17,677	20,365	23,114
BOF(steel converter) gas, m^3	509	633	Coal Gases	Coal Gases	Coal Gases	Coal Gases	Coal Gases	Coal Gases	Coal Gases
Blast furnace gas, m^3	6,804	6,428	8,690	12,104	8,822	5,933	6,093	3,658	5,051
Coke gas, m^3	693	540							
Light distillate	5	6	Oil products	Oil products	Oil products	Oil products	Oil products	Oil products	Oil products
Diesel oil	303	184	19,352	7,941	2,152	1,102	1,069	1,133	775
Heavy fuel oil	21,798	25,355							
Refinery gas	211	378							
Petroleum coke	186	189							
Gases from chemical processes	444	803	Others	Others	Others	Others	Others	Others	Others
Tar	2	-		Mm^3=978	Mm^3=1,501	Mm^3=3,391	Mm^3=3,627	Mm^3=3,509	Mm^3=3,523
Heat recovered from Pyrite	146	3		Gg= 15,460	Gg= 18,160	Gg= 16,821	Gg= 16,960	Gg= 16,257	Gg= 16,815
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 2016, becoming the main fuel for electricity production while coal consumption has 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 2012. 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 2016, 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, and reported under other fuels, since the use of this fuel for electricity generation is expanding and emission factors 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, usually 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.

The other two statistical publications quoted before, UP (UP, several years) and ENI (ENI, several years), have direct access to fuel consumption data from the associated companies, but both rely on TERNA data for the complete picture. Data from those two sources are used for cross checking and estimation of point source emissions.
To estimate CO_2 emissions, and also N_2O and CH_4 emissions, a rather complex calculation sheet is used (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 CO_2 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; same 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.

Table A2.2 reports the differences between the model and TERNA data for 2016.
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 2016

Fuels	**TERNA**			**Model**		
	GWe, gross	Gg / Mm^3	Pj	GWe, gross	Gg/ Mm^3	Pj
Coal	35,607.7	13,301	335.3	35,608.1	12,812	335.3
Coke oven gas	828.8	290	7.1	761.6	370	6.6
Blast furnace gas	1,687.9	3,027	14.5	2,026.7	4,583	17.3
Oxi converter gas	318.2	342	3.0	0.0		0.0
Total derived gases	2,831.9	5,051	24.2	2,788.4	4,953	23.9
Coal	**38,439.6**		**359.5**	**38,396.5**		**359.1**
Light distillates	3.4	0	0.02	0.0	0	0.0
Light fuel oil	382.5	104	4.4	433.7	99	4.2
Fuel oil - high sulfur content	2,199.6	791	32.5	8,723.3	1,465	60.1
Fuel oil - low sulfur content	0.0		0.0	420.9	75	3.1
Refinery gas	1,493.7	228	10.8	1,979.1	241	12.1
Petroleum coke	41.3	9	0.3	0.0	0	0.0
Oriemulsion	0.0	0	0.0			
total fuel oil	*4,126.7*		*33.5*	*11,557.0*	*1,880*	*79.5*
Gas from chemical proc.	407.0	739	4.0	1,405.8	1,259	13.1
Heavy residuals/ tar	7,196.0	5,143	43.4			
Others	636.1		0.3			
total residual	*8,239.1*		*47.6*	*1,405.8*		*13.1*
Oil+residuals	**12,365.8**		**81.2**	**12,962.8**		**92.6**
Natural gas	**126,148.0**	23,114	**803.5**	**126,147.7**	23,433	**803.5**
Biofuels	4,709.8	1,017	37.2			37.2
Biogas	7,939.4	2,784	63.7			63.7
Biomass	4,089.0	3,833	46.6	4,406.6	5,971	52.7
Municipal waste	5,002.4	5,495	63.7	4,868.6	5,954	62.3
Grand total	**198,694**		**1,455.4**	**199,431**		**1,471.2**
TERNA /BEN differences				-0.4%		-1.1%

Source: ISPRA elaborations

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 2016. 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/CO_2 emissions in CRF format, year 2016

	TJ	C, Gg	CO_2, Gg
For Table 1.A.1, a. Public Electricity and Heat Production			
Liquid fuels	57,125	1,307	4,789
Solid fuels	334,573	8,595	31,492
Natural gas	700,354	10,893	39,911
Refinery gases	6,722	80	292
Coal gases	11,936	600	2,199
Biomass	179,586	4,944	18,117
Other fuels (incl.waste)	34,548	897	3,285
Total	**1,324,843**	**22,371**	**81,968**
Industrial producers (Table 1.A.1, a-b-c) and auto-producers, to table "1.A.2 Manufacturing Industries "			
Liquid fuels	2,468	52	192
Solid fuels	8	0	1
Natural gas	106,079	1,650	6,045
Refinery gases	3,077	36	134
Other refinery products	15,050	367	1,345
Coal gases	15,441	776	2,844
Biomass			
Other fuels (incl.waste)	899	13	46
Total	**143,020**	**2,895**	**10,607**
General total	**1,467,864**	**25,266**	**92,575**

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 TERNA 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, the inventory has been based on TERNA data that are expected to be more reliable. In particular because the emission factors used are based on the energy content of the fuel, the model has been used to reproduce with the TERNA energy consumption figures ignoring discrepancies in the electricity production or in the physical quantities of fuel used. Further, in 2018 MSE provided detailed TERNA data for 2016 straight to ISPRA in order to allow the overcoming of discrepancies.

A2.3 Uncertainty and time-series consistency

The combined uncertainty in CO_2 emissions from electricity production is estimated to be about 4.2% in annual emissions; a higher uncertainty, equal to 50.1%, is calculated for CH_4 and N_2O 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 CO_2 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 2016 are reported in Table A2.3.
In Table A2.4, the time series of the total CO_2 emissions from electricity generation activities is reported, including total electricity produced and specific indicators of CO_2 emissions for the total energy production and for the thermoelectric production respectively, expressed in grams of CO_2 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 starting from 2005 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 the last years the decrease is even more accentuated because of the economic recession. In 2016 a decrease in CO_2 emissions is observed, although an increase of total energy demand and production, as a consequence of the shift from coal to natural gas; energy production from renewable sources in 2016 are at the same level of the previous year.

Table A2.4 Time series of CO_2 emissions from electricity production

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Total electricity produced (gross), TWh	216.9	241.5	276.6	303.7	302.1	302.6	299.3	289.8	279.8	283.0	289.8
Total CO_2 emitted, Mt	126.2	133.2	139.2	144.0	120.4	118.5	114.3	97.2	89.9	93.4	92.5
g CO_2 / kwh of gross thermo-electric production	708	681	634	571	522	521	527	506	512	488	466
g CO_2 / kwh of total gross* production	592	561	516	485	403	394	384	338	323	332	321

* excluding electricity production from pumped storage units using water that has previously been pumped uphill
Source: ISPRA elaborations

The trend of CO_2 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

Recalculation occurred because of the update of the energy conversion factor according to the international statistics which resulted in the update of energy fuel consumption and of national emission factors for natural gas from 2008, coal and petcoke from 2013, carbon coke and coke oven coke from 2005. Detailed information is reported in Annex 6.

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 issue 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 sector.
Another specific national circumstance is the concentration of steel works in two sites, since the year 2005, with integrated steel plants, coke ovens and electricity self-production and just in one site since 2015. 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 2006 IPCC Guidelines (IPCC, 2006), 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.
Until the 2016 submission, 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 that seldom presents problems, and then apply the 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.
Starting from the 2017 submission, data submitted by the Ministry of Economic Development to the Joint Questionnaire IEA/OECD/EUROSTAT have been used and this required specific meetings and additional verification activities in order to make the transition to the new data format, so in 2017 submission it was not yet possible to reconstruct the entire time series and only 2015 data were used. In the current submission the complete time series, from 1990 to 2015, of solid fuel consumptions and relevant calorific values have been updated on the basis of figures submitted by the Ministry of Economic Development to the Joint Questionnaire IEA/OECD/EUROSTAT. This required a considerable amount of work for the comprehension and reconstruction of trends. Consequently, this process involved significant changes, especially in the nineties, some of which are still under investigation thanks to the collaboration with the Ministry of Economic Development.

Table A3.1 summarises the quantities of coal and coal by-products used by the energy system in the year 2016; all the data mentioned are those provided by the Ministry of economic development to the the Joint Questionnaire IEA/OECD/EUROSTAT for the same year.
In Table A3.1 the quantities of coke, coke gas and blast furnace gas used by the different sectors are detailed as well as the quantities of the same energy carriers that are self-used, used for the production of coke or wasted. Inputs are indicated in the blue cells while outputs are reported in the orange ones.

Table A3.1 Energy balance, 2016, TJ

	TJ input	TJ output	
steam coal	361,633	9,419	clinker/industry
		330,851	thermoelectric power plants
		21,362	blast furnace
anthracite	960	960	steel plants
sub bituminous and lignite	331	331	clinker/industry
coking coal	75,601	0	coking coal consumption
			Non-energy use in other sectors
Coke import/export/stock change	14,497		
coke		0	other industry and domestic
			ferroalloys
		52,541	blast furnace consumption
coke oven gas		177	coke oven gas in coke oven and blast furnace
		4,504	coke oven gas reheating
		8,374	coke oven gas thermoelectric
blast furnace gas		0	BF gas in coke oven
		23,686	BF gas thermoelectric
		23	BF gas reheating
BOF gas		92	coal gasses in thermoelectric + reheating
			carbon stored in products
tot	**453,022**	**452,321**	**Input – output= 701 TJ unbalance: 0.16%**

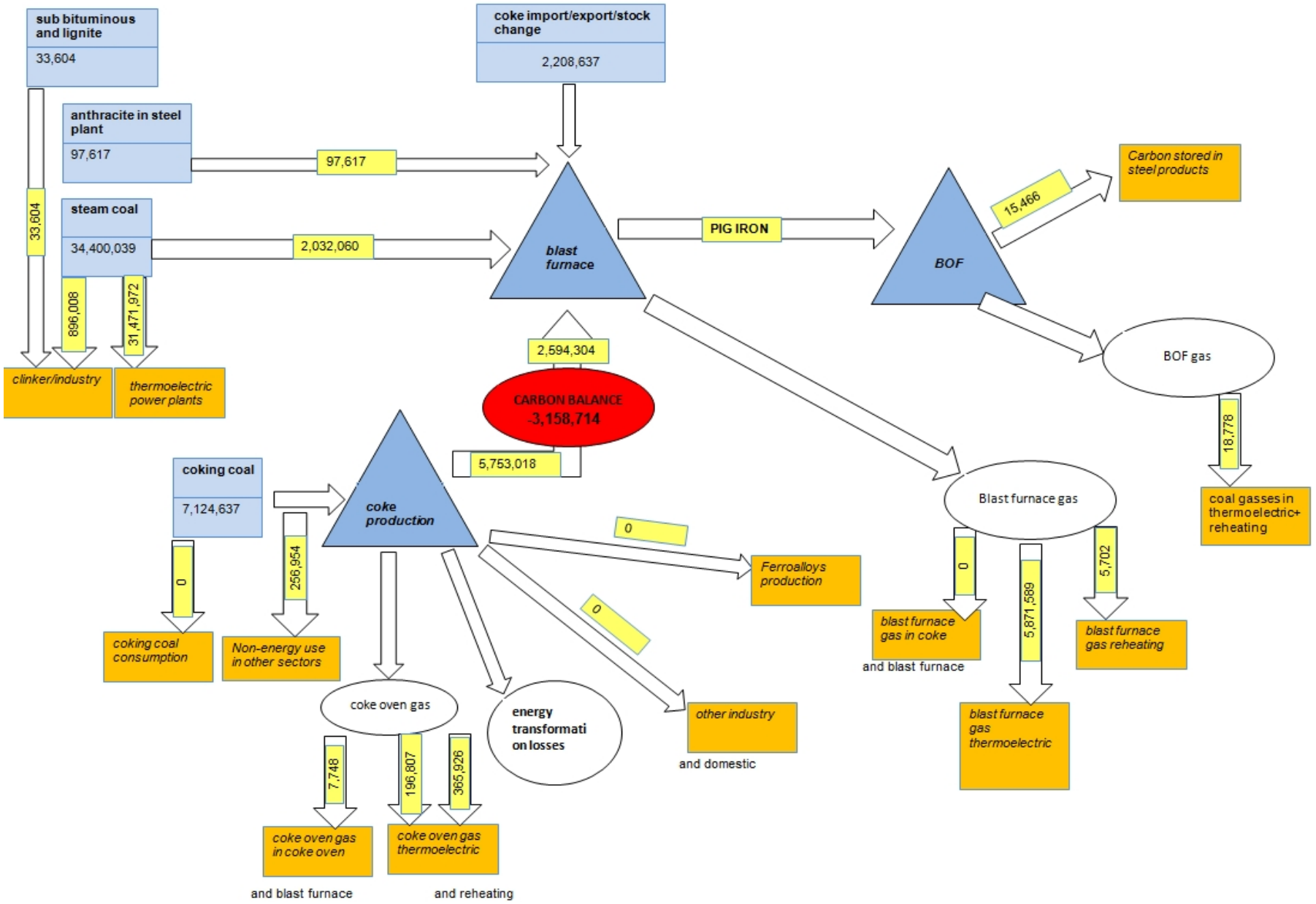
In Table A3.2, the same energy data of Table A3.1 valuated for their carbon content are reported, according to the emission factors reported in Table 3.12 of the NIR.
The balance is the resulting quantity of emissions after subtraction of carbon emissions estimated for coke ovens, electricity production, other coal uses and non energy uses.
The low implied emission factors in CRF and annual variations in the average CO_2 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.
All main installations of the iron and steel sector 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. Additional information from the operators on fuel consumptions and average emission factors is used to verify our calculation and CO_2 emissions at plant level and to calculate average CO_2 emission factors for coal and derived gases from 2005; obviously from the 2015 submission emission factors have been updated on the basis of 2006 IPCC Guidelines, see Annex 6 for further details.

Table A3.2 Carbon balance, 2016, Gg CO_2

	input	output	
steam coal	34,400,039	896,008	clinker/industry
		31,471,972	thermoelectric power plants
		2,032,060	blast furnace
anthracite	97,617	97,617	steel plants
sub bituminous and lignite	33,604	33,604	clinker/industry
coking coal	7,124,637	0	coking coal consumption
		256,954	Non-energy use in other sectors
coke import/export/stock change	2,208,637		
coke		0	other industry and domestic
		0	ferroalloys
		5,753,018	blast furnace consumption
coke oven gas		7,748	coke oven gas in coke oven and blast furnace
		196,807	coke oven gas reheating
		365,926	coke oven gas thermoelectric
blast furnace gas		0	BF gas in coke oven
		5,871,589	BF gas thermoelectric
		5,702	BF gas reheating
BOF gas		18,778	coal gasses in thermoelectric + reheating
		15,466	carbon stored in products
tot	**43,864,534**	**47,023,248**	**Input-output=-3,158,714 Gg CO_2 unbalance -6.72%**

In 2016 the unbalance in terms of CO_2 is equal to 3,158,714 Gg; this amount has been subtracted from the total to avoid double counting of carbon.The flowchart of carbon - cycle for the year 2016 is reported below. CO_2 emissions from primary input fuels and from final fuel consumptions are compared. Emissions related to fuel input data are enhanced in light-blue whereas emissions estimated from final fuel consumptions are highlighted in orange. 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 2016. The amount of carbon stored in steel produced was estimated and subtracted from the balance to avoid the subsequent overestimation of CO_2 .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.

CO_2 emission calculation (Gg) Year 2016



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, 2006); table 1.A(b) of the Common Reporting Format "Sectoral background data for energy - CO_2 from Fuel Combustion Activities - Reference Approach" is a self sustaining explanation of the methodology.
However it was necessary to make a few adaptations to allow full use of 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, for an example of the year 2016 and the web site of the Ministry of Economic Development for the whole time series http://dgerm.sviluppoeconomico.gov.it/dgerm/. For the reference approach, as for the inventory, data submitted by the Ministry of Economic Development to the Joint Questionnaire IEA/OECD/EUROSTAT have been used for solid fuels. At the time it was not possible to reconstruct the entire time series for all the fuels, but the complete use of the energy data provided by the MSE to the Joint Questionnaire is planned in substitution of the national energy balances.

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 paragraph 3.8 and directly subtracted to the emission balance. 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 matter[84];

[84] 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

6) all coal data are available in the Joint Questionnaire IEA/OECD/EUROSTAT;
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 sources not accounted for in the IPCC Reference Approach, as Offshore flaring and well testing and non-fuel industrial processes, and so gives a higher estimate of CO_2 emissions.

First of all, the IPCC Reference total CO_2 can be compared with the CRF Table 1A total. Results show the IPCC Reference totals are between +0.5 and -3.4 percent with respect to the comparable 'bottom up' totals.

Differences are observed both for energy and emissions and in particular for liquid fuels. Quality control activities have been done and a detail explanation of them will require specific meetings and additional verification activities with the energy experts responsible for the official communication of the energy statistics in order to make the transition to the new data format for the whole time series.

For 1990-2016 the highest differences between the two approaches are observed in 1999 and 2000 and are higher than 2%; input data have been checked in details, the difference could be attributed to a 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, till 2006, 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 CO_2 emission estimates 1990-2016 (Mt) and percentage differences

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Sectoral approach	405.6	419.7	440.9	463.2	400.0	388.9	370.6	343.6	329.8	337.4	332.4

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.

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Reference approach	398.8	409.5	425.9	453.4	401.5	390.9	371.5	343.0	321.7	327.6	330.5
Δ %	-1.66	-2.43	-3.40	-2.11	0.40	0.50	0.22	-0.18	-2.45	-2.91	-0.59

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 no energy use of fuel where they can be specifically identified and estimated such as with fertilizer production and iron and steel production. The IPCC Reference approach implicitly treats the non-energy use of fuel as if it were combustion. A correction is then applied by deducting an estimate of carbon stored from non-energy fuel use. The carbon stored is estimated from an approximate procedure which does not identify specific processes. The result is that the IPCC Reference approach is based on a higher estimate of non-energy use emissions than the 'bottom-up' approach.

The IPCC Reference Approach uses data on primary fuels such as crude oil and natural gas liquids which are then corrected for imports, exports and stock changes of secondary fuels. Thus the estimates obtained will be highly dependent on the default carbon contents used for the primary fuels.
The 'bottom-up' approach is based wholly on the consumption of secondary fuels where the carbon contents are known with greater certainty. In particular the carbon contents of the primary liquid fuels are likely to vary more than those of secondary fuels. Carbon content of solid fuels and of natural gas is quite precisely accounted for.
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.

A4.3 Comparison of the the sectoral approach with the reference approach and international statistics

A verification of national energy balance and CO_2 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 CO_2 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. 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 review process and corrected in the following submission. In terms of CO_2 emissions, for Italy the comparison results in a difference in total equal to 2% in 2009, with higher differences for solid and other fuels.

ANNEX 5: NATIONAL ENERGY BALANCE, YEAR 2016

The official national energy balance (BEN) from the year 1998 onwards is available, in Italian, on the website of the Italian Ministry of the Economic Development (MSE): http://dgsaie.mise.gov.it/dgerm/ben.asp/. At the same web address data communicated by Italy to the Joint Questionnaire OECD/IEA/EUROSTAT are available in the format revisited by EUROSTAT. Some differences between data communicated to the international organizations and EUROSTAT publication have been observed and are under investigation; they should mainly due to the use of default instead of country specific energy conversion factors and different classification criteria of fuels.

For 2016, data submitted by the Ministry of Economic Development to the Joint Questionnaire IEA/OECD/EUROSTAT have been used, in particular for solid fuel consumptions, and fuel consumption in transport and other non industrial sectors. At the time it was not possible to reconstruct the entire time series and data from national energy balance (BEN) have been also used for the all time series; moreover the complete use of the energy data provided by the MSE to the Joint Questionnaire is planned in substitution of the national energy balances.

The national energy balance consists of two "sets" of tables fuel consumptions expressed in physical quantities (Gg or Mm^3) and in energy equivalents (10^9 kcal). In the annex, tables reproduce only figures expressed in amount of energy equivalents for the year 2016 (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 Mm^3. 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 2016, Primary fuels, 10^9 kcal

BALANCE	PRIMARY SOURCES															
	Coking coal	Steam coal	Coal other uses	Lignite	Subproducts (a)	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy	Geothermal Energy	Wind and Photovoltaic Energy	Waste	Wood	Biomass	Biodiesel	TOTAL PRIMARY SOURCES
Conversion factor (c)	7,400	6,250	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 (d)	0	0	0	0	3.123	47.379	37.460	29.040	93.350	13.835	87.545	14.886	51.813	36.684	5.402	420.5
2. IMPORTS	17.871	89.025	333	5	0	534.676	608.780	63.280	0	0	0	0	12.068	0	7.111	1.333.1
3. EXPORTS	0	0	0			1.736	6240	11640					258	0	2.047	21.9
4. Stock changes (e)	-185	-1.950	30	0	0	-475	-5.860	-1.370	0	0	0	0	0	0	-28	-9.8
5. TOTAL RESOURCES	18.056	90.975	303	5	3.123	580.794	645.860	82.050	93.350	13.835	87.545	14.886	63.623	36.684	10.494	1.741.5
6. Transformations (Enclosure 1/a)	18.056	80.078		0	3.122	191.919	727.910	0	93.350	13.835	87.545	14.886	50	36.684	0	1.267.4
7. Consumptions and Losses (Encl.2/a)	0		1	0	1	16.664	0	0	0	0	0	0	0	0	1	16.6
8. Final Consumptions (Enclosure 3/a)	0	10.897	302	5	0	372.211	0	0				0	63.572	0	10.493	457.4
a) Agriculture	0	0	0	0	0	1.302	0	0	0	0	0	0	350	0	0	1.6
b) Industry	0	10.897	302	5	0	119.051		0				0	1.218	0	0	131.4
c) Services						8.935		0					0		10.493	19.4
d) Domestic and civil uses			0	0		236.396		0					62.004		0	298.4
Total (a+b+c+d)	0	10.897	302	5	0	365.684		0				0	63.572	0	10.493	450.9
e) Non energy uses						6.527	0	0	0	0	0	0	0	0	0	6.5
TOTAL ENERGY CONSUMPTIONS (7+8)	0	10.897	303	5	1	388.875	0	0	0	0		0	63.573	0	10.494	474.1
9. Non energy final uses																
10. BUNKERS																
12. TOTAL USES	18.056	90.975	303	5	3.123	580.794	727.910	0	93.350	13.835	87.545	14.886	63.623	36.684	10.494	1.741.5

(a) - Including secondary products, heat recovered, oxygen furnace gas and compressed gas expansion evaluated at the thermic equivalent of 2200 kcal/kWh, used by electric energy production

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

(d) - Oil products include: returns from petrochemical industry, some reclassification of feedstocks and regeneration of lubricant oils

(f) - Residual gases of chemical processes have been included.

Table A5.2 -National Energy Balance, year 2016, Secondary fuels, 10^9kcal

BALANCE	SECONDARY SOURCES																		
	Electric Energy	Char- coal	Coke	Coke oven gas	Blast furnace Gas	Non energy use of coal products	Gas works Gas	L. P. G.	Refinery gas (f)	Light Distillates (naphtha)	Gasoline	Jet fuel	Kerosene	Gas Oil / Diesel Oil	Residual Oil, HS	Residual Oil, LS	Petroleum Coke	Non energy use of petroleum products	TOTAL SECONDARY SOURCES
Conversion factor (c)	0,860	7,500	6,900	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	6,450	
1. PRODUCTIONS (d)	247.631	74	13.648	3.608	4.159	651	0	15.136	41.760	26.998	161.448	22.214	2.132	315.894	(g) 67.248	23.510	6.922	37.958	990.99
2. IMPORTS	37.135	458	6.797					26.433	0	21.944	3.696	21.715	4.378	45.002	(h) 4.136	3.969	8.400	4.180	188.24
3. EXPORTS	5.292	8	2.581			89		3.586		15.985	85.376	686	4.378	95.105	38.592	7.105	66	20.879	279.72
4. Stock changes (e)		0	-690			-30		440		-1.165	-1.449	146	-103	-1.061	-745	-666	17	-329	-5.63
5. TOTAL RESOURCES	279.474	524	18.554	3.608	4.159	592	0	37.543	41.760	34.122	81.217	43.097	2.235	266.852	33.537	21.040	15.239	21.588	905.14
6. Transformations (Encl.1/a)			4.133	1.573	(c) 4.125	0		0	2.896	1	0	0	0	1.007	14.361	733	0	0	28.82
7. Consumptions and Losses (Encl.2/a)	33.491	0	7	42	5	1	0	297	21.692	-1	-2	-1	-1	1	37	912	5.221	13	61.27
8. Final Consumptions (Encl.3/a)	245.983	524	14.414	1.993	29	591	0	37.246	17.172	34.122	81.219	43.098	2.236	260.805	4.869	9.428	10.018	2.006	785.10
a) Agriculture	4.788							209	0	0	32	0	0	21.481	0	0	0	0	26.51
	92.140	75	14.414	1.993	29		0	2.420	2.580	0	189	52	0	3.377	2.782	7.850	10.018	2.006	139.92
b) Industry	38.642							18.172			79.097	43.046	21	222.880	0	0	0	0	401.85
c) Services	110.413	449	0				0	16.104	0	0	0		21	11.710	0	10	0	0	138.70
d) Domestic and civil uses	245.983	524	14.414	1.993	29	0	0	36.905	2.580	0	79.318	43.098	42	259.448	2.782	7.860	10.018	2.006	707.00
Total (a+b+c+d)				0		591		341	14.592	34.122	1.901	0	2.194	1.357	2.087	1.568	0	19.349	78.10
e) No energetic uses	279.474	524	14.421	2.035	34	592	0	37.543	38.864	34.121	81.217	43.097	2.235	260.806	4.906	10.340	15.239	2.019	827.46
TOTAL ENERGY CONSUMPTIONS (7+8)																			
9. Non energy final uses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19.350	19.35
10. BUNKERS	0	0	0	0	0	0	0	0	0	0	0	0	0	5.039	14.270	9.967	0	219	29.49
12. TOTAL USES	279.474	524	18.554	3.608	4.159	592	0	37.543	41.760	34.122	81.217	43.097	2.235	266.852	33.537	21.040	15.239	21.588	905.14

Table A5.3 -National Energy Balance, year 2014, Primary fuels used by transformation industries, "Enclosure 1/a", 10^9kcal

TRANSFORMATIONS	PRIMARY SOURCES															
	Coking coal	Steam coal	Coal other uses	Lignite	Subproducts (a)	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy (e)	Geothermal Energy	Wind and Photovoltaic Energy	Waste	Wood	Biomass for electricity	Biodiesel	TOTAL PRIMARY SOURCES
Conversion factor (b)	7,400	6,250	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) INPUT QUANTITY																
a) Charcoal pit													50			50
b) Coking	18.056															18.056
c) Town gas Workshop																
d) Blast furnaces																
e) Petroleum refineries							727.910									727.910
f) Hydroelectric power plants									93.350							93.350
g) Geothermal power plants										13.835						13.835
h) Thermoelectric power plants		80.078			3.122	191.919						14.886		36.684		326.689
i) Wind / Photovoltaic power plants						-					87.545					87.545
TOTAL	18.056	80.078			3.122	191.919	727.910		93.350	13.835	87.545	14.886	50	36.684		1.267.435
2) OUTPUT QUANTITY																
A) Obtained sources																
a) Charcoal pit													25			25
b) Coking	17.279															17.279
c) Town gas Workshop																
d) Blast furnaces																
e) Petroleum refineries							683.252									683.252
f) Hydroelectric power plants									36.491							36.491
g) Geothermal power plants										5.408						5.408
h) Thermoelectric power plants		30.623			1.209	108.487						4.187		14.668		159.174
i) Wind / Photovoltaic power plants											34.222					34.222
Sub-Total A	17.279	30.623			1.209	108.487	683.252		36.491	5.408	34.222	4.187	25	14.668		935.851

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	Wood	Biomass for electricity	Biodiesel	TOTAL PRIMARY SOURCES
B) Losses of transformation																
a) Charcoal pit													25			25
b) Coking	126															126
c) Town gas Workshop																
d) Blast furnaces																
e) Petroleum refineries							6.700									6.700
f) Hydroelectric power plants									56.859							56.859
g) Geothermal power plants										8.427						8.427
h) Thermoelectric power plants		49.455			1.913	83.432						10.699		22.016		167.515
i) Wind / Photovoltaic power											53.323					53.323
Sub-Total B	126	49.455			1.913	83.432	6.700		56.859	8.427	53.323	10.699	25	22.016		292.975
C) Non energy products																
a) Coke ovens (c)	651															651
b) Town Gas Workshop																
c) Petroleum refineries (d)							37.958									37.958
Sub-Total C	651						37.958									38.609
TOTAL A+B+C	18.056	80.078			3.122	191.919	727.910		93.350	13.835	87.545	14.886	50	36.684		1.267.435

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

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

(c) - see note (f) in the corresponding table in quantity units

Table A5.4 -National Energy Balance, year 2016, Secondary fuels used by transformation industries, "Enclosure 1/a", 10^9kcal

TRANSFORMATIONS	SECONDARY SOURCES																	
	Electric Energy	Char- coal	Coke	Coke oven gas	Blast furnace Gas	Non energy use of coal products	Gas works Gas	L. P. G.	Refinery gas	Light Distillates (naphtha)	Gasoline	Jet fuel	Kerosene	Gas Oil / Diesel Oil	Residual Oil, HS	Residual Oil, LS	Petroleum Coke	Non energy use of petroleum products	TOTAL SECONDARY SOURCES
Conversion factor (b)	0,860	7,500	6,900	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	6,450	
1) INPUT QUANTITY																			
a) Charcoal pit																			
b) Coking																			
c) Town gas Workshop																			
d) Blast furnaces			4.133																4.133
e) Petroleum refineries																			
f) Hydroelectr.power plants																			
g) Geothermal power plants																			
h) Thermoelectr. power plants				1.573	4.125				2.896	1				1.007	14.361	733			24.696
i) Wind / Photovoltaic power plants																			
T O T A L			4.133	1.573	4.125				2.896	1				1.007	14.361	733			28.829
2) OUTPUT QUANTITY																			
A) Obtained sources																			
a) Charcoal pit																			
b) Coking																			
c) Town gas Workshop																			
d) Blast furnaces																			
e) Petroleum refineries			4.133																4.133
f) Hydroelectric power plants																			
g) Geothermal power plants																			
h) Thermoelectric power plants																			
i) Wind / Photovoltaic power plants				655	1.743				1.702					373	7.502	362			12.337
Sub-Total A			4.133	655	1.743				1.702					373	7.502	362			16.470

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
B) Losses of transformation																			
a) Charcoal pit																			
b) Coking																			
c) Town gas Workshop																			
d) Blast furnaces																			
e) Petroleum refineries																			
f) Hydroelectric power plants																			
g) Geothermal power plants																			
h) Thermoelectric power plants				918	2.382				1.194	1				634	6.859	371			12.359
i) Wind / Photovoltaic power plants																			
Sub-Total B				918	2.382				1.194	1				634	6.859	371			12.359
C) Non energy products																			
a) Coking																			
b) Town Gas Workshop																			
c) Petroleum refineries																			
Sub-Total C																			
TOTAL A+B+C			4.133	1.573	4.125				2.896	1				1.007	14.361	733			28.829

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

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

(c) - See note (f) in the corresponding table in quantity units

(d) - It includes tar, crude benzol and ammonium sulphate.

(e) - It Includes: white spirit, lubricants, vaseline, paraffin, bitumen and other products.

Table A5.5 -National Energy Balance, year 2016, Primary fuels losses, "Enclosure 2/a", 10^9kcal

CONSUMPTIONS AND LOSSES (d)	PRIMARY SOURCES															
	Coking coal	Steam coal	Coal other uses	Lignite	Subproducts (a)	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy	Geothermal Energy	Wind and Photovoltaic Energy	Waste	Wood	Biomass for electricity	Biodiesel	TOTAL PRIMARY SOURCES
Conversion factor (b)	7,400	6,250	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) Consumptions for production																
of primary sources																
a) Biomass																
b) Coal																
c) Lignite																
d) Nuclear fuels																
e) Natural Gas						3.284										3.284
f) Natural gas liquids																
g) Crude oil																
h) Hydraulic Energy																
i) Geothermal Energy																
Sub-total						3.284										3.284
2) Consumptions for production																
of secondary sources (c)																
a) Charcoal pit																
b) Coke ovens																
c) Town Gas Workshop																
d) Blast furnaces																
e) Petroleum refineries						11.261										11.261
f) Hydraulic power plants																
g) Geothermal power plants																
h) Thermoelectric power plants																
i) Nuclear power plants																
Sub-total						11.261										11.261

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	Wood	Biomass for electricity	Biodiesel	TOTAL PRIMARY SOURCES
3) Consumptions and Losses of																
transport and distribution						2.121										2.121
4) Differences :																
- Statistics																
- of conversion			1		1	-2							1		1	2
TOTAL (1+2+3+4)			1		1	16.664									1	16.668

(a) - Excluding transformation losses counted separately in the balance of transformations.

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

(c) Consumptions for internal uses of energy industries

Table A5.6 -National Energy Balance, year 2016, Secondary fuels losses, "Enclosure 2/a", 10^9kcal

CONSUMPTIONS AND LOSSES	SECONDARY SOURCES																		
	Electric Energy	Char- coal	Coke	Coke oven gas	Blast furnace Gas	Non energy use of coal products	Gas works Gas	L. P. G.	Refinery gas	Light Distillates (naphtha)	Gasoline	Jet fuel	Kerosene	Gas Oil / Diesel Oil	Residual Oil, HS	Residual Oil, LS	Petroleum Coke	Non energy use of petroleum products	TOTAL SECONDARY SOURCES
Conversion factor (b)	0,860	7,500	6,900	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	8,450	
1) Consumptions for production																			
of primary sources																			
a) Biomass																			
b) Coal	32																		32
c) Lignite																			
d) Nuclear fuels	5																		5
e) Natural Gas	261																		261
f) Natural gas liquids	-																		
g) Crude oil																			
h) Hydraulic Energy	553	(d)																	553
i) Geothermal Energy	-																		
Sub-total	851																		851

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
2) Consumptions for production of secondary sources (c)																			
a) Charcoal pit																			
b) Coke ovens	36		7	43	5														91
c) Town Gas Workshop	295																		295
d) Blast furnaces	-																		
e) Petroleum refineries	4.452							297	21.695						38	910	5.221	13	32.626
f) Hydraulic power plants	406																		406
g) Geothermal power plants	363																		363
h) Thermoelectric power plants	7.447																		7.447
i) Wind / Photovoltaic power plants	441																		
Sub-total	13.440		7	43	5			297	21.695						38	910	5.221	13	41.228
3) Consumptions and Losses of transport and distribution	19.200																		19.200
4) Differences :																			
- Statistics	-																		
- of conversion				-1		1			-3	-1	-2	-1	-1	1	-1	2			-6
TOTAL (1+2+3+4)	33.491		7	42	5	1		297	21.692	-1	-2	-1	-1	1	37	912	5.221	13	61.273

Table A5.7 -National Energy Balance, year 2016, Primary fuels used by end use sectors, "Enclosure 3/a", 10^9kcal

FINAL CONSUMPTIONS	PRIMARY SOURCES															
	Coking coal	Steam coal	Coal other uses	Lignite	Subproducts	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy	Geothermal Energy	Wind and Photovoltaic Energy	Waste	Wood	Biomass for electricity	Biodiesel	TOTAL PRIMARY SOURCES
Conversion factor (a)	7,400	6,250	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) AGRICULTURE AND FISHING																
I- Agriculture						1.302							350			1.652
II- Fishing																
Sub-Total						1.302							350			1.652
2) INDUSTRY																
I- Iron and steel industry		8.113	229			15.479										23.821
II- Other industry		2.784	73	5		103.572							1.218			107.652
a) Mining industry						295										295
b) Non-Ferrous Metals			7			4.070							345			4.422
c) Metal works factories						16.470							23			16.493
d) Food Processing, Beverages						14.095										14.095
e) Textile and clothing						5.799										5.799
f) Construction industries (cement, bricks)		2.784	59	5		5.594							295			8.737
g) Glass and pottery						17.232										17.232
h) Chemical			7			19.877										19.884
i) Petrochemical													10			10
l) Pulp, paper and print						16.626										16.626
m) Other industries						3.514							100			3.614
n) Building and civil works													445			445
Sub-Total		10.897	302	5		119.051							1.218			131.473

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	Biomass for electricity	Biodiesel	TOTAL PRIMARY SOURCES
3) SERVICES																
I - Railways																
II - Navigation																
III - Road transportation						8.935									10.493	19.428
IV - Civil aviation																
V - Other transportation																
VI - Public Service																
Sub-Total						8.935									10.493	19.428
4) DOMESTIC AND COMMERCIAL USES						236.396							62.004			298.400
TOTAL (1+2+3+4)		10.897	302	5		365.684							63.572		10.493	450.953
5) NON ENERGY USE (b)																
I - Chemical industry																
II - Petrochemical						6.527										6.527
III - Agriculture																
IV - Other sectors																
Sub-Total						6.527										6.527
TOTAL (1+2+3+4+5)		10.897	302	5		372.211							63.572		10.493	457.480

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

Table A5.8-National Energy Balance, year 2016, Secondary fuels used by end use sectors, "Enclosure 3/a", 10^9kcal

FINAL CONSUMPTIONS	SECONDARY SOURCES																	
	Electric Energy	Char- coal	Coke	Coke oven gas	Blast furnace Gas	Non energy use of coal products	Gas works Gas	L. P. G.	Refinery gas	Light Distillates (naphtha)	Gasoline	Jet fuel	Kerosene	Gas Oil / Diesel Oil	Residual Oil, HS	Residual Oil, LS	Petroleum Coke	Non energy use of petroleum products	TOTAL SECONDARY SOURCES
Conversion factor	0,860	7,500	6,900	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	6,450	
1) AGRICULTURE AND FISHING																			
I- Agriculture	4.788							209			32			19.849					24.878
II- Fishing														1.632					1.632
Sub-Total	4.788							209			32			21.481					26.510
2) INDUSTRY																			
I- Iron and steel industry	15.705		14.359	1.993	29			165						122	274	353			33.000
II- Other industry	76.434	75	55					2255	2.580		189	52		3.255	2.508	7.497	10.018	2.006	106.924
a) Mining industry	551							22	792					194	127				1.686
b) Non-Ferrous Metals	2.103		14					132						51	343				2.643
c) Metal works factories	20.415							440			189	52		1.000	382	980			23.458
d) Food Processing, Beverages	10.466	75						275						265	578	1.617			13.276
e) Textile and clothing	4.738							99						245		559			5.641
f) Construction industries (cement, bricks)	3.812		28					429						326	294	470	10.018	1.683	17.060
g) Glass and potter	3.779							660						82	137	1.725			6.383
h) Chemical	15.694		7					33						163	118	764			16.779
i) Petrochemical	1.386							66	1.788					500	196	608		323	4.867
l) Pulp, paper and print	7.436							66						143	88	529			8.262
m) Other industries	4.890		6					33						82	137	245			5.393
n) Building and civil works	1.164													204	108				1.476
Sub-Total	92.139	75	14.414	1.993	29			2.420	2.580		189	52		3.377	2.782	7.850	10.018	2.006	139.924

FINAL	SECONDARY SOURCES

CONSUMPTIONS	Electric Energy	Char- coal	Coke	Coke oven gas	Blast furnace Gas	Non energy use of coal products	Gas works Gas	L. P. G.	Refinery gas	Light Distillates (naphtha)	Gasoline	Jet fuel	Kerosene	Gas Oil / Diesel Oil	Residual Oil, HS	Residual Oil, LS	Petroleum Coke	Non energy use of petroleum products	TOTAL SECONDARY SOURCES
3) SERVICES																			
I - Railways	5.421													143					5.564
II - Navigation	39													2.713					2.752
III - Road transportation	3.950							18.128			79.055			218.759					319.892
IV - Civil aviation	190										21	41.590							41.801
V - Other transportation	19.705												21						19.726
VI - Public Service	9.337							44			21	1.456		1.265					12.123
Sub-Total	38.642							18.172			79.097	43.046	21	222.880					401.858
4) DOMESTIC AND COMMERCIAL USES	110.413	449						16.104					21	11.710		10			138.707
TOTAL (1+2+3+4)	245.982	524	14.414	1.993	29			36.905	2.580		79.318	43.098	42	259.448	2.782	7.860	10.018	2.006	706.999
5) NON ENERGY USE (b)																			
I - Chemical industry																			
II - Petrochemical								341	14.592	34.122	1.901		2.194	1.357	2.087	1.568		1.664	59.826
III - Agriculture						51													51
IV - Other sectors						540												17.685	18.225
Sub-Total						591		341	14.592	34.122	1.901		2.194	1.357	2.087	1.568		19.349	78.102
TOTAL (1+2+3+4+5)	245.982	524	14.414	1.993	29	591		37.246	17.172	34.122	81.219	43.098	2.236	260.805	4.869	9.428	10.018	21.356	785.101

Table A5.9 -National Energy Balance, year 2016, 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	Wood	Biomass for electricity	Biodiesel	TOTAL PRIMARY SOURCES
Unit of measurement	kt	kt	kt	kt		Mmc	kt	kt	GWh	GWh	GWh	kt	kt	kt	kt	
1) AGRICULTURE AND FISHING																
I- Agriculture						159							140			
II- Fishing																
Sub-Total	0	0	0	0		159	0	0	0	0	0	0	140	0		
2) INDUSTRY																
I- Iron and steel industry		1.298	31			1.890										
II- Other industry	0	446	10	2		12.646	0		0	0		0	487	0		
a) Mining industry						36										
b) Non-Ferrous Metals			1			497							138			
c) Metal works factories						2.011							9			
d) Food Processing, Beverages						1.721							0			
e) Textile and clothing						708										
f) Construction industries (cement, bricks)		446	8	2		683							118			
g) Glass and pottery						2.104										
h) Chemical			1			2.427										
i) Petrochemical						0							4			
l) Pulp, paper and print						2.030										
m) Other industries						429							40			
n) Building and civil works						0							178			
Sub-Total	0	1.744	41	2	0	14.536	0	0	0	0		0	487	0		

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	Biomass for electricity	Biodiesel	TOTAL PRIMARY SOURCES
3) SERVICES																
I - Railways																
II - Navigation																
III - Road transportation						1.091									1.179	
IV - Civil aviation																
V - Other transportation																
VI - Public Service																
Sub-Total	0	0	0	0		1.091	0	0	0	0	0	0	0	0	1.179	
4) DOMESTIC AND COMMERCIAL USES			0			28.864							24.802			
TOTAL (1+2+3+4)	0	1.744	41	2		44.650	0	0	0	0	0	0	25.429	0	1.179	
5) NON ENERGY USE (a)																
I - Chemical industry																
II - Petrochemical						797										
III - Agriculture																
IV - Other sectors																
Sub-Total	0	0	0	0		797	0	0	0	0					-	
TOTAL (1+2+3+4+5)	0	1.744	41	2		45.447	0	0	0	0	0	0	25.429	0	1.179	

(a) - Non energy uses of energetic sources

(b) - Biodiesel for road transport

Table A5.10 -National Energy Balance, year 2014, 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	TOTAL SECONDARY SOURCES
	15	16	17	18	20	21	19	22	23	24	25	26	27	28	29	30	31	32	33
Unit of measurement	GWh	kt	kt	Mmc	Mmc	kt	Mmc	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	
1) AGRICULTURE AND FISHING																			
I- Agriculture	5.372							51			8			1.868					
II- Fishing								2			1			150					
Sub-Total	5.372	0	0	0	0		0	53	0	0	9	0	0	2.018	0	0	0	0	
2) INDUSTRY																			
I- Iron and steel industry	18.355		2.327	461	119			13						15	22	29			
II- Other industry	88.580	9	13	0	0	0	0	186	539	0	14	6	1	371	239	615	1.868	401	
a) Mining industry	678							2						20	11	0			
b) Non-Ferrous Metals	2.488		2					9						5	34	0			
c) Metal works factories	22.871							34			14	6	1	93	35	83			
d) Food Processing, Beverages	11.972	7						22						32	58	119			
e) Textile and clothing	5.684							10						25	0	45			
f) Construction industries (cement, bricks)	4.754		6					35						35	27	38	1.868	357	
g) Glass and pottery	4.421							53						9	13	108			
h) Chemical	18.362	2	2					2						17	11	62			
i) Petrochemical	1.738							10	539	0	0	0	0	90	21	97	0	44	
l) Pulp, paper and print	8.672							4						15	8	43			
m) Other industries	5.689		3					4						10	12	20			
n) Building and civil works	1.251							1						20	9	0			
Sub-Total	106.935	9	2.340	461	119	0	0	199	539	0	14	6	1	386	261	644	1.868	401	

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
3) SERVICES																			
I - Railways	5.586													18					
II - Navigation	51													280					
III - Road transportation	4.576							1.564			(b) 7.868			20.843					
IV - Civil aviation	250										2	3.628	5						
V - Other transportation	22.763																		
VI - Public Service	10.772							(a) 4			8	141		(a) 144					
Sub-Total	43.998	0	0	0	0	0	0	1.568	0	0	7.878	3.769	3	21.285	0	0	0	0	
4) DOMESTIC AND COMMERCIAL USES																			
	125.192	58						1.259					1	1.223		1			
TOTAL (1+2+3+4)	281.497	67	2.340	461	119	0	0	3.079	539	0	7.901	3.775	5	24.912	261	645	1.868	401	29.583
5) NON ENERGY USE																			
I - Chemical industry																			
II - Petrochemical								216	449	2024	547	0	458	307	87	54	0	57	
III - Agriculture						11													
IV - Other sectors						92												2.742	
Sub-Total	-	0	0	0	0	103	0	216	449	2.024	547	0	458	307	87	54	0	2.799	
TOTAL (1+2+3+4+5)	281.497	67	2.340	461	119	103	0	3.295	988	2.024	8.448	3.775	463	25.219	348	699	1.868	3.200	

(a) 31 kt of gas oil and 2 kt of LPG used for heating for Public Service

(b) 11 kt of EBTE and 1.5 kt of bioethanol

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 trough 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) (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.
As shown in the table, the ranges of national EFs are within the lower and upper threshold of the IPCC 2006 guidelines.
With regard the oxidation factors, increasing values have been used from 0.995 in the 1990 to 1.000 in 2005 according to the improvement of combustion efficiency in the nineties.

Table A6.1 Natural gas carbon emission factors

	t CO_2 / TJ (stechiometric)	t CO_2 / TJ	t CO_2 / 10^3 std cubic mt	t CO_2 / toe
Natural gas (dry) IPCC '96	56.061	55.780	1.927	2.335
Natural gas, IPCC '06 average	56.100	56.100	1.932	2.349
lower	54.300			
upper	58.300			
National Emission Factors				
Natural gas , 1990	55.570	55.292	1.911	2.315
Natural gas, 1995	55.666	55.388	1.922	2.319
Natural gas , 2000	55.753	55.599	1.937	2.328
Natural gas , 2001	55.702	55.578	1.931	2.327
Natural gas , 2002	56.257	56.163	1.945	2.351
Natural gas, 2003	55.874	55.812	1.950	2.337
Natural gas, 2004	55.874	55.843	1.954	2.338
Natural gas, 2005	55.870	55.870	1.954	2.339
Natural gas, 2006	55.947	55.947	1.959	2.342
Natural gas, 2007	55.917	55.917	1.957	2.341
Natural gas, 2008, with 8190 lhv	57.158	57.158	1.960	2.393
Natural gas, 2009, with 8190 lhv	57.380	57.380	1.968	2.402
Natural gas, 2010, with 8190 lhv	57.488	57.488	1.971	2.407
Natural gas, 2011, with 8190 lhv	57.005	57.005	1.955	2.387
Natural gas, 2012, with 8190 lhv	57.182	57.182	1.961	2.394
Natural gas, 2013, with 8190 lhv	56.951	56.951	1.953	2.384
Natural gas, 2014, with 8190 lhv	57.920	56.920	1.952	2.383
Natural gas, 2015, with 8190 lhv	57.206	57.206	1.962	2.395
Natural gas, 2016, with 8190 lhv	57.693	57.693	1.978	2.415

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/m^3 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 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 and produced natural gas in 2016 is 8442 kcal/m^3.
As mentioned above, in the BEN 2008 the average lhv has been changed from 8250 kcal/m^3 (historical value) to 8190 kcal/m^3, to harmonize national data with Eurostat methodology. Eurostat considers the lhv as being 10% less than hhv, regardless of the actual value. This change influences the EF if it is referred to the energy content (lhv) of the fuel, but it has no influence if the EF is referred to cubic meters.

A6.2 Diesel oil, petrol and LPG

ISPRA has made investigations on the carbon content of the main transportation fuels sold in Italy, petrol, diesel and LPG, with the aim of testing the average fuels in 2000 and 2012. The goal of this work is the verification of CO_2 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; Innovhub, several years) were compared with emission factors used in Reference Approach of the Intergovernmental Panel for Climate Change (IPCC, 1997; IPCC, 2006) 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 lhv for a series of fuels representative of the national production in the years 2000-2001 and 2012-2014, 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 to 2011. The figures from the last surveys have been used for the years 2012-2016.

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 are used, for the period 1990-1999 it has been decided to use an interpolate factor between IPCC emission factors and the measured value, using the lhv as the link between the national products and the international database.
The list of emission factors used is reported in Table A6.2.

Table A6.2 Fuels, national production, carbon emission factors

	t CO_2 / TJ	t CO_2 / t	t CO_2 / toe
Petrol, IPCC / OECD	68.559	3.071	2.870
Petrol, IPCC Europe	72.270	3.148	3.026
Petrol (Italian National Energy Balance), interpolated emission factor 1990-1999	71.034	3.123	2.974
Petrol, experimental averages 2000-2011	71.864	3.143	3.009
Petrol, experimental averages 2012-2016	73.338	3.140	3.071
Gas oil, IPCC / OECD	73.274	3.175	3.068
Gas oil, IPCC Europe	73.260	3.108	3.067
Gas oil, 1990 – 1999	73.274	3.129	3.068
Gas oil, engines, experimental averages 2000-2011	73.892	3.171	3.094
Gas oil, engines, experimental averages 2012-2016	73.648	3.151	3.084
Gas oil, heating, experimental averages 2000-2011	74.438	3.175	3.117
Gas oil, heating, experimental averages 2012-2016	73.578	3.155	3.081
LPG, IPCC / OECD	62.392	2.952	2.612
LPG, IPCC / Europe	64.350	3.000	2.694
LPG, 1990 – 1999	62.392	2.873	2.612
LPG, experimental averages 2000-2016	65.592	3.026	2.746

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	t CO_2 / t	t CO_2 / toe
Fuel oil , IPCC, 1996	77.312	76.539	3.150	3.205
Fuel oil , IPCC, 2006 average	77.400	77.400	3.127	3.241
lower	75.500			
upper	78.800			
National emission factors				
Fuel oil, average 1990	77.339	76.565	3.113	3.206
Fuel oil, average 1995	77.425	76.650	3.129	3.209
Fuel oil, average 2000	76.665	76.239	3.140	3.192
Fuel oil, average 2001	76.655	76.315	3.141	3.195
Fuel oil, average 2002	76.709	76.454	3.148	3.201
Fuel oil, average 2003	76.921	76.750	3.158	3.213
Fuel oil, average 2004	76.939	76.853	3.162	3.218
Fuel oil, average 2005	75.875	75.875	3.144	3.177
Fuel oil, average 2006	75.952	75.952	3.144	3.180
Fuel oil, average 2007	76.326	76.326	3.147	3.196
Fuel oil, average 2008	76.680	76.680	3.145	3.210
Fuel oil, average 2009	76.633	76.633	3.145	3.208
Fuel oil, average 2010	76.863	76.863	3.145	3.218
Fuel oil, average 2011	77.061	77.061	3.147	3.226
Fuel oil, average 2012	76.505	76.505	3.145	3.203
Fuel oil, average 2013	76.693	76.693	3.145	3.211
Fuel oil, average 2014	76.696	76.696	3.145	3.211
Fuel oil, average 2015	76.604	76.604	3.144	3.207
Fuel oil, average 2016	76.604	76.604	3.143	3.207

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. With regard the oxidation factors, increasing values have been used from 0.99 in the 1990 to 1.00 in 2005 according to the improvement of combustion efficiency in the nineties.

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 2016 in Table A6.4.

Table A6.4 – Coal imported by country in 2016 (Mg)

Country	Coking coal	Coke	Steam coal	Lignite	Total Coal	Petroleum coke
GERMANY				2,000		
POLAND		887,501				
SPAIN			208,389			51,848
TOTAL EU		**887,501**	**208,389**	**2,000**	**1,097,890**	**51,848**
AUSTRALIA	710,990		6,000			
BOSNIA-ERZEGOVINA		56,312				
CANADA	300,411					
COLOMBIA			4,405,855			
INDONESIA			1,078,547			
KAZAKISTAN			632,186			
RUSSIA			4,501,448			
SOUTH AFRICA			3,196,024			
U.S.A.	1,418,992		287,238			867,552
VENEZUELA			73,698			92,212
CHINA		41,870.00				
TOTAL NON_EU	**2,430,393**	**98,182**	**14,180,996**			**959,764**
TOTAL	**2,430,393**	**985,683**	**14,389,386**	**2,000**	**17,807,461**	**1,011,612**

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.
The intention is to improve the quality of the collected statistical data including moisture content of coals; currently this obstacle has been overcome 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 are reported. National emission factors result in the range given by the lower and upper values for "other bituminous coal" in the IPCC 2006 Guidelines (IPCC, 2006).
From the 2011 submission, with the aim to improve the estimation of the coal CO_2 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 CO_2 emission factors, resulting from ETS data, have been applied from 2005.

With regard the oxidation factors, increasing values have been used from 0.98 in the 1990 to 1.00 in 2005 according to the improvement of combustion efficiency in the nineties.

Table A6.5 – Coal, average carbon emission factors

	t CO_2 / TJ (stechiometric)	t CO_2 / TJ	t CO_2 / t	t CO_2 / toe
Other bituminous coal, IPCC 1996	94.534	92.643	2.425	3.879
Other Bituminous coal, IPCC 2006, av	94.600	94.600	2.441	3.961
lower	92.800			
upper	100.00			
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	92.276	2.427	3.863
Steam coal, 2001	95.304	94.457	2.463	3.955
Steam coal, 2002	94.727	94.096	2.457	3.940
Steam coal, 2003	95.385	94.961	2.476	3.976
Steam coal, 2004	95.382	95.170	2.476	3.985
Steam coal, 2005	94.305	94.305	2.399	3.948
Steam coal, 2006	93.741	93.741	2.346	3.925
Steam coal, 2007	94.078	94.078	2.324	3.939
Steam coal, 2008	93.451	93.451	2.287	3.913
Steam coal, 2009	93.847	93.847	2.325	3.929
Steam coal, 2010	93.717	93.717	2.318	3.924
Steam coal, 2011	93.365	93.365	2.318	3.909
Steam coal, 2012	93.668	93.668	2.346	3.922
Steam coal, 2013	93.645	93.645	2.331	3.921
Steam coal, 2014	94.029	94.029	2.339	3.937
Steam coal, 2015	94.619	94.619	2.335	3.962
Steam coal, 2016	95.124	95.124	2.351	3.983

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 CO_2 emission factors have been applied from 2005.

In the following, values of CO_2 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.

Oxidation factors have been considered equal to 1 for all the fuels (IPCC, 2006) with exception of residual gases of chemical processes where the oxidation factors resulting from ETS data have been used.

Table A6.6 – Refinery gas, average carbon emission factors

Refinery gas	t CO_2 / TJ (stechiometric)	t CO_2 / TJ	t CO_2 / t	t CO_2 / toe
Refinery gas, 1990-2004	57.600	57.600	2.851	2.412
Refinery gas, 2005	58.320	58.320	2.756	2.442
Refinery gas, 2006	57.369	57.369	2.644	2.402
Refinery gas, 2007	57.110	57.110	2.645	2.391
Refinery gas, 2008	58.137	58.137	2.686	2.434
Refinery gas, 2009	57.477	57.477	2.673	2.406
Refinery gas, 2010	57.361	57.361	2.693	2.402
Refinery gas, 2011	57.397	57.397	2.694	2.403
Refinery gas, 2012	57.227	57.227	2.700	2.396
Refinery gas, 2013	57.339	57.339	2.644	2.401
Refinery gas, 2014	58.095	58.095	2.659	2.432
Refinery gas, 2015	56.956	56.956	2.657	2.385
Refinery gas, 2016	58.211	58.211	2.652	2.437

Source: ISPRA elaborations

Table A6.7 – Coke oven gas, average carbon emission factors

Coke oven gas	t CO_2 / TJ (stechiometric)	t CO_2 / TJ	t CO_2 / 10^3 std cubic mt	t CO_2 / toe
Coke oven gas, 1990-2004	42.111	42.111	0.807	1.763
Coke oven gas, 2005	42.128	42.128	0.754	1.764
Coke oven gas, 2006	42.678	42.678	0.743	1.787
Coke oven gas, 2007	42.416	42.416	0.714	1.776
Coke oven gas, 2008	42.250	42.250	0.733	1.769
Coke oven gas, 2009	42.980	42.980	0.748	1.799
Coke oven gas, 2010	42.816	42.816	0.735	1.793
Coke oven gas, 2011	43.328	43.328	0.746	1.814
Coke oven gas, 2012	44.046	44.046	0.773	1.844
Coke oven gas, 2013	42.861	42.861	0.760	1.794
Coke oven gas, 2014	43.767	43.767	0.775	1.832
Coke oven gas, 2015	43.314	43.314	0.751	1.813
Coke oven gas, 2016	43.700	43.700	0.758	1.830

Source: ISPRA elaborations

Table A6.8 – Blast furnace gas, average carbon emission factors

Blast furnace gas	t CO_2 / TJ (stechiometric)	t CO_2 / TJ	t CO_2 / 10^3 std cubic mt	t CO_2 / toe
Blast furnace gas, 1990-2004	270.575	270.575	0.954	11.328
Blast furnace gas, 2005	263.653	263.653	0.870	11.039
Blast furnace gas, 2006	255.948	255.948	0.849	10.716
Blast furnace gas, 2007	261.469	261.469	0.835	10.947
Blast furnace gas, 2008	256.133	256.133	0.838	10.724
Blast furnace gas, 2009	259.560	259.560	0.834	10.867
Blast furnace gas, 2010	257.390	257.390	0.863	10.776

Blast furnace gas	t CO_2 / TJ (stechiometric)	t CO_2 / TJ	t CO_2 / 10^3 std cubic mt	t CO_2 / toe
Blast furnace gas, 2011	255.351	255.351	0.877	10.691
Blast furnace gas, 2012	252.808	252.808	0.885	10.585
Blast furnace gas, 2013	251.428	251.428	0.929	10.527
Blast furnace gas, 2014	245.964	245.964	0.958	10.298
Blast furnace gas, 2015	250.072	250.072	0.931	10.470
Blast furnace gas, 2016	247.893	247.893	0.952	10.379

Source: ISPRA elaborations

Table A6.9 – Oxygen furnace gas, average carbon emission factors

Oxygen furnace gas	t CO_2 / TJ (stechiometric)	t CO_2 / TJ	t CO_2 / 10^3 std cubic mt	t CO_2 / toe
Oxygen furnace gas, 1990-2004	195.086	195.086	1.504	8.168
Oxygen furnace gas, 2005	197.579	197.579	1.437	8.272
Oxygen furnace gas, 2006	202.372	202.372	1.390	8.473
Oxygen furnace gas, 2007	195.871	195.871	1.320	8.201
Oxygen furnace gas, 2008	196.465	196.465	1.277	8.226
Oxygen furnace gas, 2009	196.970	196.970	1.253	8.247
Oxygen furnace gas, 2010	197.029	197.029	1.216	8.249
Oxygen furnace gas, 2011	198.482	198.482	1.160	8.310
Oxygen furnace gas, 2012	198.199	198.199	1.226	8.298
Oxygen furnace gas, 2013	185.522	185.522	1.068	7.767
Oxygen furnace gas, 2014	200.970	200.970	1.335	8.414
Oxygen furnace gas, 2015	201.532	201.532	1.351	8.438
Oxygen furnace gas, 2016	203.868	203.868	1.309	8.536

Source: ISPRA elaborations

Table A6.10 – Heavy residual fuels, average carbon emission factors

Heavy residual fuels	t CO_2 / TJ (stechiometric)	t CO_2 / TJ	t CO_2 / t	t CO_2 / toe
Heavy residual fuels, 1999-2006	81.817	81.817	3.213	3.426
Heavy residual fuels, 2007	81.823	81.823	3.214	3.426
Heavy residual fuels, 2008	80.350	80.350	3.156	3.364
Heavy residual fuels, 2009	79.612	79.612	3.125	3.333
Heavy residual fuels, 2010	78.829	78.829	3.100	3.300
Heavy residual fuels, 2011	79.164	79.164	3.081	3.314
Heavy residual fuels, 2012	79.350	79.350	3.090	3.322
Heavy residual fuels, 2013	80.756	80.756	3.145	3.381
Heavy residual fuels, 2014	80.499	80.499	3.135	3.370
Heavy residual fuels, 2015	79.738	79.738	3.105	3.338
Heavy residual fuels, 2016	79.700	79.700	3.104	3.337

Source: ISPRA elaborations

Table A6.11 – Synthesis gas, average carbon emission factors

Synthesis gas	t CO_2 / TJ (stechiometric)	t CO_2 / TJ	t CO_2 / t	t CO_2 / toe
Synthesis gas, 1999-2005	98.103	98.103	0.906	4.107
Synthesis gas, 2006	98.566	98.566	0.982	4.127
Synthesis gas, 2007	98.321	98.321	0.830	4.117
Synthesis gas, 2008	98.860	98.860	0.886	4.139
Synthesis gas, 2009	105.956	105.956	0.956	4.436
Synthesis gas, 2010	109.042	109.042	0.898	4.565
Synthesis gas, 2011	109.043	109.043	0.911	4.565
Synthesis gas, 2012	99.823	99.823	0.825	4.179
Synthesis gas, 2013	100.817	100.817	0.895	4.221
Synthesis gas, 2014	100.596	100.596	0.898	4.212
Synthesis gas, 2015	100.732	100.732	0.930	4.217
Synthesis gas, 2016	103.993	103.993	0.929	4.354

Source: ISPRA elaborations

Table A6.12 – Residual gas of chemical processes, average carbon emission factors

Residual gas of chemical processes	t CO_2 / TJ (stechiometric)	Oxidation factor	t CO_2 / TJ	t CO_2 / t	t CO_2 / toe
Residuals gas of chem. processes, 1990-2007	51.500	0.995	51.243	2.365	2.145
Residuals gas of chem. processes, 2008	51.308	0.995	51.052	2.505	2.137
Residuals gas of chem. processes, 2009	50.588	0.995	50.342	2.502	2.108
Residuals gas of chem. processes, 2010	50.425	0.996	50.209	2.516	2.102
Residuals gas of chem. processes, 2011	50.886	0.995	50.652	2.534	2.121
Residuals gas of chem. processes, 2012	51.543	0.995	51.310	2.153	2.148
Residuals gas of chem. processes, 2013	51.660	1.000	51.660	2.426	2.163
Residuals gas of chem. processes, 2014	43.589	1.000	43.589	2.539	1.825
Residuals gas of chem. processes, 2015	55.511	1.000	55.511	2.420	2.324
Residuals gas of chem. processes, 2016	48.814	1.000	48.814	2.367	2.044

Source: ISPRA elaborations

Table A6.13 – Petroleum coke for no refinery plants, average carbon emission factors

Petroleum coke	t CO_2 / TJ (stechiometric)	t CO_2 / TJ	t CO_2 / t	t CO_2 / toe
Petroleum coke, 1990-2004	97.700	97.700	3.175	4.091
Petroleum coke, 2005	92.957	92.957	3.097	3.892
Petroleum coke, 2006	93.295	93.295	3.125	3.906
Petroleum coke, 2007	93.427	93.427	3.193	3.912
Petroleum coke, 2008	93.525	93.525	3.203	3.916
Petroleum coke, 2009	94.106	94.106	3.227	3.940
Petroleum coke, 2010	94.764	94.764	3.207	3.968
Petroleum coke, 2011	95.596	95.596	3.284	4.002
Petroleum coke, 2012	95.905	95.905	3.294	4.015

Petroleum coke, 2013	93.178	93.178	3.128	3.901
Petroleum coke, 2014	93.513	93.513	3.122	3.915
Petroleum coke, 2015	93.843	93.843	3.121	3.929
Petroleum coke, 2016	93.459	93.459	3.121	3.913

Source: ISPRA elaborations

Table A6.14 – Petroleum coke for refinery plants, average carbon emission factors

Petroleum coke	t CO_2 / TJ (stechiometric)	t CO_2 / TJ	t CO_2 / t	t CO_2 / toe
Petroleum coke, 2013	99.335	99.335	3.415	4.159
Petroleum coke, 2014	95.875	95.875	3.400	4.014
Petroleum coke, 2015	96.774	96.774	3.432	4.052
Petroleum coke, 2016	96.332	96.332	3.416	4.033

Source: ISPRA elaborations

Table A6.15 –Coke, average carbon emission factors

Coke	t CO_2 / TJ (stechiometric)	t CO_2 / TJ	t CO_2 / t	t CO_2 / toe
Coke, 1990-2004	110.368	108.161	3.170	4.528
Coke, 2005	110.916	110.916	3.246	4.644
Coke, 2006	111.049	111.049	3.181	4.649
Coke, 2007	111.814	111.814	3.191	4.681
Coke, 2008	111.649	111.649	3.187	4.675
Coke, 2009	111.303	111.303	3.161	4.660
Coke, 2010	111.828	111.828	3.204	4.682
Coke, 2011	109.440	109.440	3.162	4.582
Coke, 2012	111.599	111.599	3.272	4.672
Coke, 2013	110.755	110.755	3.171	4.637
Coke, 2014	109.125	109.125	3.198	4.569
Coke, 2015	108.909	108.909	3.206	4.560
Coke, 2016	109.495	109.495	3.217	4.584

Source: ISPRA elaborations

Table A6.16 –Coking coal, average carbon emission factors

Petroleum coke	t CO_2 / TJ (stechiometric)	t CO_2 / TJ	t CO_2 / t	t CO_2 / toe
Coking coal, 1990-2004	94.600	94.600	2.668	3.961
Coking coal, 2005	92.466	92.466	2.971	3.871
Coking coal, 2006	94.058	94.058	2.968	3.938
Coking coal, 2007	94.479	94.479	2.971	3.956
Coking coal, 2008	94.869	94.869	2.961	3.972
Coking coal, 2009	94.718	94.718	2.970	3.966
Coking coal, 2010	94.626	94.626	3.007	3.962
Coking coal, 2011	94.502	94.502	2.969	3.957

Coking coal, 2012	94.422	94.422	2.984	3.953
Coking coal, 2013	94.384	94.384	2.982	3.952
Coking coal, 2014	93.994	93.994	2.992	3.935
Coking coal, 2015	94.249	94.249	3.011	3.946
Coking coal, 2016	94.240	94.240	2.969	3.946

Source: ISPRA elaborations

Table A6.17 –Anthracite, average carbon emission factors

Petroleum coke	t CO_2 / TJ (stechiometric)	t CO_2 / TJ	t CO_2 / t	t CO_2 / toe
Anthracite, 1990-2004	98.300	98.300	2.625	4.116
Anthracite, 2005	93.035	93.035	2.856	3.895
Anthracite, 2006	95.127	95.127	2.817	3.983
Anthracite, 2007	97.722	97.722	2.796	4.091
Anthracite, 2008	97.183	97.183	2.764	4.069
Anthracite, 2009	98.335	98.335	2.861	4.117
Anthracite, 2010	97.093	97.093	2.835	4.065
Anthracite, 2011	98.922	98.922	2.898	4.142
Anthracite, 2012	98.276	98.276	2.855	4.115
Anthracite, 2013	98.265	98.265	2.886	4.114
Anthracite, 2014	98.386	98.386	2.877	4.119
Anthracite, 2015	101.885	101.885	2.906	4.266
Anthracite, 2016	101.637	101.637	2.924	4.255

Source: ISPRA elaborations

Table A6.18 –Industrial waste (fossil), average carbon emission factors

	t CO_2 / TJ (stechiometric)	t CO_2 / TJ	t CO_2 / t	t CO_2 / toe
Industrial waste, 2005-2012	79.968	79.968	1.924	3.348
Industrial waste, 2013	79.076	79.076	1.853	3.311
Industrial waste, 2014	81.851	81.851	1.931	3.427
Industrial waste, 2015	78.976	78.976	1.988	3.307
Industrial waste, 2016	78.592	78.592	2.019	3.291

Source: ISPRA elaborations

ANNEX 7: AGRICULTURE SECTOR

Additional information used for estimating categories 3A, 3B and 3D from the agriculture sector is reported in this section.

A7.1 Enteric fermentation (3A)

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 the 2006 IPCC Guidelines (IPCC, 2006).

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)	REM	REG	GE (MJ/day)
1990	46.95	0.40	0.97	33.52	0.00	4.57	0.51	0.31	**260.66**
1995	46.95	0.40	0.97	43.38	0.00	4.45	0.51	0.31	**289.83**
2000	46.95	0.40	0.97	44.31	0.00	4.35	0.51	0.31	**292.33**
2005	46.95	0.40	0.97	50.84	0.00	4.27	0.51	0.31	**311.66**
2010	46.95	0.40	0.97	55.54	0.00	4.23	0.51	0.31	**325.60**
2011	46.95	0.40	0.97	54.87	0.00	4.24	0.51	0.31	**323.62**
2012	46.95	0.40	0.97	52.55	0.00	4.17	0.51	0.31	**316.46**
2013	46.95	0.40	0.97	52.06	0.00	4.19	0.51	0.31	**315.05**
2014	46.95	0.40	0.97	55.55	0.00	4.21	0.51	0.31	**325.56**
2015	46.95	0.40	0.97	56.89	0.00	4.18	0.51	0.31	**329.48**
2016	46.95	0.40	0.97	58.81	0.00	4.24	0.51	0.31	**335.42**

Source: ISPRA elaborations

For non-dairy cattle, emission factors are derived by the Nitrogen Balance Inter-regional Project that involved Emilia Romagna, Lombardy, Piedmont and Veneto regions, where animal breeding is concentrated and for that they have been assumed representative of the national level.
The project was aimed to develop models to calculate the nitrogen balance for different types of breeding, including cattle. The following information was collected: the movement of the heads and feed at farm level, animal nutrition plans, food consumption per animal category and bred, management techniques, reproductive phase and the productive results, mortality, age, weight at different growth and fattening phases, number and type of stable places in the herd, the type of simple foods or compound feed used, the estimated nitrogen content, the composition of the feed ration, average levels daily consumption per animal category and stage of breeding cycle (Xiccato *et al.*, 2004).

The survey data related to heifers replacement and other non-dairy cattle are described below.

Heifers replacement

Breeding performance
In the following box national average values of the main characteristics of the heifers replacement breeding are reported. Friesian, Brown and Red-spotted livestock breeds have been considered.
The national value are the average of the result of the survey carried out in Veneto, Emilia Romagna, Lombardy and Piedmont which monitores the food consumption, the composition of the rations and the numeric movements and weight of livestock in the period between 2002 and 2003. For Veneto, specifically, data from 89 representative farms, for a total of 8,466 heads, were collected (Regione Veneto, 2008; Bittante *et al.*, 2004).

Main characteristics of the heifers replacement breeding

	Unit of measure	Average value	Sd (2)
Age at weaning	day	85	23
Age at first calving	month	28.5	
Live weight at birth	kg/head	39	
Average live weight at weaning	kg/head	101	19
Average live weight at first calving	kg/head	540	
Food ration distribution			
Traditional	%	25	
Unified	%	38	
Mixed	%	37	
Intake of dry matter from weaning at first calving	kg/head/period	6473	1459
Daily dry matter intake	kg/d	8.24	1.89
Average crude protein ration (Nx6,25)	kg/kg	0.121	0.018
Nitrogen balance			
N consumed from birth to weaning	kg/head/period	5.3	2.7
N consumed from weaning to calving	kg/head/period	123.9	29.7
N retention in products from birth to calving	kg/head/period	14.41	
N excreted from birth to calving	kg/head/period	114.8	29.6
N annually excreted	kg/head/year	48.3 (1)	12.5

(1) the value was divided by the average weight and used to calculate the annual average nitrogen excretion for females from breeding between 1 and 2 years and more than 2 years (reported in CRPA, 2006[a]); (2) Standard deviation

Food consumption and composition of rations

Average value of dry matter intake from weaning at first calving is 6473 kg/head/period (8.24 kg of dry matter intake per day).

Animals receive rations based, even in summer, on hay fodder, corn silage and fibrous products with minimal additions of food concentrates.

The protein content of these rations is on average 12% of dry matter intake. The use of fresh grass is generally avoided, the best fodder are normally reserved for dairy cows and those inferior to heifers replacement.

Digestibility

The food ration is rich in fiber (as described above) and therefore less digestible than the ration of fattening animals. Methane conversion factors were estimated as a function of digestibility on the basis of factors in the 2006 IPCC guidelines.

Other cattle

Breeding performance

In Italy are widespread mainly the following breeding patterns: beef from intensive farming (representing 70-75% of the animal category), light or heavy, raised in confinement environment (fattening centers) in the Po valley; beef from extensive farming (representing 25-30% of the animal category), bred in unconfined environment in Piedmont, South Apennines center and in the islands, belonging to Italian beef breeds, fed through the pasture and concentrated foods, up to a final weight of about 650 kg (ISMEA, 2005).

Almost all of the animals sent to the slaughterhouse comes from national farms (97%) who breed for 45% of foreign origin animals and 55% of national origin animals (ISMEA, 2005). The latter are related to about 30% by specialized farms for meat and for the remaining part of dairy herds.

Food consumption and composition of rations

Since the beginning of the sixties, the intensive farming under confinement, the most prevalent in the Po valley, has been closely linked to the development of the cultivation of maize, as the main energy source, and the availability of flour from imported soybean, as a protein source (Regione Veneto, 2008). In the same years, in agricultural areas in Northern Italy a substantial abandonment of the cattle from traditional meat, based on a wide use of permanent and/or temporary fodder was recorded. This process has developed as a result of the development of the product ensiling technique obtained by chopping of the whole plant,

harvested in the milky-wax ripeness phase of kernels (corn silage). The use of corn silage increases by about 50% the amount of energy per hectare, reducing, consequently, the cost of the unit forage (Regione Veneto, 2008). The use of corn silage and concentrated feed, suitably integrated, in diets for cattle, increases the speed of growth of animals, improving the energy efficiency of the ration, reducing the duration of the production cycle and raising the yields of slaughter and the qualitative level of carcasses and meat (Regione Veneto, 2008).
In the survey conducted on 135 farms in Veneto, Lombardy and Piedmont useful information on the average type of the food composition and crude protein content of rations for Charolais cattle can be drawn (Cozzi, 2007). Despite some differences between farms located in different regions it is observed that in all cases the corn silage, the corn mash and cereals are the main constituents of rations. The use of dried beet pulp, in particular in the Veneto region, is significant. In Veneto and Lombardy, the long-fiber forages are represented almost exclusively by straw, while in Piedmont these are partially or totally replaced by permanent pasture hay. The supplement of protein is generally based on soybean flour. The protein content is in all cases around 14% of dry matter, a little more content than that found by Xiccato *et al.*, (Xiccato *et al.*, 2005) on 40 farms in Veneto (14.4% + 0.9%) and a slightly higher than that found by Mazzenga *et al.*, (Mazzenga *et al.*, 2007) on 406 farms in the Po valley (13% + 1.1%).

Food and chemical composition of unifeed rations for Charolais cattle in different regions (Cozzi, 2007)

Diet	**Veneto**	**Lombardy**	**Piedmont**	**Standard error**
Farms, n.	101	23	11	
Food ration, kg				
Silage corn	8.3	9.6	5.9	2.2
Mash corn	0.8	1.4	2.7	1.5
Cereals, flour and grains	2.7	1.8	2.1	1.2
Dried beet pulp	1.1	0.6	0.5	0.7
Fodder long fiber	0.7	0.7	1.0	0.4
Protein supplements, vitamins and	2.3	2.6	2.4	1.1
Molasses and vegetable fats	0.1	0.1	0.2	0.2
Chemical composition:				
Dry matter %	55.2	52.6	62.3	7.0
Crude protein %	14.0	13.9	14.0	0.9

Digestibility
As mentioned above, the rations consist mainly of silage and cereals and for fattening animals, the ration has been assumed more digestible. Therefore, for these categories of animals, lower default values of the methane conversion factor (from the 2006 IPCC Guidelines) with respect to the breeding categories have been assigned

A7.2 Manure management (3B)

In this section the country-specific methodology for estimating the amount of manure sent to the bio-digesters and the amount of methane produced, to be subtracted from the total amount of methane deriving from manure management, is explained.

Foreword
The inventory of methane emissions from manure management is based on a country specific methodology which also takes into account the share of manure sent to bio-digesters annually to recover power and heat.
In Italy the number of bio-digesters has been increasing for the last years in a significant way. Anaerobic digestion of animal manure allows for the recovery of energy and heat and also for reducing methane emissions to air.

1) The anaerobic bio-digesters in Italy and relevant assumptions
The information available concerning heat and power production from biogas at anaerobic digesters fed with animal manure and agriculture residues (energy crops, agro-industrial by-products) is supplied by TERNA and CRPA.

TERNA, the Italian electricity transmission grid operator, reports annually the production of energy from traditional sources and from renewable. As for energy from biogas production in anaerobic digesters TERNA

accounts for the number of digesters connected to the national grid and reports the power capacity, the energy production, combined heat and energy production and provides the figures separately for two categories:

- Bio-digesters receiving animal manure
- Bio-digesters receiving agriculture residues

The information is collected electronically and submitted by bio-digesters operators. TERNA's data about installed power, energy production, biogas used for energy production are then available for the inventory purposes (see data from renewable sources in sections "power plants" and "production" at http://www.terna.it/default/home_en/electric_system/statistical_data.aspx).
CRPA is the Research Centre on Animal Production, among other activities it has been studying the implementation of anaerobic digestion in the agricultural sector of our country and it has been carrying out surveys to build a picture of the anaerobic digestion plants in the livestock and agro-industrial sector in Italy. In the surveys total number of Italian anaerobic systems is considered, so the plants not connected to the national energy grid are included too. CRPA archive includes also information about the feed (plants working with animal manure, energy crops and agro-industrial by-products). Information about technologies and changes in technologies along the inventory time series is then also available for the inventory purposes.
Comparing the number of plants using manure in the CRPA surveys and those to TERNA, there is evidence that many operators using manure together with crops as a feed to digesters report their information to TERNA under the most general category agriculture residues.

Based on official data by TERNA and on information collected by CRPA (CRPA, 2013; CRPA, 2011; ENAMA, 2011; CRPA, 2008[a]) the inventory team provides with the following picture concerning bio-digesters in Italy:

- As for technology, up to 2005 anaerobic digestion of animal manure was implemented at about less than 100 plants. In the '90s typical reactor was a coverage storage structure where manure was stored and anaerobic digestion could occur, the output of the process being biogas mainly burned to recover heat for the livestock facility. In the following years, due to an increasing interest into anaerobic digestion and thanks to incentives to the sector, the implementation of multiple substrates (biomass) co-digestion at the same digester can be observed. As a consequence, the type of process reactor has been changing too, with CSTR (completely stirred tank reactor) reactors becoming the largest share out of the total number of digesters.
- The number of installations has been significantly increasing for the last years (following table), thus affecting also the amount of CH_4 emissions released actually to the atmosphere, that's why the GHG emissions inventory shall take into account also this practice.

In the following table a summary of the information provided by TERNA is supplied.

N° of plants and productions			**1990**	**1995**	**2000**	**2005**	**2010**	**2013**	**2014**	**2015**	**2016**
Anaerobic digesters	Total	n.	-	5	10	24	176	1,299	1,362	1,466	1,529
	Animal manure bio-digesters	n.	-	4	5	14	95	379	421	493	539
Energy production	Total	GWh	-	10.7	8.8	142	611.2	5,716	6,440	6,557	6,654
	Animal manure	GWh	-	8.1	4.9	26	221	817	989	1,067	1,160
	Agricultural residues	GWh	-	2.6	3.9	117	390.2	4,900	5,451	5,490	5,494
Biogas production	Total	Mm^3	-	Not available	Not available	631	798	2,849	3,180	3,034	3,051
	Animal manure	Mm^3	-	Not available	Not available	31	111	430	512	530	568
	Agricultural residues	Mm^3	-	Not available	Not available	601	686	2,419	2,667	2,505	2,482

Source: TERNA

Official information about biogas and energy production at bio-digesters, provided by TERNA, and information about feed of the bio-digesters, provided by CRPA, allow for estimating the amount of slurry and manure fed annually to the Italian bio-digesters.

The biogas average yield and the chemical characteristics of substrates fed to digesters are described in the following table supplied by CRPA (CRPA, 2012):

Tabella 8 - Rese medie e caratteristiche chimiche medie di alcuni substrati utilizzabili per la produzione di biogas

Matrice	Solidi volatili (kg/t)	Biogas (m^3/kg SV)	CH_4 (%)	NTK (% ST)	Matrice	Solidi volatili (kg/t)	Biogas (m^3/kg SV)	CH_4 (%)	NTK (% ST)
Liquami zootecnici									
Liquame suino	30	0,50	67	8	Liquame bovino	82	0,35	55	4,7
Solido separato bovino	200	0,4	55	2,5	Letame bovino	210	0,40	55	2,7
Prodotti vegetali									
Insilato di sorgo zuccherino	282	0,6	53	1,8	Insilato di grano	289	0,60	53	1,7
Insilato di erba	248	0,56	52	2,7	Insilato di mais	310	0,65	53	1,4
Scarti agro-industriali animali									
Siero di latte	55	0,75	60	2,3	Sangue bovino	101	0,65	65	11,4
Contenuti ruminali bovini	176	0,75	53	2,6	Fanghi di macelli suini	160	0,35	60	3
Fango di flottazione avicolo	85	0,35	60	14,7	Fanghi di macelli bovini	122	0,35	60	4,8
Scarti agro-industriali vegetali									
Scarti di lavorazione del mais dolce	154	0,48	55	2,2	Buccette e semi di pomodori	291	0,35	55	3,1
Scarti di leguminose	169	0,6	60	4,9	Scarti di lavorazione della patata	230	0,60	53	1,5

Dati CRPA

As for the types of feed treated in bio-digesters there has been a significant shift from single substrate feed to multiple substrates feed during the last years (CRPA, 2013; CRPA, 2011); the share of bio-digesters treating animal manure only has been decreasing while the share of plants operating co-digestion of multiple substrates feed has been increasing.

Type of feed	2007	2010	2011	2012
animal manure only (%)	56	36	29	18
animal manure+energy crops+ agricultural residues (%)	38	55	58	62
energy crops only (%)	6	9	13	20

Source: CRPA

Because of multiple substrates fed to bio-digesters, the following average characteristics of the feed, as supplied by CRPA, are considered for the Italian bio-digesters in order to calculate the total amount of feed from animal manure anaerobic digestion:

Type of feed	Units	animal manure	energy crops	agro-industrial by-products
Animal manure only	% in the feed	100	0	0

Animal manure + energy crops + agro-industrial by-products	% in the feed	70	15	15
Animal manure + energy crops	% in the feed	70	30	0
Animal manure + agro-industrial by-products	% in the feed	70	0	30
Energy crops + agro-industrial by-products	% in the feed	0	70	30

Source: CRPA

On the basis of the information reported above and in consideration of the typical feed of the bio-digesters the average parameters for animal manure, energy crops and agro-industrial by-products are those reported in the following table. The biogas methane content is generally reported to range from 50% to 65%, for the inventory purposes and according to CRPA methane content is assumed to be 55% (CRPA/AIEL, 2008; CRPA, 2008[b]).

Parameters	**Units**	**animal manure**	**energy crops**	**agro-industrial by-products**
Average biogas producing potential	m^3 biogas/kg VS	0.4	0.6	0.6
Average CH_4 content	%	55	55	55
Average Volatile Solids content	kg/t feed	80	280	150

Source: CRPA

On the basis of all this information total biogas generated from the amount of slurry and manure fed to bio-digesters can be estimated assuring that for the inventory purposes it does not include biogas generated based on other carbon sources than animal manure.

2) Losses from bio-digesters

Based on the information collected about the Italian bio-digesters, losses of biogas/methane can be characterized as:

- Biogas losses from anaerobic digestion unit (biogas escaping from the digester)
- Biogas losses from digestate storage
- Biogas losses from the combustion unit in the power&heat production step

As for point 1) according to the available literature on Italian bio-digesters (Fabbri *et al.*, 2011) and to the NIR of other EU Country (UBA, 2014) and to the 2016 EMEP/EEA Guidebook (see chapter 5.B.2 Biological treatment of waste – anaerobic digestion at biogas facilities, paragraph 2.3), where manure is processed in bio-digesters with similar technology implemented, the average losses of biogas is reported to be about 1% of the total biogas produced.

As for point 2) according to the IPCC Guidelines this contribution to the emission is equal to zero when covered storage units are in place. Based on our information, digestate covered storage units are in places at the Italian bio-digesters.

As for point 3) emissions resulting from power&heat production step are not to be allocated under agriculture for the purposes of the GHG emissions inventory and are already estimated and allocated in the energy sector.

3) Methodology and parameters

Based on the information supplied by TERNA and CRPA, a country specific methodology to estimate the *amount of animal manure treated in the bio-digesters* has been developed for the years 2007, 2010, 2011 and 2012 onwards. The amount of animal manure sent to anaerobic digesters is used to estimate both the equivalent number of heads and their related *CH_4 emissions to be subtracted* from the total CH_4 emissions from manure management and *CH_4 emissions from losses of the digesters*.

N_2O emissions from manure management have been revised too, because the emission factors (EFs) for animal manure sent to digesters are different from EFs for the other manure management systems (liquid system and solid storage).
In addition, for the reporting purposes the CH_4 producing potentials (Bo), the percentages of nitrogen allocation (by climate region and manure management systems) and methane conversion factors (MCF) have been revised for the relevant animal categories.

Amount of animal manure treated in bio-digesters
Official data about power capacity of digesters (TERNA) have been disaggregated based on the *distribution of digesters' installed power by type of feed* (CRPA).
On the basis of the operating hours, calculated from TERNA data on total energy production divided by the total installed power at digesters, the *energy production by type of feed* has been calculated for the relevant years.
TERNA data are used also to calculate the average energy efficiency and the lower heating value (LHV) that applied to energy productions allow for deriving the *amount of biogas used to produce energy per type of feed*.
Taking into account the percentage of biogas losses at digesters, equal to 1%, and the percentage of biogas flared at digesters, equal to 4%, it is possible to estimate the *biogas produced per type of feed* from biogas used. In 2017 submission, in response to the UNFCCC review process, the percentage of biogas flared has been estimated.
From biogas produced per type of feed it is possible to estimate the *total amount of feed* using the maximum biogas producing capacity (m^3 biogas/kg VS – volatile solid) and the VS content in the feed (kg VS/t feed).
In order to estimate the *amount of animal manure sent to digesters*, multiple substrates in the feed have to be considered taking in account the shares of different substrates in the feeds.

CH_4 emissions to be subtracted
In order to take into account the practice of manure management in anaerobic bio-digesters, the equivalent, in terms of MMS (liquid and solid), CH_4 emissions should be calculated on the basis of the amount of manure treated in these plants considering the equivalent number of heads and then subtracted from the total CH4 emissions from manure management. This is because the country specific methodology calculates the average EFs by livestock on the basis of national and international literature which refer to the "conventional" MMS of liquid and solid manure.
Manure sent to digesters has been distributed according to the type of manure (liquid/slurry and solid) and the animal category using the distribution of the national inventory.
Based on the coefficients of the national inventory related to annual production of manure per head and animal category and type of manure, it is possible to estimate *the number of head equivalent* per animal category and type of manure.
Finally, *CH_4 emissions from manure* sent to digesters are calculated multiplying these equivalent heads by EFs of the inventory expressed in kg CH_4/head per year.

CH_4 emissions from losses of bio-digesters
Losses from digesters are equal to 1% of biogas produced. Considering that CH_4 content is equal to 55% of biogas the resulting amount of CH_4 is calculated and added to the total CH_4 emissions from manure management and distributed by animal category.

N_2O emissions
The number of head equivalent per animal category and type of manure have been used to estimate also the amount of nitrogen stored in digesters multiplying the value by the relevant excreted nitrogen in housing coefficient for each animal category and type of manure.
Consequently, the amount of nitrogen stored in the other storage system has been revised too subtracting these N amounts from the relevant animal categories and their type of manure.
Emission factor of the 2006 IPCC Guidelines has been used to estimate the N_2O emissions from manure stored in digesters. The value is zero as reported in the 2006 IPCC Guidelines (IPCC, 2006).

MCF for anaerobic digester
The methane conversion factor has been calculated according to Formula 1 in table 10.17 in the 2006 IPCC Guidelines:

MCF = [{CH_4 prod - CH_4 used - CH_4 flared + (MCFstorage /100 * Bo * VSstorage * 0.67)}/ (Bo* VSstorage * 0.67)] *100

Where:
CH_4 prod = methane production in digester, (kg CH_4).
Note: When a gas tight coverage of the storage for digested manure is used, the gas production of the storage should be included.
CH_4 used = amount of methane gas used for energy, (kg CH_4)
CH_4 flared = amount of methane flared, (kg CH_4)
MCFstorage = MCF for CH_4 emitted during storage of digested manure (%)
VSstorage = amount of VS excreted that goes to storage prior to digestion (kg VS)
When a gas tight storage is included: MCFstorage = 0; otherwise MCFstorage = MCF value for liquid storage

In addition, digestate covered storage units are in places at the Italian bio-digesters so according to the Guidelines $MCF_{storage}$ is equal to 0.
The biogas flared at bio-digesters has been assumed equal to 4% of the total biogas produced (CRPA, 2016[a]).
In the CRF table 3B(a)s2, the nitrogen allocation and MCF supplied by climate region and manure management systems are reported.
The average CH_4 producing potential reported in Table 3B(a)s1 of the CRF has been revised accordingly using the average MCF for all manure management systems and the 2006 IPCC Guidelines' Equation 10.23.

4) Time series of total manure sent to anaerobic digestion
The amount of animal manure treated in the bio-digesters has been developed for the years 2007, 2010, 2011 and 2012 onwards, as described in the previous paragraphs. In order to develop the complete time series the following assumptions have been considered taking in account the information provided by TERNA:

- For the years 1990 no changes in the estimation occurred because digesters were not in place;
- For the years 1991-2000 the amount of animal manure treated in the bio-digesters has been estimated based on the energy production from anaerobic digestion of animal manure;
- For the years 2001-2006 the amount of animal manure treated in the bio-digesters has been estimated based on the biogas from animal manure used for energy production;
- For the years 2008 and 2009 the amount of animal manure treated in the bio-digesters has been estimated based on the total biogas used for energy production.

In Table A.7.2 the percentages of animals in temperate zone based on data from the FSS 2005, provided by ISTAT, and the average temperature at provincial level are shown.

A7.3 Agricultural soils (3D)

In Table A.7.3 parameters used for estimating direct and indirect N_2O emissions from sewage sludge applied to soils are presented.

Table A.7.3 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
1995	157,512	5.2	8,137
2000	217,424	5.0	10,954
2005	215,742	4.1	8,874
2010	248,215	4.0	10,040
2011	299,159	3.7	11,119
2012	274,095	4.7	12,864
2013	203,545	4.0	8,142

Year	Total amount sewage sludge for agriculture (t dry matter)	N content (%)	N sewage sludge (t)
2014	201,156	4.0	8,046
2015	215,287	4.0	8,611
2016	220,428	4.0	8,817

Source: ISPRA elaborations from MATTM (MATTM, 2014)

In Tables A.7.4-9, the cultivated surface, crops production, residues production and parameters used for emission calculation of nitrogen input from crop residues (FCR) for each type of crop are shown, respectively.

Table A.7.4 Cultivated surfaces for the estimation of crop residues

Cultivated surfaces (ha)	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Sorghum	23,676	34,417	33,900	31,578	40,311	42,335	37,099	51,066	51,914	45,374	43,840
Asparagus	6,046	6,520	5,516	6,442	6,359	6,347	6,010	5,560	6,313	6,397	6,476
Salad	48,725	49,288	51,219	50,010	47,371	45,838	43,358	46,180	42,085	40,647	43,427
Spinach	7,573	7,959	6,992	7,367	6,406	6,810	4,862	6,660	6,574	6,461	6,502
Cauliflower	19,405	23,991	24,827	18,150	17,867	16,990	17,098	15,657	16,377	15,624	16,259
Pumpkin and zucchini	13,253	13,490	14,621	16,736	17,354	18,071	16,955	18,011	18,934	18,614	19,234
Cucumber	4,373	3,814	2,048	2,331	2,219	2,420	2,130	2,415	2,191	2,071	2,082
Eggplant	10,574	10,334	12,355	12,169	10,816	11,063	9,770	10,059	10,331	10,148	10,031
Pepper and chili	14,864	13,099	14,489	13,787	11,881	12,882	11,358	12,135	11,555	11,521	11,037
Onion	17,453	15,725	14,562	12,281	12,603	13,004	10,749	11,513	12,531	11,877	12,710
Garlic	4,707	4,070	3,677	3,163	2,966	3,124	2,980	3,133	3,182	3,044	3,303
Bean,freshseed	29,096	23,943	23,448	23,146	19,027	20,292	17,256	19,646	16,590	17,059	18,686
Bean,dryseed	23,002	14,462	11,046	8,755	7,001	6,235	6,154	5,312	4,904	5,870	5,895
Broadbean,freshseed	16,564	14,180	11,998	9,484	8,487	7,440	6,515	9,235	8,484	7,914	7,592
Broadbean,dryseed	104,045	63,257	47,841	48,507	52,108	43,477	46,130	42,584	41,074	42,157	50,167
Pea,freshseed	28,192	21,582	11,403	11,636	8,691	24,026	15,283	14,190	15,821	14,940	16,255
Pea,dryseed	10,127	6,625	4,498	11,134	11,692	10,770	9,861	9,458	9,970	11,181	14,113
Chickpea	4,624	3,023	3,996	5,256	6,813	5,830	7,928	8,259	9,037	11,167	13,940
Lentil	1,048	1,038	1,016	1,786	2,458	2,156	2,629	2,643	2,463	3,099	3,215
Vetch	5,768	6,532	6,800	7,656	8,000	8,000	8,200	8,200	8,230	8,230	8,230
Lupin	3,303	3,070	3,300	2,500	4,000	4,000	5,000	5,000	4,620	4,620	4,620
Soyabean	521,169	195,191	256,647	152,331	159,511	165,955	152,993	184,146	232,867	308,979	288,060
Alfalfa	987,000	823,834	810,866	779,430	745,128	728,034	599,031	708,208	699,296	667,325	677,524
Clovergrass	224,087	125,009	114,844	103,677	102,691	101,819	86,976	108,310	115,902	119,942	124,864
Other forages	563,734	1,343,541	1,320,196	1,160,316	1,247,097	1,179,893	1,140,217	1,304,313	1,338,218	1,313,522	1,437,071
Total	**2,692,408**	**2,827,994**	**2,812,104**	**2,499,628**	**2,558,857**	**2,486,810**	**2,266,542**	**2,611,893**	**2,689,463**	**2,707,782**	**2,845,133**

Table A.7.5 Crops production for the estimation of crop residues

Crops production (t)	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Wheat	8,108,500	7,946,081	7,427,660	7,717,129	6,849,858	6,641,807	7,654,248	7,312,025	7,141,926	7,394,495	8,037,872
Rice	1,290,700	1,320,851	1,245,555	1,444,818	1,574,320	1,560,128	1,601,478	1,433,111	1,415,906	1,505,804	1,587,346
Barley	1,702,500	1,387,069	1,261,560	1,214,054	944,257	950,934	940,234	875,553	848,681	955,131	988,285
Maize, stalks	5,863,900	8,454,198	10,139,639	10,427,930	8,495,946	9,752,373	7,888,668	7,899,617	9,250,045	7,073,897	6,839,499
Maize, cobs	5,863,900	8,454,198	10,139,639	10,427,930	8,495,946	9,752,373	7,888,668	7,899,617	9,250,045	7,073,897	6,839,499
Rye	20,800	19,780	10,292	7,876	13,926	14,381	16,083	14,306	11,529	13,183	13,170
Oats	298,400	301,322	317,926	429,153	288,880	297,079	292,357	246,916	241,138	261,366	260,798
Triticum	10,480	13,210	0	0	0	0	0	0	0	0	0
Potatoes	2,308,700	2,080,896	2,053,043	1,755,686	1,558,030	1,557,489	1,486,292	1,272,211	1,365,440	1,355,409	1,368,920
Sweet potatoes	11,300	14,273	14,496	20,251	8,681	10,195	4,959	6,354	6,723	7,547	12,456
Sugar beet	11,768,400	13,188,317	11,569,182	14,155,683	3,549,871	2,501,159	2,492,466	2,159,381	3,784,435	2,183,878	2,046,297
Sunflower	403,500	533,581	460,714	289,365	212,900	274,520	185,494	285,233	250,377	248,007	268,331
Cabbage	491,600	450,687	482,147	478,972	502,955	485,725	474,539	495,763	458,572	467,412	416,513
Artichoke	487,000	517,229	512,946	469,975	480,112	474,550	364,871	457,799	451,461	401,335	365,991
Tomato	5,469,068	5,172,611	7,487,358	7,187,014	6,026,766	6,478,837	5,592,302	5,321,249	5,598,082	6,410,249	6,437,572
Soyabean	1,750,500	732,448	908,290	553,002	552,454	564,638	422,130	624,360	933,140	1,116,982	1,081,340
Alfalfa	30,094,610	27,858,100	25,662,700	25,924,100	21,928,700	20,833,200	15,142,100	18,389,700	19,342,200	17,255,600	20,880,700
Clovergrass	6,304,100	2,899,100	2,397,800	2,203,300	1,982,500	1,955,700	1,511,700	1,947,300	2,089,200	2,107,700	2,342,800
Other forages	16,111,141	37,748,200	34,952,100	32,448,400	29,615,200	29,709,700	27,477,600	27,471,700	33,717,000	30,620,000	32,843,700

Table A.7.6 Parameters used for emission of nitrogen input from crop residues (FCR)

Crops	Residues/Crop product mass ratio (1)	Residues/Crop surface (t/ha) (2)	Dry matter (%) (3)	Reincorporated fraction (4)	Protein in dry matter (5)	Nitrogen in dry matter (5)	Ratio of belowground residues to above-ground biomass (R_{BG-BIO}) (6)	N content of below-ground residues (N_{BG}) (6)	Dry matter fraction of harvested product (DRY) (6)	Slope (6)	Intercept (6)
Wheat	0.1725		85	0.9	0.03	0.0048	0.24	0.009			
Rice	0.1675		75	0.5	0.045	0.0072	0.16	0.014			
Barley	0.2		85	0.9	0.04	0.0064	0.22	0.014			
Maize, stalks	0.13		40	1	0.045	0.0072	0.22	0.007			
Maize, cobs	0.02		50	1	0.035	0.0056	0.22	0.007			
Rye	0.175		85	0.9	0.04	0.0064	0.24	0.011			
Oats	0.175		85	0.9	0.04	0.0064	0.25	0.008			
Sorghum		0.625		0.9	0.045	0.0072	0.24	0.006			
Triticum	0.2		85	0.9	0.04	0.0064	0.25	0.008			
Potatoes	0.4		40	0.9	0.09	0.0144	0.2	0.014			
Sweet potatoes	0.4		40	0.9	0.09	0.0144	0.2	0.014			
Sugar beet	0.07		20	0.9	0.125	0.02	0.2	0.014			
Sunflower	0.4		60	0.9	0.025	0.004	0.24	0.006			
Cabbage	2.5		15	0.9	0.175	0.028	0.2	0.014			
Artichoke	2.5		15	0.9	0.135	0.0216	0.2	0.014			
Asparagus		2.8		0.9	0.09375	0.015	0.2	0.014			
Salad		3.4		0.9	0.09375	0.015	0.2	0.014			
Spinach		3.4		0.9	0.09375	0.015	0.2	0.014			
Tomato	0.3		15	0.9	0.08	0.0128	0.2	0.014			
Cauliflower		3.8		0.9	0.09375	0.015	0.2	0.014			
Pumpkin and zucchini		9.5		0.9	0.09375	0.015	0.2	0.014			
Cucumber		8.5		0.9	0.09375	0.015	0.2	0.014			
Eggplant		9.5		0.9	0.09375	0.015	0.2	0.014			
Pepper and chili		9.5		0.9	0.09375	0.015	0.2	0.014			
Onion		0.7		0.9	0.09375	0.015	0.2	0.014			
Garlic		0.7		0.9	0.09375	0.015	0.2	0.014			
Bean,freshseed		17.7	20	0.9	0.125	0.02	0.19	0.008			
Bean,dryseed		0.6699	85	0.9	0.1	0.016	0.19	0.01			

Crops	Residues/Crop product mass ratio (1)	Residues/Crop surface (t/ha) (2)	Dry matter (%) (3)	Reincorporated fraction (4)	Protein in dry matter (5)	Nitrogen in dry matter (5)	Ratio of belowground residues to above-ground biomass (R_{BG-BIO}) (6)	N content of below-ground residues (N_{BG}) (6)	Dry matter fraction of harvested product (DRY) (6)	Slope (6)	Intercept (6)
Broadbean,freshseed		17.7	20	0.9	0.125	0.02	0.19	0.008			
Broadbean,dryseed		0.6699	85	0.9	0.1	0.016	0.19	0.008			
Pea,freshseed		17.7	20	0.9	0.125	0.02	0.19	0.008			
Pea,dryseed		0.6699	85	0.9	0.1	0.016	0.19	0.008			
Chickpea		0.6699	85	0.9	0.1	0.016	0.19	0.008			
Lentil		0.6699	85	0.9	0.1	0.016	0.19	0.008			
Tare		0.6699	85	0.9	0.1	0.016	0.19	0.008			
Lupin		0.6699	85	0.9	0.1	0.016	0.19	0.008			
Soyabean		2.6	47.5	0.9	0.075	0.012	0.19	0.008			
Alfalfa			15	0.2	0.16875	0.027	0.4	0.019			
Clovergrass			15	0.2	0.16875	0.027	0.8	0.016			
Perennial grasses				0.2		0.015	0.8	0.012	0.9	0.3	0

(1) CESTAAT, 1988 and ENEA, 1994; (2) CRPA/CNR, 1992 and ENEA, 1994; (3) IPCC, 1997; CRPA/CNR, 1992; CESTAAT, 1988; Borgioli, 1981; (4) Values are the complement of the fraction of fixed residues burned (CRPA, 1997 [b]); (5) Nitrogen in dry matter is equal to raw protein in residues (dry matter fraction) (CESTAAT, 1988; Borgioli, 1981) dividing by factor 6.25 (100 g of protein/16 g of nitrogen); (6) Table 11.2 of the 2006 IPCC Guidelines.

Table A.7.7 Fixed residues production for the estimation of crop residues

Fixed residues production (t dry matter)	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Wheat	1,188,909	1,165,094	1,089,081	1,131,524	1,004,360	973,855	1,122,304	1,072,126	1,047,185	1,084,218	1,178,553
Rice	162,144	165,932	156,473	181,505	197,774	195,991	201,186	180,035	177,873	189,167	199,410
Barley	289,425	235,802	214,465	206,389	160,524	161,659	159,840	148,844	144,276	162,372	168,008
Maize, stalks	304,923	439,618	527,261	542,252	441,789	507,123	410,211	410,780	481,002	367,843	355,654
Maize, cobs	58,639	84,542	101,396	104,279	84,959	97,524	78,887	78,996	92,500	70,739	68,395
Rye	3,094	2,942	1,531	1,172	2,072	2,139	2,392	2,128	1,715	1,961	1,959
Oats	44,387	44,822	47,292	63,837	42,971	44,190	43,488	36,729	35,869	38,878	38,794
Sorghum	14,798	21,511	21,188	19,736	25,194	26,459	23,187	31,916	32,446	28,359	27,400
Triticum	1,782	2,246	0	0	0	0	0	0	0	0	0
Potatoes	369,392	332,943	328,487	280,910	249,285	249,198	237,807	203,554	218,470	216,865	219,027
Sweet potatoes	1,808	2,284	2,319	3,240	1,389	1,631	793	1,017	1,076	1,208	1,993
Sugar beet	164,758	184,636	161,969	198,180	49,698	35,016	34,895	30,231	52,982	30,574	28,648
Sunflower	96,840	128,059	110,571	69,448	51,096	65,885	44,519	68,456	60,091	59,522	64,399
Cabbage	184,350	169,008	180,805	179,615	188,608	182,147	177,952	185,911	171,964	175,280	156,193
Artichoke	182,625	193,961	192,355	176,241	180,042	177,956	136,827	171,675	169,298	150,501	137,246
Asparagus	16,929	18,256	15,444	18,038	17,805	17,771	16,828	15,569	17,676	17,913	18,134
Salad	165,665	167,579	174,144	170,035	161,060	155,849	147,416	157,013	143,090	138,199	147,651
Spinach	25,748	27,061	23,774	25,049	21,781	23,155	16,531	22,644	22,353	21,966	22,106
Tomato	246,108	232,767	336,931	323,416	271,204	291,548	251,654	239,456	251,914	288,461	289,691
Cauliflower	73,739	91,166	94,343	68,970	67,895	64,562	64,972	59,497	62,233	59,371	61,784
Pumpkin and zucchini	125,904	128,155	138,898	158,987	164,863	171,672	161,075	171,100	179,875	176,831	182,727
Cucumber	37,171	32,419	17,405	19,813	18,865	20,569	18,104	20,526	18,621	17,600	17,694
Eggplant	100,453	98,173	117,371	115,602	102,751	105,100	92,814	95,561	98,145	96,404	95,290
Pepper and chili	141,208	124,441	137,648	130,975	112,871	122,376	107,902	115,284	109,772	109,454	104,854
Onion	12,217	11,008	10,193	8,597	8,822	9,103	7,524	8,059	8,772	8,314	8,897
Garlic	3,295	2,849	2,574	2,214	2,076	2,187	2,086	2,193	2,227	2,131	2,312
Bean,freshseed	103,000	84,758	83,004	81,936	67,354	71,832	61,086	69,545	58,728	60,388	66,149
Bean,dryseed	13,098	8,235	6,290	4,985	3,986	3,550	3,504	3,025	2,792	3,342	3,357
Broadbean,freshseed	58,637	50,197	42,473	33,573	30,044	26,338	23,063	32,692	30,033	28,016	26,876
Broadbean,dryseed	59,245	36,019	27,241	27,621	29,671	24,756	26,267	24,248	23,388	24,005	28,566
Pea,freshseed	99,800	76,400	40,366	41,193	30,766	85,051	54,101	50,234	56,007	52,887	57,542
Pea,dryseed	5,766	3,772	2,561	6,340	6,658	6,133	5,615	5,386	5,677	6,367	8,036
Chickpea	2,633	1,721	2,275	2,993	3,879	3,320	4,514	4,703	5,146	6,359	7,938
Lentil	597	591	579	1,017	1,400	1,228	1,497	1,505	1,402	1,765	1,831
Vetch	3,284	3,719	3,872	4,359	4,555	4,555	4,669	4,669	4,686	4,686	4,686
Lupin	1,881	1,748	1,879	1,424	2,278	2,278	2,847	2,847	2,631	2,631	2,631

Fixed residues production (t dry matter)	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Soyabean	643,644	241,061	316,959	188,129	196,996	204,954	188,946	227,420	287,591	381,589	355,754
Alfalfa	4,514,192	4,178,715	3,849,405	3,888,615	3,289,305	3,124,980	2,271,315	2,758,455	2,901,330	2,588,340	3,132,105
Clovergrass	945,615	434,865	359,670	330,495	297,375	293,355	226,755	292,095	313,380	316,155	351,420
Other forages	2,416,671	5,662,230	5,242,815	4,867,260	4,442,280	4,456,455	4,121,640	4,120,755	5,057,550	4,593,000	4,926,555
Total	**12,884,370**	**14,891,306**	**14,183,307**	**13,679,961**	**12,036,301**	**12,013,451**	**10,557,014**	**11,126,877**	**12,351,766**	**11,583,658**	**12,570,265**

Table A.7.8 Estimate of nitrogen from crop residues of perennial grasses (1)

Total nitrogen (t N)	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Surface (ha)	855,117	931,388	893,737	828,835	879,405	928,929	704,447	898,498	943,435	923,759	842,531
Production (kt)	15,213	16,946	15,842	13,854	14,478	14,581	11,461	12,215	11,215	11,645	10,236
Crop (kg dm/ha) (2)	16,012	16,375	15,953	15,043	14,817	14,127	14,643	12,236	10,698	11,346	10,934
AG_{DM} (t/ha) (3)	4.80	4.91	4.79	4.51	4.45	4.24	4.39	3.67	3.21	3.40	3.28
R_{AG} (kg dm/ kg dm) (4)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.30	0.30
R_{BG} (kg dm/ kg dm) (5)	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
F_{CR} of perennial grasses (t N) (6)	**36,640**	**40,812**	**38,153**	**33,365**	**34,870**	**35,117**	**27,603**	**29,420**	**27,009**	**28,047**	**24,652**

(1) According to the equations 11.6 and 11.7 of the 2006 IPCC Guidelines; (2) Harvested annual dry matter yield - kg harvested fresh yield / ha * DRY (dry matter fraction); (3) Above-ground residue dry matter calculated as (Crop/1000)*slope+intercept; (4) Ratio of above-ground residues dry matter to harvested yield, calculated as AG_{DM}*1000/Crop; (5) Ratio of below-ground residues to harvested yield, calculated as $R_{BG\text{-}BIO}$*[(AG_{DM}*1000+Crop)/Crop]; (6) Calculated according to equation 11.6 assuming $Frac_{Renew}$=1/5, Area burnt=0, $Frac_{Remove}$=0.8.

Table A.7.9 Total nitrogen content in the above-ground and belowground biomass of crop residues

Total nitrogen (t N)	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Wheat	7,704	7,550	7,057	7,332	6,508	6,311	7,273	6,947	6,786	7,026	7,637
Rice	947	969	801	929	1,013	1,003	1,030	922	911	969	1,021
Barley	2,559	2,084	1,896	1,824	1,419	1,429	1,413	1,316	1,275	1,435	1,485
Maize, stalks	2,665	3,842	4,608	4,739	3,861	4,432	3,585	3,590	4,204	3,215	3,108
Maize, cobs	419	604	724	745	607	696	563	564	660	505	488
Rye	26	25	13	10	17	18	20	18	14	16	16
Oats	344	348	367	495	333	343	337	285	278	302	301
Sorghum	117	170	168	156	200	210	184	253	257	225	217
Triticum	14	17	0	0	0	0	0	0	0	0	0
Potatoes	5,822	5,247	5,177	4,427	3,929	3,927	3,748	3,208	3,443	3,418	3,452
Sweet potatoes	28	36	37	51	22	26	13	16	17	19	31
Sugar beet	3,427	3,840	3,369	4,122	1,034	728	726	629	1,102	636	596
Sunflower	488	645	557	350	258	332	224	345	303	300	325
Cabbage	5,162	4,732	5,063	5,029	5,281	5,100	4,983	5,206	4,815	4,908	4,373
Artichoke	4,062	4,314	4,278	3,920	4,004	3,958	3,043	3,818	3,765	3,347	3,052
Asparagus	276	298	252	294	290	290	274	254	288	292	296
Salad	2,700	2,732	2,839	2,772	2,625	2,540	2,403	2,559	2,332	2,253	2,407
Spinach	420	441	388	408	355	377	269	369	364	358	360
Tomato	3,524	3,333	4,825	4,631	3,884	4,175	3,604	3,429	3,607	4,131	4,148
Cauliflower	1,202	1,486	1,538	1,124	1,107	1,052	1,059	970	1,014	968	1,007
Pumpkin and zucchini	2,052	2,089	2,264	2,591	2,687	2,798	2,626	2,789	2,932	2,882	2,978
Cucumber	606	528	284	323	307	335	295	335	304	287	288
Eggplant	1,637	1,600	1,913	1,884	1,675	1,713	1,513	1,558	1,600	1,571	1,553
Pepper and chili	2,302	2,028	2,244	2,135	1,840	1,995	1,759	1,879	1,789	1,784	1,709
Onion	199	179	166	140	144	148	123	131	143	136	145
Garlic	54	46	42	36	34	36	34	36	36	35	38
Bean,freshseed	2,011	1,654	1,620	1,599	1,315	1,402	1,192	1,358	1,146	1,179	1,291
Bean,dryseed	213	134	103	81	65	58	57	49	46	54	55
Broadbean,freshseed	1,145	980	829	655	586	514	450	638	586	547	525
Broadbean,dryseed	943	573	434	440	472	394	418	386	372	382	455
Pea,freshseed	1,948	1,491	788	804	601	1,660	1,056	981	1,093	1,032	1,123
Pea,dryseed	92	60	41	101	106	98	89	86	90	101	128
Chickpea	42	27	36	48	62	53	72	75	82	101	126
Lentil	10	9	9	16	22	20	24	24	22	28	29
Vetch	52	59	62	69	73	73	74	74	75	75	75
Lupin	30	28	30	23	36	36	45	45	42	42	42
Soyabean	7,930	2,970	3,905	2,318	2,427	2,525	2,328	2,802	3,543	4,701	4,383

Total nitrogen (t N)	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Alfalfa	58,684	54,323	50,042	50,552	42,761	40,625	29,527	35,860	37,717	33,648	40,717
Clovergrass	17,210	7,915	6,546	6,015	5,412	5,339	4,127	5,316	5,704	5,754	6,396
Other forages	31,417	73,609	68,157	63,274	57,750	57,934	53,581	53,570	65,748	59,709	64,045
Perennial grasses	36,640	40,812	38,153	33,365	34,870	35,117	27,603	29,420	27,009	28,047	24,652
Total	**207,122**	**233,831**	**221,621**	**209,831**	**189,991**	**189,820**	**161,745**	**172,108**	**185,518**	**176,417**	**185,076**

Table A.7.2 Distribution of animals in temperate zone

Percentage of animals in temperate zone based on data from the FSS 2005 (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	141,054	9,422	11,842	5,399	16,626	285	1,384,201	605,549	121,305	476,111
(002) Vercelli	11.4	11.4	6,139	3,361	0	19,044	3,023	4,530	2,747	378	177	240,844	90	367,320	38,487
(003) Novara	11.7	11.8	11,634	11,941	659	36,837	4,066	442	1,464	2,024	0	163,436	135,522	26,764	206,579
(004) Cuneo	11.4	11.5	360,266	79,864	0	731,302	51,882	24,890	7,375	353	7	1,906,594	513,460	794,541	1,533,321
(005) Asti	11.7	11.9	44,507	965	0	16,147	1,305	2,118	3,771	2,531	83	517,799	407,027	34,957	144,573
(006) Alessandria	11.5	11.6	37,346	3,671	0	24,322	1,120	3,109	3,929	277	80	73,144	216,432	360,226	43,049
(007) Aosta	11.5	11.6	17,379	22,332	0	26	0	2,586	3,339	116	32	9	2,602	98	1,832
(008) Imperia	11.1	11.1	2,372	353	0	3	0	843	2,686	53	0	26	557	4	7,288
(009) Savona	12.7	13.2	4,030	58	0	107	0	16,799	450	154	8	5,370	19,638	156	84,045
(010) Genova	12.4	12.9	5,357	1,551	0	134	39	4,984	3,266	2,844	149	12,259	46,343	5,251	29,698
(011) La Spezia	12.2	12.7	3,063	591	0	184	11	2,627	978	654	36	5,012	12,435	1,077	43,258
(012) Varese	11.4	11.5	13,632	5,249	7	2,161	88	5,275	2,655	3,128	465	50,165	344,100	175,959	22,252
(013) Como	12.1	12.4	11,270	7,743	2	844	178	5,475	9,227	3,616	591	135,711	29,395	13,744	88,340
(014) Sondrio	12.3	12.6	9,318	15,448	0	835	13	7,028	12,890	654	503	679,686	58,918	24	293
(015) Milano	12.2	12.5	62,266	36,960	1,782	105,264	7,399	2,833	1,551	2,431	122	97,755	710,011	59,622	5,330
(016) Bergamo	11.9	12.0	112,201	69,614	643	301,455	30,604	28,808	14,355	9,783	753	1,475,925	1,529,460	516,977	5,959
(017) Brescia	12.1	12.3	342,654	148,660	859	1,325,421	107,005	40,160	10,360	6,638	12	14,969,749	3,551,027	2,087,292	78,676
(018) Pavia	11.8	12.0	20,446	9,054	0	239,372	15,395	0	2,045	640	23	2,104	174,942	215,736	0
(019) Cremona	12.1	12.3	165,913	115,308	676	619,897	70,275	2,299	65	1,255	18	2,799,928	1,541,962	1,641,787	6,804
(020) Mantova	12.1	12.4	265,591	109,883	0	1,055,515	60,972	0	870	683	87	1,182,334	5,613,807	817,826	17,568
(021) Bolzano-Bozen	11.7	11.8	67,713	83,892	0	13,775	311	50,645	19,508	6,354	428	85	139,010	2,096	40,398
(022) Trento	10.8	11.3	17,303	29,737	0	7,205	171	29,731	9,778	3,313	571	1,182,144	397,493	34,367	174,295
(023) Verona	11.2	11.8	190,794	35,635	0	308,473	11,067	56	177	9,441	0	16,208,619	4,569,421	11,982,064	3,443,690
(024) Vicenza	10.6	11.3	125,108	55,512	17	40,793	2,005	5,790	456	1,482	525	3,768,250	462,832	802,257	196,126
(025) Belluno	10.6	11.3	7,385	5,953	0	51,281	10,121	3,693	840	1,578	525	2,673	163	3,312	84,823
(026) Treviso	10.7	11.3	155,378	23,915	1,260	90,117	13,957	1	149	293	2	2,551,739	1,784,328	123,347	2,367,946
(027) Venezia	10.9	11.5	50,470	10,028	366	64,423	4,807	0	1,291	1,784	48	766,865	2,518,034	409,170	17,047
(028) Padova	10.7	11.3	157,703	35,518	916	116,291	12,043	3,763	86	3,291	41	1,988,851	1,801,912	1,194,511	3,613,169
(029) Rovigo	10.6	11.2	42,008	3,964	0	63,709	6,297	1,633	427	805	648	529,387	117,033	586,075	12,874
(030) Udine	10.8	11.4	28,891	32,597	0	61,905	2,591	2,065	1,821	1,717	202	2,801,700	5,597	284,658	871,719
(031) Gorizia	10.9	11.5	3,379	3,626	0	26,850	0	0	0	107	0	248,250	131,708	924,779	69,399
(032) Trieste	10.9	11.6	598	201	0	1,395	0	0	0	0	0	8,303	6,894	9,909	3,825
(033) Piacenza	10.7	11.2	46,684	31,700	13	73,967	4,598	44	8	2,589	273	84,174	173,053	0	153

Percentage of animals in temperate zone based on data from the FSS 2005 (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
(034) Parma	10.8	11.4	68,174	99,234	0	143,740	9,496	20	91	4,681	33	89,323	43,864	314	8,811
(035) Reggio nell'Emilia	10.8	11.4	66,270	79,949	247	458,294	21,186	607	725	3,827	243	361,411	76,942	42,922	3,023
(036) Modena	11.9	12.1	67,416	60,029	0	406,547	41,590	64	208	2,533	120	87,552	214,697	113,066	631,984
(037) Bologna	11.6	11.8	20,526	8,482	0	41,449	3,503	12,056	236	9,883	163	47,197	1,276,246	122,438	0
(038) Ferrara	11.7	12.0	45,143	10,999	0	23,212	3,623	0	98	4,385	91	0	102,049	57,109	7,138
(039) Ravenna	11.7	12.0	13,141	3,179	0	43,760	3,106	14,092	682	3,522	764	698,792	2,308,670	3,301,798	379,957
(040) Forli'-Cesena	11.8	12.1	18,275	2,382	1	93,476	15,742	26,716	1,127	3,380	12	16,350,182	7,581,497	7,795,705	243,449
(041) Pesaro e Urbino	12.4	12.7	30,155	2,429	0	12,423	623	100,473	1,654	3,286	64	39,984	311,955	51,308	298,142
(042) Ancona	12.0	12.3	9,137	1,141	0	14,308	1,415	11,661	486	137	25	1,382,625	67,488	19,237	108,960
(043) Macerata	13.0	13.3	13,794	1,378	0	9,894	738	46,279	903	589	102	1,167,510	67	0	375,329
(044) Ascoli Piceno	13.3	13.8	20,587	288	0	77,063	1,228	76,380	4,166	3,286	507	1,060,249	2,310,685	4,027	164,214
(045) Massa-Carrara	12.4	12.6	4,167	926	57	3,480	263	11,899	855	2,752	386	14,659	21,813	931	54,446
(046) Lucca	12.3	12.9	3,560	988	0	847	6	16,156	289	262	0	33,688	53,335	958	39,418
(047) Pistoia	12.5	13.2	8,092	86	0	673	38	5,605	388	4,210	804	0	516	0	1,645
(048) Firenze	12.0	12.8	13,514	3,265	0	36,506	1,557	31,180	1,899	3,729	678	101,134	48,525	135,053	29,539
(049) Livorno	12.9	13.7	1,999	459	0	273	153	11,793	133	1,723	175	980	3,449	59,521	7,174
(050) Pisa	12.2	12.9	9,570	1,548	0	31,749	5,708	54,005	869	1,172	335	8,725	246,875	1,619	3,208
(051) Arezzo	12.2	12.7	9,710	246	22	76,399	8,336	33,407	3,649	1,144	491	187,271	105,848	1,436	283,164
(052) Siena	12.8	13.0	19,327	1,026	0	25,569	3,053	144,022	788	693	311	3,574	285,186	7,576	41,695
(053) Grosseto	13.8	14.0	24,968	5,363	395	30,962	2,853	375,071	1,617	7,262	241	6,741	16,471	8,498	68,160
(054) Perugia	13.2	13.3	41,054	11,904	0	223,062	4,769	145,178	6,516	7,151	251	2,786,387	1,035,490	310,913	146,088
(055) Terni	14.0	14.4	14,305	1,268	0	16,236	1,279	34,266	780	3,671	286	312,851	71,851	0	170,015
(056) Viterbo	14.0	14.1	21,859	10,870	921	14,188	1,027	290,585	415	2,287	641	509,739	124,450	80,398	238,483
(057) Rieti	14.0	14.1	26,425	7,172	868	3,744	204	92,899	4,755	9,425	861	362,698	126,234	1,552	51,895
(058) Roma	14.3	14.6	50,058	30,440	178	7,339	60	136,543	1,068	9,081	847	352,347	4,391	411	74,045
(059) Latina	14.6	15.0	37,987	31,533	28,647	13,181	96	62,152	20,800	2,925	509	39,081	292,776	1,160	632,981
(060) Frosinone	14.0	14.0	38,070	12,196	9,745	11,437	140	83,099	4,415	3,602	318	53,017	53,417	1,036	61,351
(061) Caserta	14.6	14.8	27,251	23,498	94,898	14,949	861	31,420	393	206	115	129,455	487,659	4,417	113,682
(062) Benevento	14.6	14.8	34,280	11,568	486	27,936	7,221	84,341	7,127	755	1,581	2,272,767	14,875	2,544	63,136
(063) Napoli	15.0	15.4	3,224	2,032	49	3,245	180	55	3,886	10	65	111,888	327,038	262,730	2,960
(064) Avellino	15.0	15.4	23,552	7,994	0	7,708	78	68,246	4,530	993	473	106,903	210,764	9,201	150,075
(065) Salerno	14.9	15.2	50,412	36,366	55,014	41,469	1,763	112,374	38,780	3,231	1,189	93,292	106,829	7,965	88,775
(066) L'Aquila	12.2	13.5	12,215	4,450	0	14,687	807	104,169	1,516	11,451	833	2,537	65,951	583	151,727
(067) Teramo	11.8	13.2	26,091	12,463	0	26,659	2,743	157,028	1,411	2,608	73	182,779	77,359	218,748	50,584

Percentage of animals in temperate zone based on data from the FSS 2005 (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
(068) Pescara	11.1	12.2	12,430	4,218	0	12,178	737	49,259	191	152	136	201,951	54,764	163	121,929
(069) Chieti	11.4	12.6	21,034	3,141	0	13,904	1,146	23,913	1,610	1,567	285	968,714	96,927	11,236	65,367
(070) Campobasso	13.9	14.3	18,793	13,149	229	27,232	1,345	60,164	3,301	1,482	29	7,067,027	144,105	923	3,226
(071) Foggia	13.6	14.1	27,297	6,128	4,543	10,279	61	100,938	23,540	2,851	1,403	699,034	14,783	102	6,242
(072) Bari	13.7	14.2	35,866	31,546	199	5,149	752	64,117	3,937	3,065	32	4,673	306,370	1,409	117,228
(073) Taranto	13.9	14.5	22,345	25,796	0	12,844	178	24,980	6,611	3,611	93	1,163	211,415	60,027	80,720
(074) Brindisi	14.0	14.6	2,156	7,166	0	559	40	6,321	5,116	531	57	1,097	324,767	300	34,077
(075) Lecce	13.4	13.8	3,546	2,251	0	503	235	27,399	6,805	552	24	14	165,333	13	238
(076) Potenza	13.1	13.5	65,499	25,430	99	56,040	1,998	404,287	77,440	4,746	581	72,778	44,609	2,889	512,259
(077) Matera	13.5	13.8	15,452	9,590	515	7,642	293	102,658	37,197	2,988	103	3,752	74,191	5,249	314,349
(078) Cosenza	14.8	15.5	35,907	5,883	82	44,360	2,064	170,629	84,350	3,003	227	145,554	160,280	2,669	98,547
(079) Catanzaro	14.1	14.9	4,183	920	0	6,377	343	24,168	7,030	38	0	622	9,367	0	475
(080) Reggio di Calabria	14.5	15.5	19,585	1,807	0	14,070	1,037	50,802	38,585	253	0	13,029	48,974	253	40,978
(081) Trapani	14.4	15.3	3,430	888	0	186	69	57,240	1,065	3,544	73	129	31,954	34	3,647
(082) Palermo	14.5	15.4	46,032	4,790	0	2,679	875	132,035	12,444	1,562	63	32	316,059	0	290
(083) Messina	14.6	15.5	65,155	2,062	0	13,432	1,005	93,336	52,551	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	1,332	19	20	0	26,829	0	35,568
(085) Caltanissetta	14.3	15.1	5,459	1,216	0	116	28	48,617	1,889	332	30	0	76,878	0	0
(086) Enna	15.0	15.6	48,664	1,489	0	4,227	440	110,030	5,190	594	172	5	65,692	0	0
(087) Catania	15.7	16.3	17,120	2,856	0	311	110	38,035	2,502	1,389	5	16	241,512	212	16,676
(088) Ragusa	15.7	16.3	49,505	26,664	0	4,967	315	18,496	0	903	90	392,370	721,491	0	561
(089) Siracusa	16.0	16.7	57,381	8,293	71	16,803	35	75,830	6,523	1,098	426	242,604	654,764	0	30,031
(090) Sassari	14.1	14.6	117,502	2,374	0	31,935	14,538	1,217,792	30,994	5,935	1,098	0	100,557	0	140,560
(091) Nuoro	15.0	15.4	64,036	5,800	0	35,439	13,568	918,328	85,029	10,951	687	42,136	211,093	282,830	272,447
(092) Cagliari	14.4	14.6	16,639	1,074	0	82,024	23,342	819,856	156,043	2,633	856	67,976	681,328	920,414	464
(093) Pordenone	11.3	11.3	26,760	14,452	0	147,435	40,071	997	0	665	10	1,303,096	262,413	138,240	78,768
(094) Isernia	11.5	11.4	16,093	7,221	131	11,785	174	45,531	3,122	1,008	35	641,701	1,511	0	14,747
(095) Oristano	11.5	11.4	37,907	24,089	0	11,760	7,127	455,419	10,775	3,026	556	14,240	6,134	767	25,286
(096) Biella	11.4	11.4	8,850	3,617	0	16,082	5,709	13,521	2,721	606	240	222	765	97,447	0
(097) Lecco	11.5	11.6	4,335	1,634	0	2,460	339	1,924	1,189	1,908	277	288,301	5,001	1,219	7,950
(098) Lodi	12.2	12.5	53,611	46,294	353	358,589	25,804	0	6	745	0	16	1,257,958	92	0
(099) Rimini	11.7	12.0	4,523	166	0	22,083	1,454	7,946	0	1,077	150	184,953	145,785	621,136	0
(100) Prato	12.0	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	3,727	50	44,091	21,369	756	235	373,670	102,356	77	4,724

Percentage of animals in temperate zone based on data from the FSS 2005 (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
(102) Vibo Valentia	14.1	14.9	6,206	2,529	3	2,082	108	48,520	3,067	143	0	235	52,649	0	1,697
(103) Verbano-Cusio-Ossola	11.7	11.8	2,570	2,567	0	163	7	12,443	11,160	624	200	381	1,854	223	1,049
Total			4,409,921	1,842,004	205,093	8,478,427	721,843	7,954,167	945,895	278,471	30,254	97,532,025	52,692,584	38,370,412	20,504,282
N animals in temperate zone			552,951	140,747	83,864	208,355	21,948	2,046,930	380,826	38,047	6,040	1,560,813	3,971,390	567,236	1,378,261
% animals in temperate zone			12.5%	7.6%	40.9%	2.5%	3.0%	25.7%	40.3%	13.7%	20.0%	1.6%	7.5%	1.5%	6.7%
Based on temperature non weighted by % animals															
N animals in temperate zone			285,415	55,975	121	76,427	14,775	1,273,110	129,030	16,695	2,153	1,269,593	2,534,710	555,050	477,474
% animals in temperate zone			6.5%	3.0%	0.1%	0.9%	2.0%	16.0%	13.6%	6.0%	7.1%	1.3%	4.8%	1.4%	2.3%

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 and 10s6 from the Common Reporting Format 2016, submitted in 2018, in which time series of emission estimates for the following gases are reported:

- CO_2 eq.
- All gases and sources categories

Table A8.1.1.1 CO_2 emissions trends, CRF year 2016

TABLE 10 EMISSION TRENDS

$CO_{2\ eq}$

Inventory 2016

Submission 2018

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(kt CO_2 eq)										
Total (net emissions)[2]	515,321	515,321	502,825	502,702	509,800	490,384	511,066	502,855	518,950	532,639	528,561
1. Energy	425,499	425,499	426,224	424,763	419,926	414,507	439,343	434,233	439,015	449,955	453,977
A. Fuel combustion (sectoral approach)	412,622	412,622	413,511	412,007	407,110	402,007	427,216	422,414	427,075	438,078	443,129
1. Energy industries	137,158	137,158	132,722	131,496	125,758	127,890	141,694	136,530	138,299	148,691	144,847
2. Manufacturing industries and construction	93,235	93,235	89,631	87,735	87,167	89,255	91,346	88,867	92,455	85,710	89,039
3. Transport	102,100	102,100	104,722	109,864	111,499	111,173	113,621	115,042	116,766	120,904	122,077
4. Other sectors	78,986	78,986	85,130	81,515	81,105	72,097	78,991	80,690	78,217	81,641	85,961
5. Other	1,143	1,143	1,306	1,397	1,581	1,591	1,566	1,284	1,337	1,132	1,204
B. Fugitive emissions from fuels	12,877	12,877	12,714	12,756	12,815	12,501	12,127	11,820	11,941	11,877	10,848
1. Solid fuels	132	132	117	130	87	81	74	70	70	66	64
2. Oil and natural gas and other emissions from energy production	12,745	12,745	12,597	12,626	12,729	12,419	12,052	11,750	11,871	11,811	10,784
C. CO_2 transport and storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Industrial Processes	40,473	40,473	40,016	39,399	36,418	35,029	38,292	35,279	35,924	36,556	37,112
A. Mineral industry	20,720	20,720	20,682	21,477	19,076	18,591	20,240	18,575	18,844	19,106	19,903
B. Chemical industry	10,546	10,546	10,843	10,320	9,816	9,158	10,362	9,216	9,438	9,514	9,344
C. Metal industry	6,421	6,421	5,743	4,827	4,790	4,400	4,320	3,703	3,487	3,282	2,726
D. Non-energy products from fuels and solvent use	1,710	1,710	1,693	1,719	1,655	1,610	1,564	1,510	1,512	1,452	1,454
E. Electronic industry	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	199	194	216	276	260
F. Product uses as ODS substitutes	NO	NO	0	2	5	162	314	512	818	1,366	2,047
G. Other product manufacture and use	1,077	1,077	1,054	1,054	1,075	1,108	1,294	1,567	1,608	1,562	1,378
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Agriculture	35,078	35,078	35,729	35,166	35,488	35,108	34,992	34,816	35,415	34,782	35,160
A. Enteric fermentation	15,497	15,497	15,731	15,239	15,066	15,138	15,319	15,457	15,423	15,282	15,468
B. Manure management	6,824	6,824	6,814	6,533	6,493	6,322	6,439	6,441	6,422	6,477	6,534
C. Rice cultivation	1,876	1,876	1,791	1,860	1,950	2,000	1,989	1,959	1,945	1,838	1,800
D. Agricultural soils	10,396	10,396	10,851	10,976	11,337	11,039	10,713	10,499	11,080	10,637	10,786
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	19	19	20	20	19	19	18	19	18	20	20
G. Liming	1	1	1	1	1	1	1	1	1	1	2
H. Urea application	465	465	519	536	622	588	512	439	525	526	551
I. Other carbon-containing fertilizers	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table A8.1.1.1 CO_2 emissions trends, CRF year 2016

TABLE 10 EMISSION TRENDS

$CO_{2\ eq}$

Inventory 2016

Submission 2018

J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry[2]	-3,043	-3,043	-17,122	-14,991	-870	-13,744	-21,574	-22,157	-12,737	-9,734	-18,769
A. Forest land	-16,840	-16,840	-29,032	-27,544	-16,760	-27,450	-30,605	-30,303	-22,496	-20,894	-26,031
B. Cropland	2,225	2,225	1,531	1,614	1,715	1,803	1,861	2,498	2,388	2,289	2,149
C. Grassland	4,936	4,936	1,560	1,831	5,458	2,863	-989	-427	1,148	2,983	-926
D. Wetlands	NE,NO	NE,NO	5	5	5	5	5	8	8	8	8
E. Settlements	7,145	7,145	8,937	8,938	8,938	8,939	8,941	6,980	6,980	6,980	6,981
F. Other land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Harvested wood products	-520	-520	-133	152	-239	81	-804	-928	-777	-1,111	-958
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Waste	17,313	17,313	17,978	18,365	18,837	19,483	20,013	20,685	21,334	21,080	21,081
A. Solid waste disposal	12,206	12,206	12,831	13,264	13,844	14,481	15,123	15,800	16,369	16,102	16,150
B. Biological treatment of solid waste	25	25	30	36	41	60	58	48	122	148	196
C. Incineration and open burning of waste	594	594	639	629	587	591	547	546	572	566	491
D. Waste water treatment and discharge	4,488	4,488	4,477	4,436	4,365	4,350	4,285	4,291	4,271	4,264	4,244
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items:											
International bunkers	8,819	8,819	8,835	8,642	9,049	9,178	9,978	9,088	9,490	10,131	10,833
Aviation	4,321	4,321	5,168	5,111	5,269	5,444	5,851	6,206	6,280	6,829	7,547
Navigation	4,498	4,498	3,667	3,530	3,780	3,734	4,127	2,882	3,210	3,302	3,286
Multilateral operations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 emissions from biomass	13,749	13,749	15,987	15,170	15,495	15,937	16,565	16,575	17,811	18,112	19,614
CO_2 captured	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Long-term storage of C in waste disposal sites	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Indirect N_2O	2,986	2,986	3,048	3,098	2,996	2,843	2,782	2,696	2,619	2,501	2,341
Indirect CO_2 [3]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total CO_2 equivalent emissions without land use, land-use change and forestry	518,363	518,363	519,947	517,693	510,670	504,128	532,640	525,013	531,687	542,373	547,330
Total CO_2 equivalent emissions with land use, land-use change and forestry	515,321	515,321	502,825	502,702	509,800	490,384	511,066	502,855	518,950	532,639	528,561
Total CO_2 equivalent emissions, including indirect CO2, without land use, land-use change and forestry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total CO_2 equivalent emissions, including indirect CO2, with land use, land-use change and forestry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A8.1.1.1 CO_2 emissions trends, CRF year 2016)

TABLE 10 EMISSION TRENDS

$CO_{2\ eq}$

Inventory 2016

Submission 2018

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(kt CO_2 eq)									
Total (net emissions)[2]	538,809	537,748	532,536	555,265	553,773	553,343	541,685	556,655	523,946	469,749
1. Energy	459,130	463,335	464,311	477,838	480,126	480,163	474,204	465,219	455,667	408,381
A. Fuel combustion (sectoral approach)	448,312	453,120	454,272	467,395	470,663	470,783	465,453	456,689	447,014	400,003
1. Energy industries	149,461	153,052	159,896	161,214	161,693	161,298	160,945	159,857	156,436	133,344
2. Manufacturing industries and construction	92,195	88,188	84,310	89,591	88,026	83,914	83,230	79,582	75,480	56,494
3. Transport	123,262	125,013	127,459	127,566	129,277	128,047	129,291	129,348	122,343	116,712
4. Other sectors	82,512	86,487	82,271	88,300	90,459	96,201	90,903	86,910	91,935	92,512
5. Other	881	380	336	724	1,208	1,323	1,085	992	820	941
B. Fugitive emissions from fuels	10,818	10,215	10,039	10,443	9,463	9,381	8,751	8,531	8,653	8,379
1. Solid fuels	97	108	107	134	85	90	66	114	97	59
2. Oil and natural gas and other emissions from energy production	10,721	10,107	9,932	10,309	9,378	9,291	8,685	8,417	8,556	8,319
C. CO_2 transport and storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Industrial Processes	39,161	41,068	41,437	43,055	45,955	46,710	42,776	43,117	40,568	35,403
A. Mineral industry	20,749	21,531	21,555	22,430	23,187	23,305	23,403	23,817	21,531	17,295
B. Chemical industry	10,058	10,358	10,109	10,221	11,417	10,735	5,863	5,088	3,992	3,193
C. Metal industry	2,762	3,029	2,783	2,501	2,424	2,780	2,671	2,647	2,657	1,921
D. Non-energy products from fuels and solvent use	1,432	1,386	1,389	1,372	1,356	1,350	1,355	1,345	1,278	1,164
E. Electronic industry	350	287	313	327	300	278	200	155	165	131
F. Product uses as ODS substitutes	2,444	3,207	4,090	5,004	6,035	7,057	8,038	8,941	9,790	10,601
G. Other product manufacture and use	1,366	1,270	1,199	1,200	1,237	1,204	1,246	1,124	1,155	1,099
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Agriculture	34,259	33,706	33,071	32,987	32,715	32,083	31,708	32,368	31,431	30,840
A. Enteric fermentation	15,048	14,408	13,968	14,030	13,723	13,709	13,446	13,953	13,834	13,891
B. Manure management	6,373	6,472	6,294	6,276	6,104	6,055	5,891	6,034	6,052	6,143
C. Rice cultivation	1,656	1,655	1,713	1,750	1,826	1,752	1,755	1,802	1,650	1,835
D. Agricultural soils	10,636	10,613	10,511	10,343	10,454	10,026	10,046	10,007	9,357	8,562
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	18	17	19	18	21	20	19	20	21	19
G. Liming	2	2	6	6	10	14	12	16	18	17
H. Urea application	525	539	560	565	576	507	539	537	498	372
I. Other carbon-containing fertilizers	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table A8.1.1.1 CO_2 emissions trends, CRF year 2016)

TABLE 10 EMISSION TRENDS

$CO_{2\ eq}$

Inventory 2016

Submission 2018

J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry[2]	-15,655	-23,571	-28,756	-20,952	-26,767	-27,509	-28,364	-5,045	-24,172	-25,464
A. Forest land	-24,904	-30,910	-34,501	-28,301	-32,750	-33,612	-33,321	-17,113	-29,797	-32,424
B. Cropland	2,046	1,465	1,456	1,469	1,465	1,459	1,248	1,290	1,252	1,344
C. Grassland	683	-881	-2,355	-670	-1,893	-2,643	-3,370	3,722	-2,724	-1,965
D. Wetlands	8	8	8	8	8	8	8	8	8	NE,NO
E. Settlements	6,982	6,985	6,987	6,989	6,992	7,804	7,813	7,816	7,858	7,895
F. Other land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Harvested wood products	-476	-245	-357	-453	-596	-531	-749	-775	-775	-320
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Waste	21,914	23,211	22,472	22,337	21,743	21,895	21,361	20,995	20,453	20,589
A. Solid waste disposal	17,200	18,446	17,719	17,538	16,942	17,002	16,429	16,104	15,633	15,746
B. Biological treatment of solid waste	249	323	397	437	431	489	519	533	520	531
C. Incineration and open burning of waste	286	305	256	278	277	313	325	293	289	327
D. Waste water treatment and discharge	4,180	4,136	4,100	4,083	4,093	4,091	4,088	4,065	4,010	3,985
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items:										
International bunkers	12,217	12,693	12,342	14,215	14,824	15,444	16,695	17,592	17,903	15,604
Aviation	8,030	7,934	6,874	7,989	8,028	8,559	9,288	9,854	9,466	8,345
Navigation	4,188	4,759	5,468	6,226	6,795	6,885	7,407	7,738	8,438	7,259
Multilateral operations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 emissions from biomass	18,678	18,436	13,408	20,016	16,206	23,652	26,825	34,517	41,695	43,156
CO_2 captured	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Long-term storage of C in waste disposal sites	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Indirect N_2O	2,225	2,165	2,066	2,068	2,007	1,909	1,798	1,771	1,593	1,476
Indirect CO_2 [3]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total CO_2 equivalent emissions without land use, land-use change and forestry	554,464	561,319	561,292	576,217	580,540	580,851	570,049	561,700	548,118	495,213
Total CO_2 equivalent emissions with land use, land-use change and forestry	538,809	537,748	532,536	555,265	553,773	553,343	541,685	556,655	523,946	469,749
Total CO_2 equivalent emissions, including indirect CO2, without land use, land-use change and forestry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total CO_2 equivalent emissions, including indirect CO2, with land use, land-use change and forestry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A8.1.1.1 CO_2 emissions trends, CRF year 2016)

TABLE 10 EMISSION TRENDS

$CO_{2\ eq}$

Inventory 2016

Submission 2018

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2010	2011	2012	2013	2014	2015	2016	Change from base to latest reported year
	(kt CO_2 eq)							
Total (net emissions)[2]	473,349	466,329	453,846	408,291	391,852	397,552	397,935	-22.78
1. Energy	417,157	404,666	387,038	359,961	345,100	352,536	347,080	-18.43
A. Fuel combustion (sectoral approach)	408,316	395,954	378,452	351,440	337,049	344,986	339,860	-17.63
1. Energy industries	134,012	132,668	128,340	108,838	100,215	105,800	104,358	-23.91
2. Manufacturing industries and construction	62,581	61,488	55,629	51,633	52,645	50,920	47,945	-48.58
3. Transport	115,159	114,093	106,471	103,784	108,619	105,988	104,505	2.36
4. Other sectors	95,873	87,160	87,650	86,559	74,970	81,799	82,519	4.47
5. Other	692	546	363	626	599	478	533	-53.36
B. Fugitive emissions from fuels	8,841	8,712	8,586	8,521	8,052	7,551	7,221	-43.93
1. Solid fuels	86	92	80	58	57	44	42	-68.22
2. Oil and natural gas and other emissions from energy production	8,755	8,620	8,506	8,463	7,994	7,506	7,178	-43.68
C. CO_2 transport and storage	NO	NO	NO	NO	NO	NO	NO	0.00
2. Industrial Processes	36,357	36,613	33,771	32,825	32,399	32,282	32,098	-20.69
A. Mineral industry	17,379	16,736	13,724	12,298	11,606	11,212	10,607	-48.81
B. Chemical industry	3,363	3,133	2,918	3,136	2,937	2,959	3,078	-70.81
C. Metal industry	2,006	2,205	2,021	1,731	1,689	1,611	1,764	-72.52
D. Non-energy products from fuels and solvent use	1,135	1,151	1,068	1,058	1,020	969	980	-42.64
E. Electronic industry	182	217	193	208	235	222	219	100.00
F. Product uses as ODS substitutes	11,343	12,226	12,847	13,464	14,073	14,447	14,660	100.00
G. Other product manufacture and use	949	945	1,001	929	839	861	789	-26.67
H. Other	NA	NA	NA	NA	NA	NA	NA	0.00
3. Agriculture	30,065	30,329	30,916	29,747	29,243	29,435	30,394	-13.35
A. Enteric fermentation	13,530	13,542	13,521	13,684	13,577	13,696	14,039	-9.41
B. Manure management	5,988	5,758	5,702	5,295	5,125	5,179	5,228	-23.39
C. Rice cultivation	1,822	1,805	1,789	1,661	1,613	1,668	1,710	-8.87
D. Agricultural soils	8,352	8,829	9,318	8,623	8,486	8,434	8,857	-14.80
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	0.00
F. Field burning of agricultural residues	19	19	20	19	19	20	21	11.67
G. Liming	18	25	16	14	12	14	12	800.50
H. Urea application	335	351	551	450	411	425	527	13.40
I. Other carbon-containing fertilizers	NO	NO	NO	NO	NO	NO	NO	0.00

Table A8.1.1.1 CO_2 emissions trends, CRF year 2016)

TABLE 10 EMISSION TRENDS

$CO_{2\ eq}$

Inventory 2016

Submission 2018

J. Other	NO	NO	NO	NO	NO	NO	NO	0.00
4. Land use, land-use change and forestry[2]	-30,640	-25,049	-17,763	-32,930	-33,425	-35,326	-29,927	883.52
A. Forest land	-35,591	-31,567	-27,110	-36,507	-37,640	-39,034	-35,802	112.60
B. Cropland	1,335	2,427	2,379	2,339	2,213	2,160	2,489	11.86
C. Grassland	-4,160	-3,995	-1,344	-7,133	-6,296	-6,656	-6,484	-231.36
D. Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NO,NE	NO,NE	0.00
E. Settlements	7,897	7,903	7,907	7,914	7,922	7,936	9,692	35.65
F. Other land	NO	NO	NO	NO	NO	NO	NO	0.00
G. Harvested wood products	-128	178	400	453	375	267	172	-133.07
H. Other	NO	NO	NO	NO	NO	NO	NO	0.00
5. Waste	20,410	19,769	19,883	18,689	18,535	18,625	18,290	5.64
A. Solid waste disposal	15,558	15,005	15,087	13,853	13,784	13,979	13,621	11.59
B. Biological treatment of solid waste	619	631	630	659	714	642	653	2513.00
C. Incineration and open burning of waste	243	246	278	298	184	173	176	-70.31
D. Waste water treatment and discharge	3,990	3,888	3,888	3,879	3,853	3,832	3,839	-14.46
E. Other	NO	NO	NO	NO	NO	NO	NO	0.00
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	0.00
Memo items:								
International bunkers	15,863	16,494	15,287	13,888	13,558	15,236	17,203	95.06
Aviation	8,890	9,295	9,008	8,951	9,105	9,651	10,384	140.29
Navigation	6,973	7,199	6,280	4,937	4,452	5,584	6,819	51.61
Multilateral operations	NE	NE	NE	NE	NE	NE	NE	0.00
CO_2 emissions from biomass	43,151	37,503	43,418	46,738	43,753	46,243	45,411	230.29
CO_2 captured	NO	NO	NO	NO	NO	NO	NO	0.00
Long-term storage of C in waste disposal sites	NO	NO	NO	NO	NO	NO	NO	0.00
Indirect N_2O	1,436	1,386	1,316	1,198	1,185	1,149	1,116	-62.64
Indirect CO_2 [3]	NO	NO	NO	NO	NO	NO	NO	0.00
Total CO_2 equivalent emissions without land use, land-use change and forestry	503,989	491,378	471,609	441,222	425,277	432,878	427,862	-17.46
Total CO_2 equivalent emissions with land use, land-use change and forestry	473,349	466,329	453,846	408,291	391,852	397,552	397,935	-22.78
Total CO_2 equivalent emissions, including indirect CO2, without land use, land-use change and forestry	NA	NA	NA	NA	NA	NA	NA	0.00
Total CO_2 equivalent emissions, including indirect CO2, with land use, land-use change and forestry	NA	NA	NA	NA	NA	NA	NA	0.00

Table A8.1.2.1 Total emission trends, CRF year 2016

TABLE 10 EMISSION TRENDS
SUMMARY

Inventory 2016
Submission 2018

GREENHOUSE GAS EMISSIONS	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (kt)										
CO_2 emissions without net CO_2 from LULUCF	439,944	439,944	440,094	439,210	431,601	425,491	451,979	444,562	449,466	460,240	464,601
CO_2 emissions with net CO_2 from LULUCF	434,595	434,595	421,418	422,536	427,977	409,847	429,231	421,347	435,073	448,525	444,629
CH_4 emissions without CH_4 from LULUCF	48,236	48,236	49,119	48,966	49,283	49,686	50,311	50,806	51,339	50,853	50,818
CH_4 emissions with CH_4 from LULUCF	49,719	49,719	49,790	49,761	51,031	50,631	50,657	51,208	52,293	52,074	51,393
N_2O emissions without N_2O from LULUCF	26,423	26,423	27,343	26,809	27,216	26,427	27,231	26,966	27,692	27,659	28,007
N_2O emissions with N_2O from LULUCF	27,246	27,246	28,226	27,697	28,222	27,381	28,059	27,622	28,394	28,420	28,635
HFCs	444	444	449	455	452	613	869	619	1,041	1,568	2,085
PFCs	2,907	2,907	2,510	1,819	1,672	1,423	1,492	1,235	1,281	1,329	1,328
Unspecified mix of HFCs and PFCs	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA
SF_6	410	410	432	434	446	489	681	763	814	689	464
NF_3	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	77	62	54	34	27
Total (without LULUCF)	518,363	518,363	519,947	517,693	510,670	504,128	532,640	525,013	531,687	542,373	547,330
Total (with LULUCF)	515,321	515,321	502,825	502,702	509,800	490,384	511,066	502,855	518,950	532,639	528,561
Total (without LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (with LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (kt)										
1. Energy	425,499	425,499	426,224	424,763	419,926	414,507	439,343	434,233	439,015	449,955	453,977
2. Industrial processes and product use	40,473	40,473	40,016	39,399	36,418	35,029	38,292	35,279	35,924	36,556	37,112
3. Agriculture	35,078	35,078	35,729	35,166	35,488	35,108	34,992	34,816	35,415	34,782	35,160
4. Land use, land-use change and forestry[5]	-3,043	-3,043	-17,122	-14,991	-870	-13,744	-21,574	-22,157	-12,737	-9,734	-18,769
5. Waste	17,313	17,313	17,978	18,365	18,837	19,483	20,013	20,685	21,334	21,080	21,081
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)[5]	515,321	515,321	502,825	502,702	509,800	490,384	511,066	502,855	518,950	532,639	528,561

Table A8.1.2.1 Total emission trends, CRF year 2016

TABLE 10 EMISSION TRENDS
SUMMARY

Inventory 2016
Submission 2018

GREENHOUSE GAS EMISSIONS	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO_2 equivalent (kt)									
CO_2 emissions without net CO_2 from LULUCF	470,768	476,202	477,709	491,481	495,528	495,234	489,750	480,492	468,062	415,932
CO_2 emissions with net CO_2 from LULUCF	453,502	451,393	448,045	469,153	467,718	466,752	460,487	472,760	442,737	389,183
CH_4 emissions without CH_4 from LULUCF	50,737	50,835	49,184	49,371	47,738	48,206	46,827	47,476	47,117	47,143
CH_4 emissions with CH_4 from LULUCF	51,669	51,444	49,512	50,097	48,166	48,565	47,122	49,311	47,611	47,739
N_2O emissions without N_2O from LULUCF	28,374	28,670	28,017	27,864	28,644	27,799	22,875	22,409	20,902	19,822
N_2O emissions with N_2O from LULUCF	29,053	29,298	28,597	28,514	29,259	28,413	23,480	23,261	21,560	20,511
HFCs	2,479	3,244	4,121	5,041	6,066	7,089	8,070	8,972	9,810	10,611
PFCs	1,488	1,503	1,491	1,882	1,951	1,940	1,935	1,886	1,712	1,215
Unspecified mix of HFCs and PFCs	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA
SF_6	605	853	741	550	585	550	570	453	496	472
NF_3	13	13	28	28	29	33	22	12	19	18
Total (without LULUCF)	554,464	561,319	561,292	576,217	580,540	580,851	570,049	561,700	548,118	495,213
Total (with LULUCF)	538,809	537,748	532,536	555,265	553,773	553,343	541,685	556,655	523,946	469,749
Total (without LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (with LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO_2 equivalent (kt)									
1. Energy	459,130	463,335	464,311	477,838	480,126	480,163	474,204	465,219	455,667	408,381
2. Industrial processes and product use	39,161	41,068	41,437	43,055	45,955	46,710	42,776	43,117	40,568	35,403
3. Agriculture	34,259	33,706	33,071	32,987	32,715	32,083	31,708	32,368	31,431	30,840
4. Land use, land-use change and forestry[5]	-15,655	-23,571	-28,756	-20,952	-26,767	-27,509	-28,364	-5,045	-24,172	-25,464
5. Waste	21,914	23,211	22,472	22,337	21,743	21,895	21,361	20,995	20,453	20,589
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)[5]	538,809	537,748	532,536	555,265	553,773	553,343	541,685	556,655	523,946	469,749

Table A8.1.2.1 Total emission trends, CRF year 2016

TABLE 10 EMISSION TRENDS
SUMMARY

Inventory 2016
Submission 2018

GREENHOUSE GAS EMISSIONS	2010	2011	2012	2013	2014	2015	2016	Change from base to latest reported year
	CO_2 equivalent (kt)							(%)
CO_2 emissions without net CO_2 from LULUCF	424,873	413,432	391,990	363,400	348,476	355,483	350,323	-20.37
CO_2 emissions with net CO_2 from LULUCF	393,234	387,139	372,256	329,721	314,121	319,310	319,245	-26.54
CH_4 emissions without CH_4 from LULUCF	46,769	45,123	45,724	44,046	43,132	43,133	42,870	-11.12
CH_4 emissions with CH_4 from LULUCF	47,126	45,693	46,936	44,236	43,475	43,424	43,266	-12.98
N_2O emissions without N_2O from LULUCF	19,057	18,450	19,066	18,145	17,627	17,636	17,954	-32.05
N_2O emissions with N_2O from LULUCF	19,699	19,124	19,826	18,703	18,213	18,192	18,710	-31.33
HFCs	11,356	12,242	12,860	13,479	14,091	14,468	14,682	3206.66
PFCs	1,520	1,661	1,499	1,705	1,564	1,688	1,629	-43.98
Unspecified mix of HFCs and PFCs	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	0.00
SF_6	394	441	445	421	359	441	377	-7.95
NF_3	20	28	25	26	28	28	28	100.00
Total (without LULUCF)	503,989	491,378	471,609	441,222	425,277	432,878	427,862	-17.46
Total (with LULUCF)	473,349	466,329	453,846	408,291	391,852	397,552	397,935	-22.78
Total (without LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	0.00
Total (with LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	0.00

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2010	2011	2012	2013	2014	2015	2016	Change from base to latest reported year
	CO_2 equivalent (kt)							(%)
1. Energy	417,157	404,666	387,038	359,961	345,100	352,536	347,080	-18.43
2. Industrial processes and product use	36,357	36,613	33,771	32,825	32,399	32,282	32,098	-20.69
3. Agriculture	30,065	30,329	30,916	29,747	29,243	29,435	30,394	-13.35
4. Land use, land-use change and forestry[5]	-30,640	-25,049	-17,763	-32,930	-33,425	-35,326	-29,927	883.52
5. Waste	20,410	19,769	19,883	18,689	18,535	18,625	18,290	5.64
6. Other	NO	NO	NO	NO	NO	NO	NO	0.00
Total (including LULUCF)[5]	473,349	466,329	453,846	408,291	391,852	397,552	397,935	-22.78

A8.2 Supplementary information under Article 7, paragraph 1

A8.2.1 KP-LULUCF

Table A8.2.1.1 Activity coverage and other information relating to activities under Article 3, paragraph 3, forest management under Article 3.4, and elected activities under Article 3.4

Table NIR 1. SUMMARY TABLE

Activity	CHANGE IN CARBON POOL REPORTED(1)							GREENHOUSE GAS SOURCES REPORTED(2)							
	Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil		HWP(4)	Fertilization(5)	Drained, rewetted and other soils(6)		Nitrogen mineralization in mineral soils(8)	Indirect N_2O emissions from managed soil(5)	Biomass burning(9)		
					Mineral	Organic(3)		N_2O	CH4(7)	N_2O	N_2O	N_2O	CO_2(10)	CH_4	N_2O
Article 3.3 activities															
Afforestation and reforestation	R	R	R	R	R	NO	R	NO	NO	NO	R	R	R	R	R
Deforestation	R	R	R	R	R	NO	R	NO	NO	NO	NO	NO	NO	NO	NO
Article 3.4 activities															
Forest management	R	R	R	R	NR	NR	R	NO	NO	NO	NO	NO	R	R	R
Cropland management	R	R	NO	NO	R	R			NO		NO		R	R	R
Grazing land management	NO	NO	NO	NO	R	NO			NO		NO		NO	NO	NO
Revegetation	NA	NA	NA	NA	NA	NA		NA	NA	NA	NA	NA	NA	NA	NA
Wetland drainage and rewetting	NA	NA	NA	NA		NA		NA	NA	NA		NA	NA	NA	NA

(1) Indicate R (reported), NR (not reported), IE (included elsewhere) or NO (not occurring), for each relevant activity under Article 3.3, forest management or any elected activity under Article 3.4, or instantaneous oxidation (IO) for carbon stock changes in harvest wood products (HWP). With the exception of HWP, if changes in a carbon pool are not reported , verifiable information in the national inventory report (NIR) must be provided that demonstrates that these unaccounted pools were not a net source of anthropogenic greenhouse gas emissions. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the NIR.
(2) Indicate R (reported), NE (not estimated), IE (included elsewhere) or NO (not occurring) for greenhouse gas sources reported, for each relevant activity under Article 3.3, forest management or any elected activity under Article 3.4. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the NIR.
(3) Includes CO_2 emissions/removals from organic soils, including CO_2 emissions from dissolved organic carbon associated with drainage and rewetting. On-site CO_2 emissions/removals from drainage and rewetting from organic soils and off-site CO_2 emissions via water-borne carbon losses from organic soils should be reported here for wetland drainage and rewetting. These emissions could be reported for other activities as appropriate.
(4) HWP from lands reported under deforestation, which originated from the deforestation event at the time of the land-use change shall be accounted for on the basis of instantaneous oxidation (IO).

(5) N_2O emissions from fertilization of afforestation/reforestation, deforestation, forest management, revegetation and wetland drainage and rewetting should be reported here when these emissions are not reported under the agriculture sector.
(6) CH_4 and N_2O emissions from drained and rewetted organic soils should be reported here, as appropriate, when emissions are not reported under the agriculture sector. For wetland drainage and rewetting only emissions from organic soils are included.
(7) CH_4 emissions from drained soils and drainage ditches should be reported here, as appropriate.
(8) N_2O emissions from nitrogen mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils under afforestation/reforestation, deforestation, forest management, cropland management, grazing land management and revegetation should be reported here when these emissions are not reported under the agriculture sector.
(9) Emissions from burning of organic soils should also be included here, as appropriate.
(10) If CO_2 emissions from biomass burning are not already included under changes in carbon stocks, they should be reported under biomass burning. Parties that include CO_2 emissions from biomass burning in their carbon stock change estimates should report IE (included elsewhere).

Table A8.2.1.2 Areas and changes in areas between the previous and the current inventory year. Land transition matrix 1990

Table NIR 2. LAND TRANSITION MATRIX 1990

	ARTICLE 3.3 ACTIVITIES		ARTICLE 3.4 ACTIVITIES					Other[6]	Total area at the end of the previous inventory year[7]
	Afforestation and reforestation	Deforestation	Forest management[5]	Cropland management (if elected)	Grazing land management (if elected)	Revegetation (if elected)	Wetland drainage and rewetting (if elected)		
	(kha)								
Article 3.3 activities									
Afforestation and reforestation	73.77	NO							73.77
Deforestation		14.44							14.44
Article 3.4 activities									
Forest management		0.72	7511.12						7511.84
Cropland management[3] (if elected)	NO		NO	10704.36	NO	NO	NO		10704.36
Grazing land management[3] (if elected)	NO		NO	NO	2.99	NO	NO		2.99
Revegetation[3] (if elected)	NA		NA	NA	NA	NA	NA		NA
Wetland drainage and rewetting[3] (if elected)	NA		NA	NA	NA	NA	NA		NA
Other[4]	78.68	NO	NO	NO	NO	NO	NO	11747.51	11826.19
Total area at the end of the current inventory year	152.45	15.17	7511.12	10704.36	2.99	NA,NO	NA,NO	11747.51	30133.60

[1] This table should be used to report land area and changes in land area subject to the various activities in the inventory year. For each activity it should be used to report area change between the end of the previous inventory year and the end of the current inventory year. For example, the total area of land subject to forest management in the previous inventory year and which was deforested in the current inventory year, should be reported in the deforestation column and in the forest management row.
[2] In accordance with relevant decisions. Some of the transitions in the matrix are not possible and the cells concerned have been shaded.

[3] Lands subject to cropland management, grazing land management, revegetation or wetland drainage and rewetting that after 2013 are subject to activities other than those under Article 3.3 and 3.4, should still be tracked and reported under cropland management, grazing land management, revegetation or wetland drainage and rewetting, respectively.
[4] Other refers to the area that is reported under Article 3.3 or 3.4 in the current inventory for the first time. This footnote does not apply to the cell belonging to the column and the row "other" to "other".
[5] Changes in area from cropland management, grazing land management, revegetation and wetland drainage and rewetting to forest management should be reported only in the case of carbon equivalent forest conversions.
[6] "Other", in this column, is the area of the country that has never been subject to any activity under Article 3.3 or 3.4

[7] The value in the cell of row "Total area at the end of the current inventory year" corresponds to the total land area of a country. The total land area should be the same for the current inventory year and the previous inventory year in this matrix.

Table A8.2.1.3 Areas and changes in areas between the previous and the current inventory year. Land transition matrix 2013

Table NIR 2. LAND TRANSITION MATRIX 2013

	ARTICLE 3.3 ACTIVITIES		ARTICLE 3.4 ACTIVITIES					Other[6]	Total area at the end of the previous inventory year[7]
	Afforestation and reforestation	Deforestation	Forest management[5]	Cropland management (if elected)	Grazing land management (if elected)	Revegetation (if elected)	Wetland drainage and rewetting (if elected)		
	(kha)								
Article 3.3 activities									
Afforestation and reforestation	1670.08	NO							1670.08
Deforestation		40.39							40.39
Article 3.4 activities									
Forest management		3.69	7467.76						7471.45
Cropland management[3] (if elected)	NO		NO	8939.12	NO	NO	NO		8939.12
Grazing land management[3] (if elected)	NO		NO	NO	290.70	NO	NO		290.70
Revegetation[3] (if elected)	NA		NA	NA	NA	NA	NA		NA
Wetland drainage and rewetting[3] (if elected)	NA		NA	NA	NA	NA	NA		NA
Other[4]	58.31	NO	NO	NO	92.14	NO	NO	11571.40	11721.85
Total area at the end of the current inventory year	1728.40	44.08	7467.76	8939.12	382.84	NA,NO	NA,NO	11571.40	30133.60

[1] This table should be used to report land area and changes in land area subject to the various activities in the inventory year. For each activity it should be used to report area change between the end of the previous inventory year and the end of the current inventory year. For example, the total area of land subject to forest management in the previous inventory year and which was deforested in the current inventory year, should be reported in the deforestation column and in the forest management row.
[2] In accordance with relevant decisions. Some of the transitions in the matrix are not possible and the cells concerned have been shaded.

[3] Lands subject to cropland management, grazing land management, revegetation or wetland drainage and rewetting that after 2013 are subject to activities other than those under Article 3.3 and 3.4, should still be tracked and reported under cropland management, grazing land management, revegetation or wetland drainage and rewetting, respectively.
[4] Other refers to the area that is reported under Article 3.3 or 3.4 in the current inventory for the first time. This footnote does not apply to the cell belonging to the column and the row "other" to "other".
[5] Changes in area from cropland management, grazing land management, revegetation and wetland drainage and rewetting to forest management should be reported only in the case of carbon equivalent forest conversions.
[6] "Other", in this column, is the area of the country that has never been subject to any activity under Article 3.3 or 3.4

[7] The value in the cell of row "Total area at the end of the current inventory year" corresponds to the total land area of a country. The total land area should be the same for the current inventory year and the previous inventory year in this matrix.

Table A8.2.1.4 Areas and changes in areas between the previous and the current inventory year. Land transition matrix 2014

Table NIR 2. LAND TRANSITION MATRIX 2014

	ARTICLE 3.3 ACTIVITIES		ARTICLE 3.4 ACTIVITIES					Other[6]	Total area at the end of the previous inventory year[7]
	Afforestation and reforestation	Deforestation	Forest management[5]	Cropland management (if elected)	Grazing land management (if elected)	Revegetation (if elected)	Wetland drainage and rewetting (if elected)		
	(kha)								
Article 3.3 activities									
Afforestation and reforestation	1728.40	NO							1728.40
Deforestation		44.08							44.08
Article 3.4 activities									
Forest management		3.69	7464.06						7467.76
Cropland management[3] (if elected)	NO		NO	8939.12	NO	NO	NO		8939.12
Grazing land management[3] (if elected)	NO		NO	NO	382.84	NO	NO		382.84
Revegetation[3] (if elected)	NA		NA	NA	NA	NA	NA		NA
Wetland drainage and rewetting[3] (if elected)	NA		NA	NA	NA	NA	NA		NA
Other[4]	58.31	NO	NO	NO	21.23	NO	NO	11491.85	11571.40
Total area at the end of the current inventory year	1786.71	47.78	7464.06	8939.12	404.07	NA,NO	NA,NO	11491.85	30133.60

[1] This table should be used to report land area and changes in land area subject to the various activities in the inventory year. For each activity it should be used to report area change between the end of the previous inventory year and the end of the current inventory year. For example, the total area of land subject to forest management in the previous inventory year and which was deforested in the current inventory year, should be reported in the deforestation column and in the forest management row.
[2] In accordance with relevant decisions. Some of the transitions in the matrix are not possible and the cells concerned have been shaded.

[3] Lands subject to cropland management, grazing land management, revegetation or wetland drainage and rewetting that after 2013 are subject to activities other than those under Article 3.3 and 3.4, should still be tracked and reported under cropland management, grazing land management, revegetation or wetland drainage and rewetting, respectively.
[4] Other refers to the area that is reported under Article 3.3 or 3.4 in the current inventory for the first time. This footnote does not apply to the cell belonging to the column and the row "other" to "other".
[5] Changes in area from cropland management, grazing land management, revegetation and wetland drainage and rewetting to forest management should be reported only in the case of carbon equivalent forest conversions.
[6] "Other", in this column, is the area of the country that has never been subject to any activity under Article 3.3 or 3.4

[7] The value in the cell of row "Total area at the end of the current inventory year" corresponds to the total land area of a country. The total land area should be the same for the current inventory year and the previous inventory year in this matrix.

Table A8.2.1.5 Areas and changes in areas between the previous and the current inventory year. Land transition matrix 2015

Table NIR 2. LAND TRANSITION MATRIX 2015

	ARTICLE 3.3 ACTIVITIES		ARTICLE 3.4 ACTIVITIES					Other[6]	Total area at the end of the previous inventory year[7]
	Afforestation and reforestation	Deforestation	Forest management[5]	Cropland management (if elected)	Grazing land management (if elected)	Revegetation (if elected)	Wetland drainage and rewetting (if elected)		
	(kha)								
Article 3.3 activities									
Afforestation and reforestation	1786.71	NO							1786.71
Deforestation		47.78							47.78
Article 3.4 activities									
Forest management		3.69	7460.37						7464.06
Cropland management[3] (if elected)	NO		NO	8939.12	NO	NO	NO		8939.12
Grazing land management[3] (if elected)	NO		NO	NO	404.07	NO	NO		404.07
Revegetation[3] (if elected)	NA		NA	NA	NA	NA	NA		NA
Wetland drainage and rewetting[3] (if elected)	NA		NA	NA	NA	NA	NA		NA
Other[4]	58.31	NO	NO	NO	22.13	NO	NO	11411.41	11491.85
Total area at the end of the current inventory year	1845.03	51.47	7460.37	8939.12	426.20	NO,NA	NO,NA	11411.41	30133.60

[1] This table should be used to report land area and changes in land area subject to the various activities in the inventory year. For each activity it should be used to report area change between the end of the previous inventory year and the end of the current inventory year. For example, the total area of land subject to forest management in the previous inventory year and which was deforested in the current inventory year, should be reported in the deforestation column and in the forest management row.
[2] In accordance with relevant decisions. Some of the transitions in the matrix are not possible and the cells concerned have been shaded.

[3] Lands subject to cropland management, grazing land management, revegetation or wetland drainage and rewetting that after 2013 are subject to activities other than those under Article 3.3 and 3.4, should still be tracked and reported under cropland management, grazing land management, revegetation or wetland drainage and rewetting, respectively.
[4] Other refers to the area that is reported under Article 3.3 or 3.4 in the current inventory for the first time. This footnote does not apply to the cell belonging to the column and the row "other" to "other".
[5] Changes in area from cropland management, grazing land management, revegetation and wetland drainage and rewetting to forest management should be reported only in the case of carbon equivalent forest conversions.
[6] "Other", in this column, is the area of the country that has never been subject to any activity under Article 3.3 or 3.4
[7] The value in the cell of row "Total area at the end of the current inventory year" corresponds to the total land area of a country. The total land area should be the same for the current inventory year and the previous inventory year in this matrix.

Table A8.2.1.6 Areas and changes in areas between the previous and the current inventory year. Land transition matrix 2016

Table NIR 2. LAND TRANSITION MATRIX 2016

	ARTICLE 3.3 ACTIVITIES		ARTICLE 3.4 ACTIVITIES					Other[6]	Total area at the end of the previous inventory year[7]
	Afforestation and reforestation	Deforestation	Forest management[5]	Cropland management (if elected)	Grazing land management (if elected)	Revegetation (if elected)	Wetland drainage and rewetting (if elected)		
	(kha)								
Article 3.3 activities									
Afforestation and reforestation	1845.03	NO							1845.03
Deforestation		51.47							51.47
Article 3.4 activities									
Forest management		3.69	7456.68						7460.37
Cropland management[3] (if elected)	NO		NO	8939.12	NO	NO	NO		8939.12
Grazing land management[3] (if elected)	NO		NO	NO	426.20	NO	NO		426.20
Revegetation[3] (if elected)	NA		NA	NA	NA	NA	NA		NA
Wetland drainage and rewetting[3] (if elected)	NA		NA	NA	NA	NA	NA		NA
Other[4]	58.31	NO	NO	80.48	NO	NO	NO	11272.62	11411.41
Total area at the end of the current inventory year	1903.34	55.17	7456.68	9019.59	426.20	NO,NA	NO,NA	11272.62	30133.60

[1] This table should be used to report land area and changes in land area subject to the various activities in the inventory year. For each activity it should be used to report area change between the end of the previous inventory year and the end of the current inventory year. For example, the total area of land subject to forest management in the previous inventory year and which was deforested in the current inventory year, should be reported in the deforestation column and in the forest management row.
[2] In accordance with relevant decisions. Some of the transitions in the matrix are not possible and the cells concerned have been shaded.

[3] Lands subject to cropland management, grazing land management, revegetation or wetland drainage and rewetting that after 2013 are subject to activities other than those under Article 3.3 and 3.4, should still be tracked and reported under cropland management, grazing land management, revegetation or wetland drainage and rewetting, respectively.
[4] Other refers to the area that is reported under Article 3.3 or 3.4 in the current inventory for the first time. This footnote does not apply to the cell belonging to the column and the row "other" to "other".
[5] Changes in area from cropland management, grazing land management, revegetation and wetland drainage and rewetting to forest management should be reported only in the case of carbon equivalent forest conversions.
[6] "Other", in this column, is the area of the country that has never been subject to any activity under Article 3.3 or 3.4

[7] The value in the cell of row "Total area at the end of the current inventory year" corresponds to the total land area of a country. The total land area should be the same for the current inventory year and the previous inventory year in this matrix.

Table A8.2.1.7 Report of supplementary information for Land Use, Land-Use Change and Forestry activities under the Kyoto Protocol - 1990

Table 4(KP). SUMMARY TABLE – 1990

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Net CO_2 emissions/ removals[3]	CH_4[4]	N_2O[5]	Net CO_2 equivalent emissions/removals
	(kt)			
A. Article 3.3 activities				24.92
A.1. Afforestation and reforestation[6]	NA,NO,IE	NO,NA	NO,NA	NA,NO,IE
A.2. Deforestation	NA,NO	NO	0.08	24.92
B. Article 3.4 activities				-644.45
B.1. Forest management	-519.80	NO,NA	NO,NA	-519.80
B.2. Cropland management (if elected)	-172.45	0.22	0.16	-119.52
B.3. Grazing land management (if elected)	-5.13	NO	NO	-5.13
B.4. Revegetation (if elected)	NA	NA	NA	NA
B.5. Wetland drainage and rewetting (if elected)	NA	NA	NA	NA

Table A8.2.1.8 Report of supplementary information for Land Use, Land-Use Change and Forestry activities under the Kyoto Protocol - 2013

Table 4(KP). SUMMARY TABLE – 2013

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Net CO_2 emissions/ removals[3]	CH_4[4]	N_2O[5]	Net CO_2 equivalent emissions/removals
	(kt)			
A. Article 3.3 activities				-5830.08
A.1. Afforestation and reforestation[6]	-7872.63	0.90	0.03	-7841.80
A.2. Deforestation	1916.85	NO	0.32	2011.72
B. Article 3.4 activities				-30458.70
B.1. Forest management	-30347.26	3.88	0.12	-30214.07
B.2. Cropland management (if elected)	375.24	0.31	0.05	396.99
B.3. Grazing land management (if elected)	-641.62	NO	NO	-641.62
B.4. Revegetation (if elected)	NA	NA	NA	NA
B.5. Wetland drainage and rewetting (if elected)	NA	NA	NA	NA

Table A8.2.1.9 Report of supplementary information for Land Use, Land-Use Change and Forestry activities under the Kyoto Protocol - 2014

Table 4(KP). SUMMARY TABLE – 2014

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Net CO_2 emissions/ removals[3]	CH_4[4]	N_2O[5]	Net CO_2 equivalent emissions/removals
	(kt)			
A. Article 3.3 activities				-6360.93
A.1. Afforestation and reforestation[6]	-8431.35	1.39	0.04	-8383.66
A.2. Deforestation	1927.69	NO	0.32	2022.73
B. Article 3.4 activities				-31535.09
B.1. Forest management	-31398.62	5.80	0.18	-31199.40
B.2. Cropland management (if elected)	329.82	0.03	0.02	336.54
B.3. Grazing land management (if elected)	-672.23	NO	NO	-672.23
B.4. Revegetation (if elected)	NA	NA	NA	NA
B.5. Wetland drainage and rewetting (if elected)	NA	NA	NA	NA

Table A8.2.1.10 Report of supplementary information for Land Use, Land-Use Change and Forestry activities under the Kyoto Protocol - 2015

Table 4(KP). SUMMARY TABLE – 2015

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Net CO_2 emissions/ removals[3]	CH_4[4]	N_2O[5]	Net CO_2 equivalent emissions/removals
	(kt)			
A. Article 3.3 activities				-6819.81
A.1. Afforestation and reforestation[6]	-8905.01	1.51	0.05	-8853.29
A.2. Deforestation	1938.27	NO	0.32	2033.48
B. Article 3.4 activities				-32820.91
B.1. Forest management	-32673.74	6.09	0.19	-32464.61
B.2. Cropland management (if elected)	346.38	0.10	0.00	349.69
B.3. Grazing land management (if elected)	-705.99	NO	NO	-705.99
B.4. Revegetation (if elected)	NA	NA	NA	NA
B.5. Wetland drainage and rewetting (if elected)	NA	NA	NA	NA

Table A8.2.1.11 Report of supplementary information for Land Use, Land-Use Change and Forestry activities under the Kyoto Protocol - 2016

Table 4(KP). SUMMARY TABLE – 2016

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Net CO_2 emissions/ removals[3]	CH_4[4]	N_2O[5]	Net CO_2 equivalent emissions/removals
	(kt)			
A. Article 3.3 activities				-6328.59
A.1. Afforestation and reforestation[6]	-8447.98	2.21	0.07	-8372.17
A.2. Deforestation	1948.22	NO	0.32	2043.58
B. Article 3.4 activities				-30472.58
B.1. Forest management	-29416.81	8.92	0.28	-29110.27
B.2. Cropland management (if elected)	-686.02	0.08	0.09	-656.32
B.3. Grazing land management (if elected)	-705.99	NO	NO	-705.99
B.4. Revegetation (if elected)	NA	NA	NA	NA
B.5. Wetland drainage and rewetting (if elected)	NA	NA	NA	NA

(1) All estimates in this table include emissions and removals from projects under Article 6 hosted by the reporting Party.
(2) If cropland management, grazing land management, revegetation and/or wetland drainage and rewetting are elected, this table and all relevant CRF tables shall also be reported for the base year for these activities.
(3) For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+). Net changes in carbon stocks are converted to CO_2 by multiplying C by 44/12 and by changing the sign for net CO_2 removals to be negative (-) and net CO_2 emissions to be positive (+).
(4) CH_4 emissions reported here for cropland management, grazing land management, revegetation and/or wetland drainage and rewetting, if elected, include only emissions from drainage or rewetting of organic soils and from biomass burning (with the exception of savanna burning and agricultural residue burning which are reported in the agriculture sector).
(5) N_2O emissions reported here for cropland management, if elected, include only emissions from biomass burning (with the exception of savannah burning and agricultural residue burning which are reported in the agriculture sector).
(6) As both afforestation and reforestation under Article 3.3 are subject to the same provisions specified in the annex to decision 2/CMP.7, they can be reported together.

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	2018
Reported year	2017
Commitment period	2

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	lCERs
Party holding accounts	NO	698,870	NO	975,671	NO	NO
Entity holding accounts	NO	410,076	NO	2,862,425	NO	NO
Retirement account	NO	NO	NO	NO	NO	NO
Previous period surplus reserve account	NO					
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation account	NO	NO	NO	NO		
Voluntary cancellation account	NO	NO	NO	NO	NO	NO
Cancellation account for remaining units after carry-over	NO	NO	NO	NO	NO	NO
Article 3.1 ter and quater ambition increase cancellation account	NO					
Article 3.7 ter cancellation account	NO					
tCER cancellation account for expiry					NO	
lCER cancellation account for expiry						NO
lCER cancellation account for reversal of storage						NO
lCER cancellation account for non-submission of certification report						NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	NO	1,108,946	NO	3,838,096	NO	NO

Table A8.2.2.2.a Annual internal transactions

Party	Italy
Submission year	2018
Reported year	2017
Commitment period	2

Table 2 (a). Annual internal transactions

Transaction type	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Art6 issuance and conversion												
Party verified projects		NO					NO		NO			
Independently verified projects		NO					NO		NO			
Art3.3 and 3.4 issuance or cancellation												
3.3 Afforestation 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		
3.4 Wetland drainage and rewetting			NO				NO	NO	NO	NO		
Art 12 afforestation and reforestation												
Replacement of expired tCERs							NO	NO	NO	NO	NO	
Replacement of expired lCERs							NO	NO	NO	NO		
Replacement for reversal of storage							NO	NO	NO	NO		NO
Cancellation for reversal of storage												NO
Replacement for non-submission of certification report							NO	NO	NO	NO		NO
Cancellation for non submission of certification report												NO
Other cancelation												
Voluntary cancellation							NO	7,659	NO	5,367	NO	NO
Article 3.1 ter and quater ambition increase cancellation							NO					
Subtotal		NO	NO				NO	7,659	NO	5,367	NO	NO

Transaction type	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Retirement	NO	NO	NO	NO	NO	NO
Retirement from PPSR	NO					
Total	NO	NO	NO	NO	NO	NO

Table A8.2.2.2.b Annual external transactions

Party	Italy
Submission year	2018
Reported year	2017
Commitment period	2

Table 2b. Annual external transactions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Transfers and acquisitions												
CDM	NO	NO	NO	647,472	NO	NO	NO	NO	NO	NO	NO	NO
EU	NO	NO	NO	NO	NO	NO	NO	NO	NO	64,529	NO	NO
DE	NO	NO	NO	NO	NO	NO	NO	NO	NO	323,106	NO	NO
Sub-total	NO	NO	NO	647,472	NO	NO	NO	NO	NO	387,635	NO	NO

Table A8.2.2.2.c Annual transactions between PPSR accounts

Table 2c. Annual transactions between PPSR accounts

	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Total (Sum of table 2(a) and 2(b))	NO						NO					

Table A8.2.2.2.d Share of proceeds transactions under decision 1/CMP.8, paragraph 21 - Adaptation Fund

Table 2d Share of proceeds transactions under decision 1/CMP.8, paragraph 21 - Adaptation Fund

	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
First international transfers of AAUs	NO						NO					
Issuance of ERU from Party-verified projects		NO						NO				
Issuance of independently verified ERUs		NO						NO				

Table A8.2.2.2.e Total annual transactions

Table 2e Total annual transactions

	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Total (Sum of sub-totals in table 2a and table 2b)	NO	NO	NO	647,472	NO	NO	NO	7,659	NO	393,002	NO	NO

Table A8.2.2.3 Expiry, cancellation and replacement

Party	Italy
Submission year	2018
Reported year	2017
Commitment period	2

Table 3. Expiry, cancellation and replacement

Transaction or event type	Requirement to replace or cancel			Replacement						Cancellation					
Transaction or event type	**tCERs**	**lCERs**	**CERs**	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Temporary CERs (tCERs)															
Expired in retirement and replacement accounts	NO			NO	NO	NO	NO	NO							
Expired in holding accounts	NO													NO	
Long-term CERs															
Expired in retirement and replacement accounts		NO		NO	NO	NO	NO								
Expired in holding accounts		NO													NO
Subject to reversal of Storage		NO		NO	NO	NO	NO		NO						NO
Subject to non submission of certification Report		NO		NO	NO	NO	NO		NO						NO
Carbon Capture and Storage CERs															
Subject to net reversal of storage			NO							NO	NO	NO	NO		
Subject to non submission of certification report			NO							NO	NO	NO	NO		
Total	NO	NO	NO	NO	NO	NO	NO	NO	NO	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	Italy
Submission year	2018
Reported year	2017
Commitment period	2

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	lCERs
Party holding accounts	NO	698,870	NO	975,671	NO	NO
Entity holding accounts	NO	402,417	NO	3,123,716	NO	NO
Retirement account	NO	NO	NO	NO	NO	NO
Previous period surplus reserve account	NO					
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation account	NO	NO	NO	NO		
Voluntary cancellation account	NO	7,659	NO	5,367	NO	NO
Cancellation account for remaining units after carry-over	NO	NO	NO	NO	NO	NO
Article 3.1 ter and quater ambition increase cancellation account	NO					
Article 3.7 ter cancellation account	NO					
tCER cancellation account for expiry					NO	
lCER cancellation account for expiry						NO
lCER cancellation account for reversal of storage						NO
lCER cancellation account for non-submission of certification report						NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	NO	1,108,946	NO	4,104,754	NO	NO

Table A8.2.2.5.a Summary information on additions and subtractions

Party	Italy
Submission year	2018
Reported year	2017
Commitment period	2

Table 5 (a). Summary information on additions and subtractions

	Additions						Subtractions					
	AAUs	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Assigned amount units issued	NO											
Article 3 Paragraph 7 ter cancellations							NO					
Cancellation following increase in ambition							NO					
Cancellation of remaining units after carry over							NO	NO	NO	NO	NO	NO
Non-compliance cancellation							NO	NO	NO	NO		
Carry-over		1.108.946		2,112,952				NO		NO		
Carry-over to PPSR	NO						NO					
Total	NO	1.108.946		2,112,952			NO	NO	NO	NO	NO	NO

Table A8.2.2.5.b Summary information on annual transactions

Table 5 (b). Summary information on annual transactions

	Additions						Subtractions					
	AAUs	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Year 1 (2013)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 2 (2014)	NO	NO	NO	168.770	NO	NO	NO	NO	NO	168.671	NO	NO
Year 3 (2015)	NO	NO	NO	3.365.100	NO	NO	NO	NO	NO	2.051.147	NO	NO
Year 4 (2016)	NO	NO	NO	715.832	NO	NO	NO	NO	NO	297.919	NO	NO
Year 5 (2017)	NO	NO	NO	647,472	NO	NO	NO	NO	NO	393,002	NO	NO
Year 6 (2018)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2019)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2020)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 2021	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 2022	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 2023	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	4,897,174	NO	NO	NO	NO	NO	2,910,739	NO	NO

Table A8.2.2.5.c Summary information on annual transactions between PPSR accounts

Table 5 (c). Summary information on annual transactions between PPSR accounts

	Additions						Subtractions					
	AAUs	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Year 1 (2013)	NO						NO					
Year 2 (2014)	NO						NO					
Year 3 (2015)	NO						NO					
Year 4 (2016)	NO						NO					
Year 5 (2017)	NO						NO					
Year 6 (2018)	NO						NO					
Year 7 (2019)	NO						NO					
Year 8 (2020)	NO						NO					
Year 2021	NO						NO					
Year 2022	NO						NO					
Year 2023	NO						NO					
Total	NO						NO					

Table A8.2.2.5.d Summary information on expiry, cancellation and replacement

Table 5d. Summary information on expiry, cancellation and replacement																
		Requirement to replace or cancel			Replacement						Cancellation					
		tCERs	lCERs	CERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
1	Year 1 (2013)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2	Year 2 (2014)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3	Year 3 (2015)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4	Year 4 (2016)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5	Year 5 (2017)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6	Year 6 (2018)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7	Year 7 (2019)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
8	Year 8 (2020)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
9	Year 2021	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
10	Year 2022	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
11	Year 2023	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
12	Total	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table A8.2.2.5.e Summary information on retirement

Table 5e. Summary information on retirement							
		AAUs	ERUs	RMUs	CERs	tCERs	lCERs
1	**Year 1 (2013)**	NO	NO	NO	NO	NO	NO
2	**Year 2 (2014)**	NO	NO	NO	NO	NO	NO
3	**Year 3 (2015)**	NO	NO	NO	NO	NO	NO
4	**Year 4 (2016)**	NO	NO	NO	NO	NO	NO
5	**Year 5 (2017)**	NO	NO	NO	NO	NO	NO
6	**Year 6 (2018)**	NO	NO	NO	NO	NO	NO
7	**Year 7 (2019)**	NO	NO	NO	NO	NO	NO
8	**Year 8 (2020)**	NO	NO	NO	NO	NO	NO
9	**Year 2021**	NO	NO	NO	NO	NO	NO
10	**Year 2022**	NO	NO	NO	NO	NO	NO
11	**Year 2023**	NO	NO	NO	NO	NO	NO
12	**Total**	NO	NO	NO	NO	NO	NO

Table A8.2.2.6.a,b,c Memo item: corrective transactions relating to addition and subtractions, replacement and retirement

Table 6a. Memo item: corrective transactions relating to additions and subtractions

Additions						Subtractions					
AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

Table 6b. Memo item: corrective transactions relating to replacement

Expiry, cancellation and requirement to replace		Replacement					
tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

Table 6c. Memo item: corrective transactions relating to retirement

Retirement					
AAUs	ERUs	RMUs	CERs	tCERs	lCERs

A8.2.3 National registry

A8.2.3.1 Changes to national registry

Changes to national registry are described in Chapter 12.

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 128 registered CDM projects where Italy is involved (as for 05/02/2018)

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	
Brazil NovaGerar Landfill Gas to Energy Project	Brazil (b)	Netherlands,**Italy**, Luxembourg, Switzerland, Japan, Spain	
La Esperanza Hydroelectric Project	Honduras (a)	Canada, Netherlands,**Italy**, Denmark, Finland, Austria, Luxembourg, Belgium, Sweden, Germany, Switzerland, Japan, Norway, Spain	Nussbaumer (2009) + CDCF + Gold Standard
Project for GHG Emission Reduction by Thermal Oxidation of HFC23 in Jiangsu Meilan Chemical CO. Ltd., 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	
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)	Netherlands,**Italy**, Denmark, Finland, Sweden, Luxembourg, Switzerland, Austria, Germany, Belgium, Japan, Norway, Spain	Nussbaumer (2009) + CDCF*
Olavarría 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*

Title	Host Parties	Other Parties	Impacts assessment
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)
Landfill gas recovery at the Norte III Landfill, Buenos Aires, Argentina.	Argentina (b)	Switzerland,**Italy**	
5 MW Wind Power Project at Baramsar and Soda Mada, district Jaisalmer, Rajasthan, India.	India (a)	**Italy**	Nussbaumer (2009), Sirohi (2007)
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**	
Facilitating Reforestation for Guangxi Watershed Management in Pearl River Basin	China (b,d)	Canada,**Italy**, Luxembourg, France, Japan, Spain	Cóndor et al. (2010)
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**	
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

Title	Host Parties	Other Parties	Impacts assessment
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	
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)
Allain Duhangan Hydroelectric Project (ADHP)	India (c)	**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
Landfill gas recovery and electricity generation at “Mtoni Dumpsite”, Dar Es Salaam, Tanzania	United Republic of Tanzania (c)	**Italy**	
Rongcheng Dongchudao Wind Farm	China (a)	**Italy**	
Laizhou Diaolongzui Wind Farm	China (c)	**Italy**	
Hebbakavadi Canal Based Mini Hydro Project in Karnataka, India	India (a)	Switzerland,**Italy**	
Quezon City Controlled Disposal Facility Biogas Emission Reduction Project	Philippines (a)	Switzerland, Sweden,**Italy**, Spain	
Chile: Quilleco Hydroelectric Project	Chile (b)	Netherlands,**Italy**, Luxembourg, United Kingdom of Great Britain and Northern Ireland, Japan, Spain	
Montevideo Landfill Gas Capture and Flare Project	Uruguay (c)	Belgium,**Italy**, Sweden, Germany, Spain	
Yunnan Lazhai Hydropower Project	China (c)	**Italy**, Spain	
Guyana Skeldon Bagasse Cogeneration Project	Guyana (c)	Canada, Netherlands,**Italy**, Denmark, Finland, Austria, Luxembourg, Belgium, Sweden, Germany, Switzerland, Japan, Norway, Spain	
Laguna de Bay Community Waste Management Project: Avoidance of methane production from biomass decay through composting -1	Philippines (a)	Canada, Netherlands,**Italy**, Denmark, Finland, Austria, Luxembourg, Belgium, Sweden, Germany, Switzerland, Japan, Norway, Spain	
Uganda Nile Basin Reforestation Project No.3	Uganda (a,d)	Canada,**Italy**, Luxembourg, France, Japan, Spain	
Coke Dry Quenching (CDQ) Waste Heat Recovery for Power Generation Project of Wugang No. 9 and 10 Coke Ovens	China (c)	**Italy**	
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,	

Title	Host Parties	Other Parties	Impacts assessment
		Norway, Spain	
Guizhou Zhenyuan Putian Hydropower Station	China (a)	Italy	
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	
Shenyang Laohuchong LFG Power Generation Project	China (c)	Switzerland,**Italy**	
Kunming Dongjiao Baishuitang LFG Treatment and Power Generation Project	China (c)	Switzerland,**Italy**	
Yingpeng HFC23 Decomposition Project	China (b)	France,**Italy**, Ireland, United Kingdom of Great Britain and Northern Ireland	
Moldova Soil Conservation Project	Republic of Moldova (b,d)	Canada, Netherlands,**Italy**, Finland, Luxembourg, France, Sweden, United Kingdom of Great Britain and Northern Ireland, Japan, Norway, Spain	Cóndor et al. (2010)
Expansion Project of Huadian Inner Mongolia Huitengxile Wind Farm	China (c)	**Italy**	
Monterrey II LFG to Energy Project	Mexico (c)	Belgium, Denmark, Sweden, Germany,**Italy**	
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	
Yunnan Tengchong Longchuan River Stage I Hydropower Plant, China	China (c)	Sweden, Netherlands,**Italy**	
NISCO Converter Gas Recovery and Utilization for Power Generation Project	China (c)	**Italy**	
Reforestation as Renewable Source of Wood Supplies for Industrial Use in Brazil	Brazil (b,d)	Netherlands,**Italy**, Finland, Luxembourg, France, Sweden, Ireland, Switzerland, Japan, Norway, Spain	
Yunnan Maguan Laqi Hydropower Project	China (c)	Italy, Spain	
Humbo Ethiopia Assisted Natural Regeneration Project	Ethiopia (b,d)	Canada, **Italy**, Luxembourg, France, Japan, Spain	CCB, validated (Gold)
Assisted Natural Regeneration of Degraded Lands in Albania	Albania (b,d)	Canada, **Italy**, Luxembourg, France, Japan, Spain	Cóndor et al. (2010)

Title	Host Parties	Other Parties	Impacts assessment
Composting of Organic Content of Municipal Solid Waste in Lahore	Pakistan (b)	Belgium, Denmark, Sweden, **Italy**, Germany	
Jiangsu Xiangshui 201MW Wind Power Project	China (c)	Sweden, **Italy**	
Félou Regional Hydropower Project	Mali (c)	Belgium, Germany, Sweden, **Italy**, Spain	
Yunnan Maguan Mihu River 3rd Level Hydropower Station	China (c)	**Italy**	
Sichuan Mabian Yi Minority Autonomous County Yonglexi Hydropower Station	China (a)	**Italy**	
Chongqing Wanzhou Xiangjiazui Hydropower Station	China (a)	**Italy**	
Wugang Gas-Steam Combined Cycle Power Plant (CCPP) Project	China (c)	**Italy**	
Aberdare Range/ Mt. Kenya Small Scale Reforestation Initiative Kamae-Kipipiri Small Scale A/R Project	Kenya (a,d)	Canada, **Italy**, Luxembourg, France, Japan, Spain	
Aberdare Range / Mt. Kenya Small Scale Reforestation Initiative Kirimara-Kithithina Small Scale A/R Project	Kenya (a,d)	Canada, **Italy**, Luxembourg, France, Japan, Spain	
Wugang Waste Gas Recovery and Power Generation Project	China (c)	**Italy**	
Landfill biogas extraction and combustion plant in El Inga I and II landfill (Quito, Ecuador)	Ecuador (c)	**Italy**	
Gas-Steam Combined Cycle Power Plant (CCPP) Project of Laiwu Iron & Steel Group Corp.	China (c)	Netherlands, **Italy**	
Rwanda Electrogaz Compact Fluorescent Lamp (CFL) distribution project	Rwanda (a)	Canada, Netherlands, **Italy**, Denmark, Finland, Sweden, Luxembourg, Switzerland, Austria, Germany, Belgium, Japan, Norway, Spain	*
Shanxi Shuangliang Cement Company LTD. 4.5MW Waste Heat for Power Generation Project	China (c)	**Italy**	
Xianggelila Huajiaopo Hydropower Station	China (a)	**Italy**	
Jinping Maocaoping Hydropower Station	China (a)	**Italy**	
Micro-hydro Promotion	Nepal (a)	Netherlands, **Italy**, Denmark, Finland, Austria, Luxembourg, Belgium, Sweden, Germany, Switzerland, Japan, Norway, Spain	*
Olkaria II Geothermal Expansion Project	Kenya (c)	Canada, Netherlands, **Italy**, Denmark, Finland, Sweden, Luxembourg, Switzerland, Austria, Germany, Belgium, Japan,	*

Title	Host Parties	Other Parties	Impacts assessment
		Norway, Spain	
Municipal Solid Waste (MSW) Composting Project in Ikorodu, Lagos State	Nigeria (b)	Italy, Portugal, Luxembourg, Sweden, Germany, Ireland, Belgium, Norway	
AES Tietê Afforestation/Reforestation Project in the State of São Paulo, Brazil	Brazil (b,d)	Canada, **Italy**, Luxembourg, France, Japan, Spain	
Mungcharoen Green Power - 9.9 MW Rice Husk Fired Power Plant Project	Thailand (a)	**Italy**	
Southern Nicaragua CDM Reforestation Project	Nicaragua (a,d)	Canada,**Italy**, Luxembourg, France, Japan, Spain	
Jinping Maguo River Hydropower Station	China (a)	**Italy**	
Uganda Nile Basin Reforestation Project No.5	Uganda (a,d)	Japan, **Italy**, Spain, Luxembourg, France	
Yunnan Yingjiang Zhina River 2nd Level Hydropower Station Phase 1 and Phase 2	China (c)	**Italy**	
Improving Rural Livelihoods Through Carbon Sequestration By Adopting Environment Friendly Technology based Agroforestry Practices	India (b,d)	Canada, **Italy**, Luxembourg, France, Japan, Spain	
Hydro electric power project by SJVNL in Himachal Pradesh	India (c)	Belgium, Germany, Sweden, **Italy**	
India-FaL-G Brick and Blocks Project No.2.	India (a)	Netherlands, **Italy**, Denmark, Finland, Austria, Luxembourg, Switzerland, Sweden, Germany, Belgium, Japan, Norway, Spain	Nussbaumer (2009) + CDCF
Monterrey I LFG to Energy Project	Mexico (c)	Belgium, Denmark, Sweden, Germany, **Italy**	
Yunnan Er'yuan Misha River Longdi Hydropower Station	China (a)	**Italy**	
Yunnan Yingjiang Zhina River 1st Level Hydropower Station	China (a)	**Italy**	
India-FaL-G Brick and Blocks Project No.3	India (a)	Netherlands, **Italy**, Denmark, Finland, Austria, Luxembourg, Switzerland, Sweden, Germany, Belgium, Japan, Norway, Spain	
Fujian Shanghang Jiantou 9.8 MW hydropower Station Project	China (a)	Italy	
Uganda Nile Basin Reforestation Project No 1	Uganda (a,d)	Japan, **Italy**, Spain, Luxembourg, France	
Uganda Nile Basin Reforestation Project No 2	Uganda (a,d)	Japan, **Italy**, Spain, Luxembourg, France	
Uganda Nile Basin Reforestation Project No 4	Uganda (a,d)	Japan, **Italy**, Spain, Luxembourg, France	
Jiangsu Hantian Cement Waste Heat Recovery Power Generation Project	China (c)	**Italy**	

Title	Host Parties	Other Parties	Impacts assessment
Redevelopment of Tana Hydro Power Station Project	Kenya (c)	Netherlands, **Italy**, Finland, Sweden, Luxembourg, Switzerland, Austria, Germany, Belgium, Japan, Norway, Spain	
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	*
Shanxi Linfen 2×6MW Coke Oven Gas Power Generation Project	China (c)	**Italy**	
Tongdao County Laorongtan Hydropower Station Project	China (a)	**Italy**	
Biogas Support Program - Nepal Activity-3	Nepal (a)	Netherlands, **Italy**, Denmark, Finland, Sweden, Luxembourg, Switzerland, Austria, Germany, Belgium, Japan, Norway, Spain	*
Biogas Support Program - Nepal Activity-4	Nepal (a)	Netherlands, **Italy**, Denmark, Finland, Sweden, Luxembourg, Switzerland, Austria, Germany, Belgium, Japan, Norway, Spain	*
Nam Mo Hydropower Project	Viet Nam (c)	**Italy**	
Nam Non Hydropower Project	Viet Nam (c)	**Italy**	
Improving Kiln Efficiency in the Brick Making Industry in Bangladesh (Bundle-2)	Bangladesh (a)	Netherlands, **Italy**, Denmark, Finland, Austria, Luxembourg, Switzerland, Sweden, Germany, Belgium, Japan, Norway, Spain	*
WISCO 1234# Coke Dry Quenching (CDQ) Waste Heat Recovery for Cogeneration Project in Hubei Province	China (c)	**Italy**	
Yunnan Province Deqin County Chunduole Hydropower Station	China (c)	**Italy**	
Sichuan Province Li County Luganqiao Hydropower Project	China (c)	**Italy**	
Xuanen County Shuangxi Hydropower Project	China (c)	**Italy**	
Fujian Shanghang Huilong 9.9 MW hydropower Station Project	China (a)	**Italy**	
Guodian Weifang Binhai Wind Farm Phase II Project	China (c)	**Italy**	
Carbon Sequestration in Small and Medium Farms in the Brunca Region, Costa Rica (COOPEAGRI Project)	Costa Rica (b,d)	Canada, **Italy**, Luxembourg, France, Japan, Spain	
Use of Charcoal from Renewable Biomass Plantations as Reducing Agent in Pig Iron Mill in Brazil	Brazil (b)	Netherlands, **Italy**, Luxembourg, Switzerland, Japan, Spain	
Ningxia Helanshan Wind-farm (Touguan) Dalisi 49.5MW Wind Power Project	China (c)	**Italy**	

Title	Host Parties	Other Parties	Impacts assessment
Ningxia Taiyangshan Windfarm Shenpeng 49.5MW Project	China (c)	**Italy**	
Wushan Houxihe Hydropower Station Project	China (c)	**Italy**	
Kainji Hydropower Rehabilitation Project, Nigeria	Nigeria (c)	Belgium, Germany, Sweden, **Italy**	
Optimisation of Kiambere Hydro Power Project	Kenya (c)	Netherlands, **Italy**, Luxembourg, Austria, Germany, Belgium, Japan, Spain	
Aeolis Beberibe Wind Park	Brazil (c)	**Italy**	
Aeolis 2011 Wind Parks	Brazil (c)	**Italy**	
Yanyuan County Majingzi Hydropower Project	China (a)	**Italy**	
Partial substitution of fossil fuels with biomass at “Les Ciments Artificiels Tunisiens” cement plant, Tunis.	Tunisia (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**	
Partial Fuel Switching to Agricultural Wastes & Refuse Derived Fuel (RDF) at Kattameya cement plant	Egypt (c)	**Italy**	
Phu Quy Wind Power Project	Viet Nam (a)	**Italy**	
Partial Fuel Switching to Agricultural Wastes, Sewage Sludge & Refuse Derived Fuel (RDF) at Helwan cement plant	Egypt (c)	**Italy**	

(a)AMS, Small scale; (b) AM - Large scale; (c) ACM - Consolidated Methodologies; (d) Afforestation/reforestation; (*) project included in the UNEP Risoe Centre Database and labelled SD Tool, Gold Standard & CCB project (validation); 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 2006 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.
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 2006 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 CATEGORIES	CO_2				CH_4				N_2O			
	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												
1.A. Fuel combustion												
1.A.1. Energy industries												
Liquid fuels	Yes				No				No			
Solid fuels	Yes				No				No			
Gaseous fuels	Yes				No				No			
Other fossil fuels	No				No				No			
Biomass	No				No				No			
Peat	No				No				No			
a. Public electricity and heat production												
Liquid fuels		T3	NS, PS	CS		T3	NS, PS	CR,D		T3	NS, PS	CR,D
Solid fuels		T3	NS, PS	CS		T3	NS, PS	CR,D		T3	NS, PS	CR,D
Gaseous fuels		T3	NS, PS	CS		T3	NS, PS	CR,D		T3	NS, PS	CR,D
Other fossil fuels		T3	NS, PS	CS		T3	NS, PS	CR,D		T3	NS, PS	CR,D
Biomass		T3	NS, PS	CS		T3	NS, PS	CR,D		T3	NS, PS	CR,D
Peat		NO	NO	NO		NO	NO	NO		NO	NO	NO
b. Petroleum refining												
Liquid fuels		T3	NS, PS	CS		T3	NS, PS	CR,D		T3	NS, PS	CR,D
Gaseous fuels		T3	NS, PS	CS		T3	NS, PS	CR,D		T3	NS, PS	CR,D

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2				CH_4				N_2O			
	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)
c. Manufacture of solid fuels and other energy industries												
Liquid fuels		T3	NS, PS	CS		T3	NS, PS	CR,D		T3	NS, PS	CR,D
Solid fuels		T3	NS, PS	CS		T3	NS, PS	CR,D		T3	NS, PS	CR,D
Gaseous fuels		T3	NS, PS	CS		T3	NS, PS	CR,D		T3	NS, PS	CR,D
1.A.2 Manufacturing Industries and Construction												
Liquid fuels	Yes				No				Yes			
Solid fuels	Yes				No				No			
Gaseous fuels	Yes				No				No			
Other fossil fuels	No				No				No			
Biomass	No				No				No			
a. Iron and Steel												
Liquid fuels		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
Solid fuels		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
Gaseous fuels		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
b. Non-Ferrous Metals												
Liquid fuels		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
Solid fuels		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
Gaseous fuels		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
c. Chemicals												
Liquid fuels		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
Solid fuels		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
Gaseous fuels		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
Other fossil fuels		NO	NO	NO		NO	NO	NO		NO	NO	NO
Biomass		NO	NO	NO		NO	NO	NO		NO	NO	NO
d. Pulp, Paper and Print												
Liquid fuels		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
Gaseous fuels		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
Biomass		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
Solid fuels		NO	NO	NO		NO	NO	NO		NO	NO	NO

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2				CH_4				N_2O			
	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)
e. Food Processing, Beverages and Tobacco												
Liquid fuels		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
Solid fuels		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
Gaseous fuels		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
Biomass		T2	NS, PS	CS		T2	NS, PS	CR,D		T2	NS, PS	CR,D
f. Non-metallic Minerals												
Liquid fuels		T2	NS, PS	CS		T2	NS, PS	CR, D		T2	NS, PS	CR, D
Solid fuels		T2	NS, PS	CS		T2	NS, PS	CR, D		T2	NS, PS	CR, D
Gaseous fuels		T2	NS, PS	CS		T2	NS, PS	CR, D		T2	NS, PS	CR, D
Biomass		T2	NS, PS	CS		T2	NS, PS	CR, D		T2	NS, PS	CR, D
Other fossil fuels		T2	PS	CS		D	PS	CR, D		D	PS	CR, D
g. Other												
Liquid fuels		T2	NS, PS	CS		T2	NS, PS	CR, D		T2	NS, PS	CR, D
Solid fuels		T2	NS, PS	CS		T2	NS, PS	CR, D		T2	NS, PS	CR, D
Gaseous fuels		T2	NS, PS	CS		T2	NS, PS	CR, D		T2	NS, PS	CR, D
Other fossil fuels		NO	NO	NO		NO	NO	NO		NO	NO	NO
1.A.3 Transport												
a. Domestic Aviation	Yes				No				No			
Aviation Gasoline		T1,T2	NS	CS		T1,T2	NS	CR		T1,T2	NS	CR
Jet Kerosene		T1,T2	NS	CS		T1,T2	NS	CR		T1,T2	NS	CR
b. Road Transportation	Yes				Yes				No			
Gasoline		T1,T3	NS, AS	CS		T3	NS, AS	M		T3	NS, AS	M
Diesel Oil		T1,T3	NS, AS	CS		T3	NS, AS	M		T3	NS, AS	M
Liquefied Petroleum Gases (LPG)		T1,T3	NS, AS	CS		T3	NS, AS	M		T3	NS, AS	M
Other liquid fuels		T1,T3	M	D								
Gaseous fuels		T1,T3	NS, AS	CS		T3	NS, AS	M		T3	NS, AS	M
Biomass		T1,T3	NS, AS	CS		T3	NS, AS	M		T3	NS, AS	M
c. Railways	No				No				No			
Liquid fuels		T2	NS	CS		T1	NS	CR		T1	NS	CR

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2				CH_4				N_2O			
	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. Navigation	Yes				No				No			
Residual Fuel Oil		T1,T2	NS	CS		T1,T2	NS	CR		T1,T2	NS	CR
Gas/Diesel Oil		T1,T2	NS	CS		T1,T2	NS	CR		T1,T2	NS	CR
Gasoline		T1,T2	NS	CS		T1,T2	NS	CR		T1,T2	NS	CR
e. Other Transportation												
Gaseous fuels	No	T2	NS	CS	No	T1	NS	CR	No	T1	NS	CR
1.A.4 Other Sectors												
a. Commercial/Institutional												
Liquid fuels	Yes	T2	NS	CS	No	T2	NS	CR	No	T2	NS	CR
Solid fuels	No	NO	NO	NO	No	NO	NO	NO	No	NO	NO	NO
Gaseous fuels	Yes	T2	NS	CS	No	T2	NS	CR	No	T2	NS	CR
Other fossil fuels	Yes	T2	NS	CS	No	T2	NS	CR	No	T2	NS	CR
Biomass	No	T2	NS	CS	Yes	T2	NS	CR	Yes	T2	NS	CR
b. Residential												
Liquid fuels	Yes	T2	NS	CS	No	T2	NS	CR	No	T2	NS	CR
Solid fuels	Yes	T2	NS	CS	No	T2	NS	CR	No	T2	NS	CR
Gaseous fuels	Yes	T2	NS	CS	No	T2	NS	CR	No	T2	NS	CR
Biomass	No	T2	NS	CS	Yes	T2	NS	CR	Yes	T2	NS	CR
c. Agriculture/Forestry/Fishing												
Liquid fuels	Yes	T2	NS	CS	No	T2	NS	CR	Yes	T2	NS	CR
Gaseous fuels	Yes	T2	NS	CS	No	T2	NS	CR	No	T2	NS	CR
Biomass	No	T2	NS	CS	Yes	T2	NS	CR	Yes	T2	NS	CR
Solid fuels	Yes	NO	NO	NO	No	NO	NO	NO	No	NO	NO	NO
1.A.5 Other												
b. Mobile												
Liquid fuels	No	T2	NS	CS	No	T2	NS	CR	No	T2	NS	CR
Solid fuels	No	NO	NO	NO	No	NO	NO	NO	No	NO	NO	NO
1.B Fugitive Emissions from Fuels												
1. Solid Fuels												

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2				CH_4				N_2O			
	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. Coal Mining and Handling: Operation	No	T1	NS	OTH	No	T1	NS	D				
b. Solid Fuel Transformation					No	T1	NS	CR				
2 Oil and Natural Gas and Other Emissions from Energy Production												
a. Oil: Operation	Yes	T1,T2	NS	CS,D	No	T1,T2	NS	CS,D				
b. Natural Gas: Operation	No	T1,T2	NS	CS,D	Yes	T1,T2	NS	CS,D				
c. Venting and Flaring: Operation	No	T1	NS	D	No	T2	NS	CS	No	T1	NS	D
d. Other Emissions from Energy Production: Flaring in refineries	No	T2	NS	CS	No	T1	NS	CR	No	T1	NS	D

Table I -2: Summary report for methods, activity data and emission factors used (Industrial processes and product use)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2				CH_4				N_2O				HFCs				PFCs				SF_6				NF_3			
	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)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)
2. Industrial Processes and Product Use																												
2.A Mineral Industry																												
1. Cement production: no classification	Yes	T2	NS	CS, PS																								
2. Lime production: no classification	Yes	T2	NS	CS,PS																								
3. Glass production	No	T2	NS	CS,PS																								
4. Other process uses of carbonates: no classification	Yes	T2	NS	CS,PS																								
2.B Chemical Industry																												
1. Ammonia production: no classification	Yes	T2	PS	PS																								
2. Nitric acid production: no classification									Yes	T2	PS	D, PS																
3. Adipic acid production	No	T2	PS	PS					Yes	T2	PS	D, PS																
4. Caprolactam, glyoxal and glyoxylic acid production									No	T2	PS	CS																
5. Carbide production	No	D	PS	CR																								
6. Titanium dioxide production	No	T2	PS	PS																								
7. Soda ash production	No	T2	PS	PS																								
8. Petrochemical and carbon black production	No	T2	PS	CR,PS	No	D,T1	NS, PS	CR,CS,D																				
9. Fluorochemical production													No	CS	PS	PS	Yes	CS	PS	PS								
10. Other chemical industry: no classification	No	NA	NA	NA	No	NA	NA	NA	No	NA	NA	NA	No	NA	NA	NA	No	NA	NA	NA	No	NA	NA	NA	No	NA	NA	NA
2.C Metal Industry																												
1. Iron and steel production: no classification	Yes	T2	NS, PS	CR,CS,PS	No	D	NS	CS,D																				
2. Ferroalloys production	No	T1	NS, PS	D																								
3. Aluminium production: no classification	No	T1,T2	NS,PS	D,PS													Yes	T1, T2	NS, PS	D,PS								

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2				CH_4				N_2O				HFCs				PFCs				SF_6				NF_3			
	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)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)
4. Magnesium production													No	T2	PS	PS												
5. Lead production																												
6. Zinc production	No	T2	PS	CS																								
2.D Non-energy Products from Fuels and Solvent Use	Yes																											
1. Lubricant use		T1	NS	D																								
2. Paraffin wax use		T1	NS	D																								
3. Other: no classification		CR,CS,T2	NS, AS	CR,CS,M,PS																								
2.E. Electronics industry																												
1. Integrated circuit or semiconductor													No	T2	PS	CS	No	T2	PS	CS	No	T2	PS	CS	No	T2	PS	CS
2. TFT flat panel display																												
3. Photovoltaics																												
4. Heat transfer fluid																												
2.F. Product uses as substitutes for ODS																												
1. Refrigeration and air conditioning: no classification													Yes	T2	AS, NS	CS, D												
2. Foam blowing agents: no classification													Yes	T2	AS, NS	D												
3. Fire protection													Yes	T2	AS, NS	CS												
4. Aerosols: no classification													No	T2	AS, NS	CS												
5. Solvents																												
2.G. Other product manufacture and use																												
1. Electrical equipment																					No	T2	AS NS	CS				
2. SF_6 and PFCs from other product use																					No	CS	PS	PS				

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2				CH_4				N_2O				HFCs				PFCs				SF_6				NF_3			
	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)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)
3. N_2O from product uses									No	CS	AS, NS	CS																

Table I -3: Summary report for methods, activity data and emission factors used (Agriculture)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2				CH_4				N_2O			
	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. Total agriculture												
3.A. Enteric fermentation					Yes							
1. Cattle						T2	NS	CS				
Dairy Cattle						T2	NS	CS				
Non-Dairy Cattle						T2	NS	CS				
2. Sheep						T2	NS	CS				
3. Swine						T1	NS	D				
4. Other livestock						T1,T2	NS	D, CS				
3.B. Manure Management												
1-4. CH4 Emissions					Yes	T1, T2	NS	D, CS				
1-4. N2O Emissions and NMVOC Emissions									No	T2	NS	D, CS
5. Indirect N2O Emissions									No	T2	NS	D, CS
3.C. Rice Cultivation												
1. Irrigated					Yes	T2	NS	CS				
3.D. Agricultural soils												
1. Direct N2O Emissions From Managed Soils									Yes	CS,T1	NS	D, CS
b. Indirect N2O Emissions From Managed Soils									Yes	T1	NS	D, CS
3.F Field Burning of Agricultural Residues												
1. Cereals					No	T1	NS	D, CS	No	T1	NS	D, CS
3.G. Liming												
1. Limestone CaCO3	No	T1	NS	D								
3.H. Urea application	No	T1	NS	D								

Table I -4: Summary report for methods, activity data and emission factors used (Land use, land-use change and forestry)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2				CH_4				N_2O			
	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)
4. Total LULUCF												
4.A. Forest land												
1. Forest land remaining forest land	Yes	T2,T3	NS	CS,D	No	T2	NS	CS,D	No	T2	NS	CS,D
2. Land converted to forest land	Yes	T1, T2	NS	CS,D	No	T2	NS	CS,D	No	T2	NS	CS,D
4.B. Cropland												
1. Cropland remaining cropland	Yes	T1, T2	NS	CS,D	No	T1	NS	D	No	T1	NS	D
2. Land converted to cropland	Yes	T1	NS	CS,D					No	T1	NS	D
4.C. Grassland												
1. Grassland remaining grassland	Yes	T1,T2,T3	NS	CS,D	Yes	T1	NS	CS	No	T1	NS	CS
2. Land converted to grassland	Yes	T1	NS	CS,D								
4.D. Wetlands												
1. Wetlands remaining wetlands												
2. Land converted to wetlands	No	T1	NS	D								
4.E. Settlements												
1. Settlements remaining settlements												
2. Land converted to settlements	Yes	T1	NS	D					Yes	T1	NS	D
4.F. Other land												
1. Other land remaining other land												
2. Land converted to other land												
4.G. Harvested wood products	Yes	T2	NS	CS								

Table I -5: Summary report for methods, activity data and emission factors used (Waste)

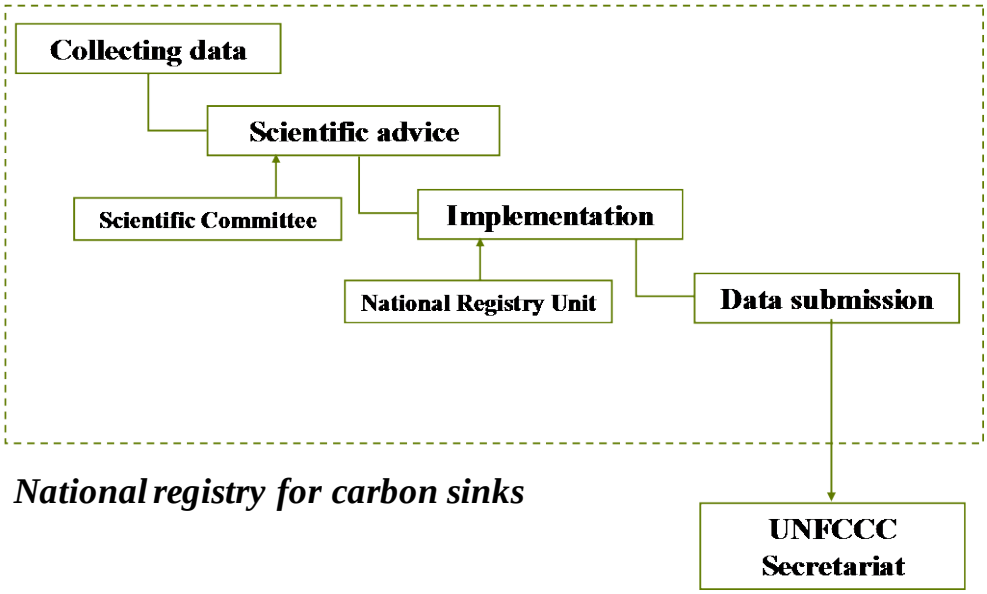
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2				CH_4				N_2O			
	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)
5.Total waste												
5.A Solid waste disposal					Yes							
1. Managed waste disposal sites						T2	NS	CS				
2. Unmanaged waste disposal sites						T2	NS	CS				
5.B Biological treatment of solid waste					No				No			
1. Composting						D	NS	CS		D	NS	D
2. Anaerobic digestion at biogas facilities						D	NS	D				
5.C Incineration and open burning of waste	No				No				No			
1. Waste incineration		D	NS, PS	CS		D	NS, PS	CR		D	NS,PS	CS
2. Open burning of waste						T1	NS	CS,D		T1	NS	CS,D
5.D Wastewater treatment and discharge					Yes				Yes			
1. Domestic wastewater						T1	NS	D		T1	NS	D
2. Industrial wastewater						T1	NS	D		T1	NS	CR

Legend for tables I -1 to I -5

(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)
RA (Reference Approach)	**T2** (IPCC Tier 2)	**CS** (Country Specific)
T1 (IPCC Tier 1)	**T3** (IPCC Tier 3)	**OTH** (Other)
(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)	**OTH** (Other)
CR (CORINAIR)	**PS** (Plant Specific)	**M** (Model)

ANNEX 10: THE NATIONAL REGISTRY FOR FOREST CARBON SINKS

The "National Registry for carbon sinks" is part of the Italian National System; it is the instrument to estimate, following the COP/MOP decisions and in accordance with the IPCC guidelines, the greenhouse gases emissions by sources and removals by sinks in the land subject to the art. 3.3 and art. 3.4 activities 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 for the first commitment period. A key requirement of CIPE decision (123/2002, article 7.4) was related to the establishment, by the Ministry for the Environment, Land and Sea (MATTM), in agreement with Ministry of Agriculture, Food and Forest Policies (MIPAAF), of the National Registry for the carbon sinks to account for the net removals, from *afforestation*, *reforestation* and *deforestation* activities (art. 3.3) and from elected activities under article 3.4 of Kyoto Protocol.

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, 2016 [a]) and includes information on lands subject to activities under Article 3.3 and activities under Article 3.4 and related carbon stock changes. The National Registry for Carbon sinks is the instrument to estimate, following the COP/MOP decisions and in accordance with the IPCC guidelines, emissions and removals related to the art. 3.3 and art. 3.4 activities 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. Several activities have been implemented and carried out; 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. For 2012, land use and land use changes data were assessed through the survey, carried out in the framework of the III NFI, on a IUTI's subgrid (i.e. 301,300 points, covering the entire country). Time series related to the areas to be included into the different IPCC categories have been assembled using IUTI data, and the data assessed by the national forest inventories (1985, 2005, 2012).Verification and validation activities have been undertaken and the resulting time series have been discussed with the institutions involved in the data

providing (i.e. National Forest Service, Ministry of Agricultural, Food and Forestry Policies (MIPAAF), Forest Monitoring and Planning Research Unit (CRA-MPF)).
The forest definition to be used in the second commitment period is the same definition adopted for the first commitment period. The forest definition adopted by Italy is in line with the definitions of 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.
Italy has elected cropland management (CM) and grazing land management (GM) as additional activities under Article 3.4. Following the Decision 2/CMP.7, the forest management (FM) has to be compulsorily accounted as an activity under Article 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.
The forest management reference level (FMRL[85]) for Italy, inscribed in the appendix to the annex to decision 2/CMP.7, is equal to –21.182 Mt CO_2 eq. per year assuming instantaneous oxidation of HWP, and –22.166 Mt CO_2 eq applying a first-order decay function for HWP. Italy intends to account for Article 3.3 and 3.4 activities at the end of the commitment period.
The key elements of the accounting system in the National Registry for carbon sinks are:

a. National Land-Use Inventory (IUTI)
aimed at identifying and quantifying:
– lands subject to art. 3.3 and art. 3.4 activities since 31 December 1989;

b. National Inventory of Carbon Stocks (ISCI)
aimed at quantifying:
- carbon stocks and carbon stock changes in any land-use category.

c. National Census of Forest Fires (CIFI)
aimed at identifying and quantifying:
– areas affected by fires.

d. National Inventory of non-CO2 emissions from forest fires (IEIF)
aimed at quantifying:
– non-CO_2 emissions from areas affected by fires.

e. Cropland and Grazing land Management

a. 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 supplies data concerning lands subject to art. 3.3 and 3.4 of the Kyoto Protocol. IUTI

[85] Submission of information on forest management reference levels by Italy:
http://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_italy_2011.pdf
Communication of 11 May 2011 regarding harvested wood products value by Italy:
http://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_italy_corr.pdf

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 TerraItaly[86] 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, TerraItaly[87] 2000 dataset, digital color aerial orthophotos with spatial resolution of 1 m;

→ 2008, TerraItaly 2008 dataset, digital color aerial orthophotos with spatial resolution of 0.5 m.

→ 2012, AGEA[88] color and infrared digital orthophoto,s with spatial resolution 0.5 m; years 2010-12.

Furthermore, visual interpretation was supported by ancillary information from available thematic forest and land use maps at regional and sub-regional scales.

a.1 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). The 2012 land use assessment has been carried out in the framework of the III NFI, on a IUTI's subgrid (i.e. 301,300 points, covering the entire country). Time series related to the areas to be included into the different IPCC categories have been assembled using IUTI data, and the data assessed by the national forest inventories (1985, 2005, 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 any land subject to art. 3.3 and art. 3.4 of the Kyoto Protocol. For the Kyoto Protocol accounting, the time series needed is related to the period 31/12/2012 - 1/1/2021.

a.2 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 national forest inventory (INFC).

Categories and subcategories:

Land use categories (Table A10.1) are defined according to IPCC requirements:

Table A10.1: IUTI classification system

IPCC Category Level I	IUTI Category Level II	IUTI Subcategory Level III	Code
1. Forest land	*Woodland*		**1.1**
	Wooded land temporarily unstocked		**1.2**
2. Cropland	*Arable land and other herbaceous cultivations*		**2.1**
	Arboreal cultivations	*Fruit orchards and plant nurseries*	**2.2.1**
		Wood product plantations	**2.2.2**
3. Grassland	*Grassland, pastures and uncultivated herbaceous areas*		**3.1**
	Other wooded land		**3.2**
4. Wetlands	*Marshlands and open waters*		**4**
5. Settlements	*Urban development*		**5**

[86] http://www.cgrit.it/prodotti/voli_italia.html
[87] http://www.terraitaly.it/
[88] http://www.agea.gov.it/portal/page/portal/AGEAPageGroup/HomeAGEA

6. Other land	*Non-productive areas or areas with scarce or absent vegetation*	**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) For 2012 the land classification, through the photo-interpretation, has been assessed on a IUTI's subgrid (i.e. 301,300 points, covering the entire country). 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)

a.3 Quality assurance/Quality control:

Data supplied by IUTI is collected in the "*National Registry for the carbon sinks*" of Kyoto Protocol, and fulfill quality needs, outlined in the IPCC guidelines and required by UNFCCC relevant decisions. 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 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

AII. **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 ≥ 5%.**

BII1. Formation with a degree of cover < 10%

OTHER WOODED AREAS

BII2. Formation with a degree of cover ≥ 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 ≥ 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-pastural 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 ≥ 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, has to 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 A10.1 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.

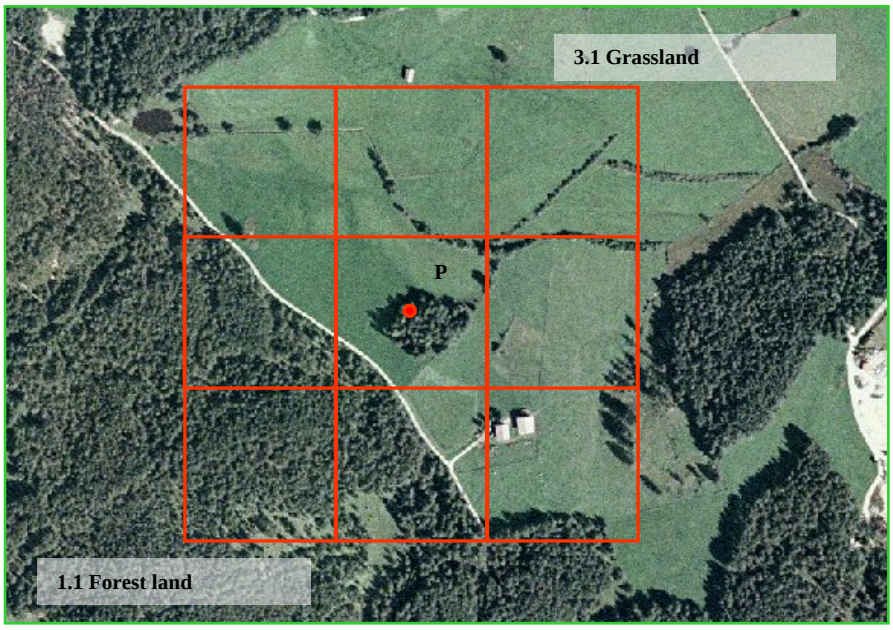


Figure A10.1: Land use classification system - grassland

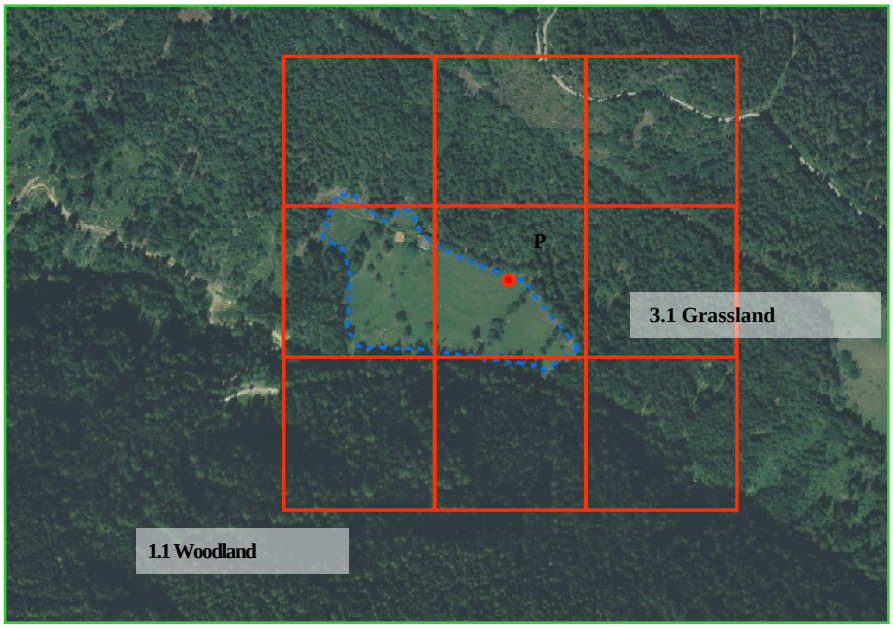


Figure A10.2: Land use classification system - Woodland

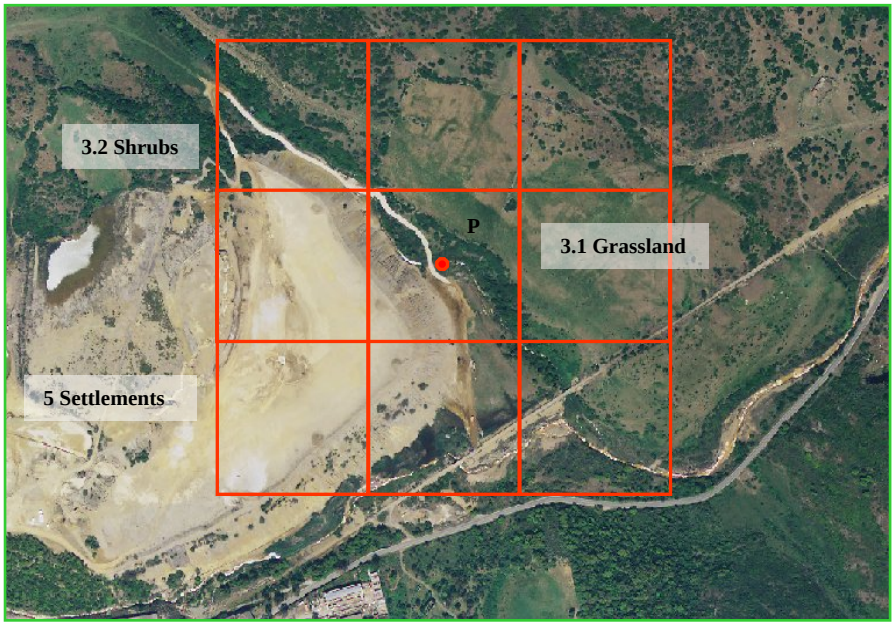


Figure A10.3: Land use classification system – grassland

b. 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 NFIs[89] 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*).

b.1 Time:

ISCI annually provides 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 accounting, the time series needed is related to the period 31/12/2012 - 1/1/2021.

b.2 Space:

Concerning the category *forest land* and any other category in conversion to and from *forest land*, the NFIs assure the spatial coverage, providing carbon stocks data, at NUT2 level.

b.3 Quality assurance:

Data supplied by ISCI is collected in the "*National Registry for the carbon sinks*" of Kyoto Protocol, and fulfill quality needs, outlined in the IPCC guidelines and required by UNFCCC relevant decisions.

c. National Census of Fires (CIFI)

The National Census of Fires is a system aimed to detect, locate and classify areas affected by fires; it provides data on burned forest land area and fires occurring in other land use categories.

The core of CIFI is the detailed database, provided by the Italian National Forest Service (CFS - Ministry of Agriculture, Food and Forest Policies), collecting data related to any fire event occurred in 15 administrative

[89] Italian National Forest Inventories: http://www.sian.it/inventarioforestale/jsp/home_en.jsp

Italian regions[90] (the 5 autonomous regions are not included), and reporting, for each fire event, the following information:

- *burned area [ha]*
- *forest typology (27 classes in line with the NFI nomenclature)*
- *scorch height [m]*
- *fire's type (crown, surface or ground fire)*

Data and information related to fire occurrences in the 5 remaining autonomous regions are collected at regional level, with different level of disaggregation and details (for example, in Sardinia region, the amount of biomass burned is reported instead of the scorch height).

Therefore the data used in the estimation process may be subdivided into the following groups with similar characteristics:

a. time series from 2008 on for the 15 Regions: data related to burned area, divided into different forest types, scorch height and fire's type;
b. time series from 2008 on for the 5 autonomous regions/provinces: data related to burned area;
c. time series from 1990 to 2007 for the 20 Italian regions: data related to burned area.

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 Italian National Forest Service (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).

c.1 Time:

CIFI annually provides, from 01/01/2008, time series of forest areas affected by fires. For the Kyoto Protocol accounting, the time series needed is related to the period 31/12/2012 - 1/1/2021.

c.2 Space:

CIFI covers 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).

Fires occurring in other land use categories (i.e. cropland, grassland and settlements) have been collected at NUTS2 level.

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;

c.3 Quality assurance:

Data supplied by CIFI is collected in the "*National Registry for the carbon sinks*" of Kyoto Protocol, and fulfill quality needs, outlined in the IPCC guidelines and required by UNFCCC relevant decisions.

d. National Inventory of non-CO_2 emissions from fires (IEIF)

The fires GHG emissions National Inventory is aimed to estimate non-CO_2 emissions from forest fires (CO_2 emissions are not taken into account, being already computed by National Inventory Carbon Stocks as

[90] The Italian territory is subdivided in 20 administrative regions, 5 of which are autonomous: Valle d'Aosta, Friuli Venezia Giulia, Sardegna, Sicilia and Trentino Alto Adige, the latest subdivided in two autonomous provinces (Trento and Bolzano).

decreases in carbon stocks) and GHG emissions from fires affecting land subject to Cropland Management and Grazing land Management activities.

It provides:

- emission estimates related to fires on the land-use category *forest land*;
- emission estimates related to fires on the land-use categories in conversion to or from *forest land* to other predominant uses.
- Emission estimates related to fires on land-use categories *cropland* and *grassland*

d.1 Time:

The fires GHG emissions National Inventory annually provides time series of GHG emissions from fires. For the Kyoto Protocol accounting, the time series needed is related to the period 31/12/2012 - 1/1/2021.

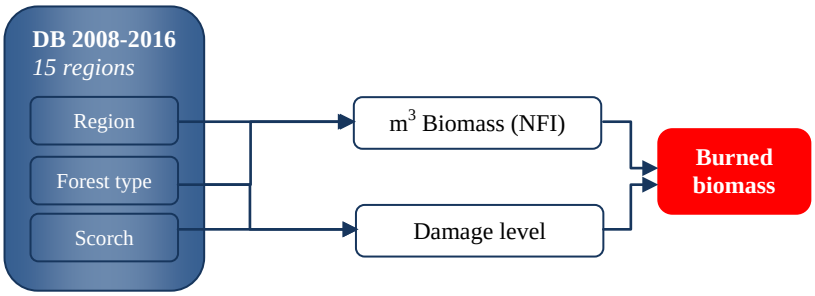
d.2 Space:

IEIF supplies estimates of emissions released by fires detected by National Census of Fires.

Key elements:

On the basis of the different datasets available, in each year and group of regions, different approaches and assumptions have been followed to estimate non CO_2 emissions from forest fires.

a. The estimation of non CO_2 emissions from fires in the 15 regions has been carried out on the basis of the following approach aimed to assess forest fire damage and related biomass losses in Italy, taking into account two main elements: the fire intensity (assessed through the scorch height) and the forest typologies affected by fire. These two elements allow an assessment of the fraction of biomass burnt in a fire event. The estimation process has been carried out using the database containing around 32,700 records, related to any fire event fires on forest and other wooded land for the period 2008-2016, including information as the scorch height and the area per forest type.



In case of missing data, record by record, a gap filling procedure has been adopted, using the following assumptions/data:

1. Scorch height data missing: the average damage level for the forest type/type of fire/region calculated over the 2008-2016 period has been attributed to the record.
2. No volume is associated with the record – this is due to the probable misclassification of the forest type by the surveyors, which have attributed a forest type that is not present in the region, thus no data from NFI can be attributed. In this case the average burned volume per region and fire's type has been attributed to the record. In case of no specific indication on fire's type, then the average of the most severe fire's type, by region, calculated over the complete dataset (2008-2016) has been used (i.e. highest average among averages calculated per fire's type in the region)
3. Scorch height and volume missing: In case information on both issues is missing the highest average burned biomass calculated per fire's type in each region has been attributed to the record.

b. The emissions from fires for the 5 autonomous regions/provinces has been estimated on the basis of the average values assessed for the 15 regions from 2008 on, using the following procedure:

1. for each of the 15 regions (group a), the highest value of C released among the averages, calculated for the years from 2008 on, has been selected, per fire's type;
2. the 15 regions have been clustered into three group with similar climatic conditions and forest types (Northern, Center and Southern Italy);
3. the average values of carbon released for fire's type have been calculated for the three abovementioned clusters;
4. the 5 autonomous regions have been classified according the 3 cluster identified at step 2;
5. an average value of carbon released, computed at step 3, is associated to the 5 autonomous regions, according the belonging cluster;
6. the emissions from fires are estimated by multiplying average value of carbon released per the burned area of each autonomous region.

d.3 Quality assurance:

Data supplied by IEIF is collected in the "*National Registry for the carbon sinks*" of Kyoto Protocol, and fulfill quality needs, outlined in the IPCC guidelines and required by UNFCCC relevant decisions.

e. Cropland and grazing land management

These sections of the *national registry for carbon sinks have been added following the decision by Italy to* elect cropland management (CM) and grazing land management (GM) as additional activities under Article 3.4 of the Kyoto Protocol for the second commitment period (2013-2020). The Ministry for the Environment, Land and Sea (MATTM) jointly with the Ministry of Agriculture, Food and Forest Policies (MIPAAF) has established a Committee of National experts at institutional and scientific level, aimed to deal with all issues related to reporting and coordination of activities related to LULUCF reporting, included also the needs set out by the Kyoto Protocol; a focus will be applied to verification activities carried out in the framework of the implementation of EU Decision n. 529/2013[91].

e.1 Cropland management

This section of the *national registry for carbon sinks* is aimed to the data collection and to estimate emissions and removals related to the cropland management activity under art. 3.4 of the Kyoto Protocol.

Land subject to cropland management have been assessed on the basis of the following subcategories:

1. land covered by arable crops and woody crops subject to inspections and certifications, in accordance with the EU Regulations on **organic production[92];**
2. land covered by arable crops grown using "**conservative practices**", including management practices aimed to preserve the soil[93] (e.g.: tillage practices to prevent/reduce soil erosion; cover crop; minimum tillage, zero tillage or sod seeding, mulching);
3. land covered by arable crops and woody crops grown using "**sustainable management systems**[94]**"**, including tillage and soil management practices usually provided for within the integrated production.

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[91] Decision n. 529/2013/EU of the European Parliament and of the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities**:** http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013D0529

[92] Council Regulation (EEC) No 2092/91: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31991R2092:EN:HTML, Commission Regulation (EC) n. 889/2008: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008R0889&from=EN; Council Regulation (EC) n. 834/2007: http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=URISERV:f86000&from=IT; Council Regulation (EEC) n. 2092/91**:** http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31991R2092:EN:HTML; Rural Development Regulations – organic farming measure (Regulations (ex) 2078/1992, (ex) 1257/1999, (ex) 1698/2005 and 1305/2013)

[93] in accordance with the Regulation (EEC) n. 2078/92: http://ec.europa.eu/agriculture/envir/programs/evalrep/text_en.pdf, (ex) 1257/1999, Council Regulation (EC) n. 1698/2005: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32005R1698&from=en**,** and Regulation (EU) n. 1305/2013: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0487:0548:EN:PDF

These practices are intended to improve the crops adaptation for maximize the production results; foster pest control; improve the efficiency of nutrients by reducing the losses due to leaching, runoff and evaporation; maintain the soil in good structural conditions; prevent erosion and landslides, preserve the soil organic matter and facilitate soil drainage.

4. land set aside[95] requiring cover crops, spontaneous or sown, all the year long and agronomic practices consisting of mowing or another equivalent operations in order to preserve the normal soil fertility, protect wild fauna, prevent a potential inoculum of burnings, especially during drought conditions, and avoid the pests spread.
5. land covered by arable crops and woody crops grown using "**ordinary agriculture**" is the land which doesn't fall within one of the above kinds of management.
6. land subject to **greening practices**, in accordance with the EU Regulation 1307/2013.

With regard to data sources:

a. Data of cropland managed with **organic practices** has been derived from the National System on Organic Farming (SINAB, http://www.sinab.it/) of the Ministry of Agriculture, Food and Forest Policies (MIPAAF). Data from SINAB are collected at national level for the total organic area starting form 1990.
b. Data of cropland managed with "**conservative practices**" are derived from the Implementation Report Tables[96] (AIRs) of the regional Rural Development Programmes (RDPs). Data have been collected at regional level (NUTS2), from 2008, and have been homogenized taken into account the different definitions adopted for these practices at NUTS level.
c. Data of cropland areas managed with "sustainable management systems" are derived from the AIRs of the regional RDPs[97] and the Annual Report of the Operative Programmes of the fruit and vegetables in the framework of CMO[98], being the integrated production funded under these two schemes. Data have been collected at regional level (NUTS2), from 2000. The AIRs provide data referred to total cropland areas. The data were broken down by arable crops and woodycrops by applying the indicators contained in the national database[99]. Verification activities have been carried out through direct information acquired by the Regions with largest share of areas under these management systems.
d. Data of land set aside are derived from Eurostat[100] and are available for 1990, 1993, 1995, 1997, 2000, 2003, 2005 and 2007. Data for the missing years have been estimed by interpolation.
e. Data of land using "ordinary agriculture" is obtained by difference between the total area detected by national statistics (ISTAT) and the data related to the abovementioned subcategories.

e.1.1 Time

Annual data of land subject to cropland management and related estimates of emissions and revomals are provided. For the Kyoto Protocol accounting, the time series needed is related to the period 31/12/2012 - 1/1/2021; data on 1990 is needed to implement the net-net accounting.

e.1.2 Space

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[94] in accordance with the national guidelines on integrated production and with the EU Regulations on the Rural Development (Regulations (ex) 2078/1992, (ex) 1257/1999, (ex) 1698/2005 and 1305/2013

[95] EU Regulations ((ex) 1094/88; (ex) 1765/92 e 1251/99: (ex) 1782/03 and 1307/2013) and National decree on cross compliance implementation (ex) DM 22.12.2009 and DM 23.1.2015

[96] http://ec.europa.eu/agriculture/cap-indicators/output/working-document-rd-monitoring-implementation-report-tables_en.pdf in the framework of the EU's rural development policy: http://ec.europa.eu/agriculture/rural-development-2014-2020/index_en.htm; for 2007-2014 referred to action 214.6)

[97] for 2007-2014 referred to action 214.1 – tables O.214(1) and O.AGRI.ENV

[98] Common Organisation of the Markets (CMO) in agricultural products http://www.europarl.europa.eu/atyourservice/en/displayFtu.html?ftuId=FTU_5.2.4.html

[99] Indicatori Agricoli Territoriali", National Rural Network: http://indiciterritorialiagricoli.ismea.it

[100] Fallow land and set-aside land: https://open-data.europa.eu/it/data/dataset/aLDul3sogcS8Hur7m4HWg

The reporting area boundaries for cropland management have been identified with the administrative boundaries of Italy (NUTS1) and administrative regions (NUTS2). The spatial assessment for cropland management refers to the cadastral unit or to a part of it, where the cropland management is carried out.

e.2 Grazing land management

The aim of this section of the *national registry for carbon sinks* is the data collection and the estimates of emissions and removals related to the grazing land management activity under art. 3.4 of the Kyoto Protocol.
Land subject to *grazing land management* have been assessed on the basis of the definition included in the Annex to the decision 16/CMP.1[101]. Lands under GM in Italy are those predominantly covered by herbaceous vegetation (introduced or indigenous) for a period longer than five years, used for grazing or fodder harvesting and /or under practices to control the amount and type of vegetation. As preliminary step, only the area related to the 'improved grazing land' have been reported; this area corresponds to lands subject to inspections and certifications procedures, in accordance with the EU Regulations[102] on organic production, as well as by the Rural Development Regulations[103] related to the organic farming measure. Data of grazing lands managed with organic practices has been derived from the National System on Organic Farming (SINAB, http://www.sinab.it/) of the Ministry of Agriculture, Food and Forest Policies (MIPAAF).
Total organic area is reported in the SINAB at national level since 1990. Quantitative information on the different subcategories, including organic grazing land, is available from the year 1999. The data related to the land subject to the organic grazing land from 1990 to 1998 has been deduced applying the average proportion of organic grazing land to the total organic area (22.6%) in the period 2000-2012.
Carbon stock changes related to land subject to *grazing land management* have been estimated on the basis of the guidance of 2013 KP Supplement (IPCC, 2014). In particular no change in carbon stocks in the living biomass pool has been assumed; Tier 1 method has been followed for dead wood and litter, assuming that the abovementioned pools are at equilibrium, and no carbon stock changes are occurring. Changes in carbon stocks in mineral soils have been estimated following the 2006 IPCC Guidelines on the basis of country specific SOC_{ref} deduced by the default reference soil organic carbon stocks for mineral soils (table 2.3, vol.4, chapter 2, IPCC, 2006). The assessment of the country specific SOC_{ref} has been carried out using the following layers: Climatic Zone layer[104], Corine Land Cover 2006[105] (classes codes: 2.3, 3.2), italian soil map (Costantini et al., 2013). The country specific SOC_{ref} have been stratifies into three macroareas in Italy (north, center and south).

e.2.1 Time

Annual data of land subject to grazing land management and related estimates of emissions and removals are provided. For the Kyoto Protocol accounting, the time series needed is related to the period 31/12/2012 - 1/1/2021; data on 1990 is needed to implement the net-net accounting.

e.2.2 Space

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[101] *Grazing land management* is the system of practices on land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced.
[102] Commission Regulation (EC) n. 889/2008: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008R0889&from=EN; Council Regulation (EC) n. 834/2007: http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=URISERV:f86000&from=IT; Council Regulation (EEC) n. 2092/91: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31991R2092:EN:HTML
[103] Regulation (EEC) n. 2078/92: http://ec.europa.eu/agriculture/envir/programs/evalrep/text_en.pdf;
Council Regulation (EC): n. 1257/1999 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31999R1257&from=en;
Council Regulation (EC) n. 1698/2005: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32005R1698&from=en;
Regulation (EU) n. 1305/2013: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0487:0548:EN:PDF
[104] European Commission's Joint Research Centre (JRC): Climatic Zones http://esdac.jrc.ec.europa.eu/projects/renewable-energy-directive
[105] Corine Land Cover 2006: http://sia.eionet.europa.eu/CLC2006

The reporting area boundaries for grazing land management have been identified with the administrative boundaries of Italy (NUTS1) and administrative regions (NUTS2). The spatial assessment for grazing land management refers to the cadastral unit or to a part of it, where the grazing land management is carried out.

e.3 Quality assurance

Data will be annually collected in the section related to cropland and grazing land management and have to fulfill 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 2016, 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 with regards to the national registry and in accordance with the guidelines set down in Decision 15 CMP.1 (Annex II.E Paragraph 32).
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 (national Institute for Environmental Protection and Research) under the supervision of the national Competent Authority for the implementation of the European directive 2003/87/EC, 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: +39 0650072544
e-mail: riccardo.liburdi@isprambiente.it
No change of name or contact occurred during the reported period.

(b) ***The names of the other Parties with which the Party cooperates by maintaining their national registries in a consolidated system***

Italy maintains its national registry in a consolidated manner with all the Parties that are also EU Member States and with the European Union, sharing the same platform hosted and facilitated by the European Commission.
No change of cooperation arrangement occurred during the reported period.

(c) ***A description of the database structure and capacity of the national registry***

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.
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.
The version of the EUCR released after 8.0.7 (the production version at the time of the last submission) introduced minor changes in the structure of the database.
These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model is provided in Annex A.
No change to the capacity of the national registry occurred during the reported period.

(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.
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.
Changes introduced since version 8.0.7 of the national registry (the production version at the time of the last submission) are listed in Annex B.
Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B).
No other change in the registry's conformance to the technical standards occurred during the reported period.

(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.
No change of discrepancies procedures occurred during the reported period.

(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.
No change regarding security occurred during the reported period.

(g) ***A list of the information publicly accessible by means of the user interface to the national registry***

Publicly available information is provided via the Union registry at the national homepage
https://ets registry.webgate.ec.europa.eu/euregistry/IT/public/reports/publicReports.xhtml

All non-confidential information required by Decision 13/CMP.1 annex II.E paragraphs 44-48, is publicly accessible with the following exceptions:

- paragraph 45(d)(e): account number, representative identifier name and contact information is deemed as confidential according to Annex III and VIII (Table III-I and VIII-I) of Commission Regulation (EU) No 389/2013;
- 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 110 of Commission Regulation (EU) No 389/2013.

No change to list of publicly available information occurred during the reported period.

(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
No change of the registry internet address occurred during the reported period.

(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.
No change of data integrity measures occurred during the reported period.

(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.***

The consolidated EU system of registries successfully completed a full certification procedure in June 2012. Notably, this procedure includes connectivity testing, connectivity reliability testing, distinctness testing and interoperability testing to demonstrate capacity and conformance to the Data Exchange Standard (DES). This included a full Annex H test. All tests were executed successfully and led to successful certification on 1 June2012.
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.
Changes introduced since version 8.0.7 of the national registry (the production version at the time of the last submission) are listed in Annex B. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission.

ANNEX 12: OVERVIEW OF THE CURRENT SUBMISSION IMPROVEMENTS

A12.1 Results of the UNFCCC review process

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, received as preliminary main findings, are described in the following table.

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
General/ QA/QC and verification	In order to improve consistency between the CRF tables and the NIR, the ERT recommends that the Party ensure consistency between NIR tables 2.2 and 2.3 and CRF table 10s1	G.1	QA/QC activities and consistency checks in the preparation of the NIR have been improved, also in the pointed out tables	Chapter 1 paragraph 1.6
General/Key category analysis	The ERT encourages the Party to provide more details on the disaggregated results of both approaches used in the key category analysis and include a legend to clarify the values included in the reported tables	G.2	All the relevant information on the disaggregation was already included in the NIR. A legend has been added	Chapter 1 paragraph 1.6 and Annex 1
Energy/ manufacturing industries and construction - other fossil fuels – CO_2, CH_4, N_2O	No issues related to inconsistencies in the time series have been identified but the ERT recommends that Italy include a discussion in the NIR on the impact of any recalculations on the trend in CO2, CH4 and N2O emissions at the category, sector and national total levels, as appropriate	E.2	Additional information has been added in the NIR	Chapter 3 paragraph 3.4
Energy/ 1.A.2.d Pulp, paper and print - biomass – CO_2	The ERT noted that in pulp, paper and print industry, biomass fuel consumption includes black liquor and industrial sludge and biogas from industrial organic wastes. In response to the question raised by the ERT regarding a country-specific EF for biomass (112.57 t/TJ), the Party explained that the EF is derived from EU ETS data reported by the pulp and paper operators for 2008, and applied to the whole time series, where the specific CO2 EF results from the average mix of biomass fuel used in the year 2008. The ERT recommends that Italy further analyse the EU ETS data for the time series available, taking into consideration biomass fuel mix in the relevant year, and document the relevant information in the NIR	E.3	Additional information has been added in the NIR	Chapter 3 paragraph 3.4
Energy/ 1.A.2.e Food processing, beverages and tobacco – biomass– CH_4	The applied emission factor for CH_4 emissions for biogas is much higher that the default value in 2006 GLs…. The Party explained that EF takes in account the technology used to produce energy and heat which results in higher emissions of VOC, CO and PM. The ERT recommends that Italy further analyse and collect information at plant level in order to verify and, if appropriate, update the CH_4 EF.	E.4	Additional information has been added in the NIR	Chapter 3 paragraph 3.6
Energy	Inconsistencies between NIR and CRF regarding CH_4 and N_2O emission factors for other fuels. Party explained that CORINAIR EFs applied at plant level are considered for non-CO2 gases but for CH4 and N2O it does not result in changes of the IEF.	Provide corrected information in the NIR	Inconsistencies have been removed	Chapter 3 paragraph 3.6
Energy/ 1.A.3 Transport — CO_2, CH_4, N_2O	The ERT noted that there was no clear explanation regarding the allocation of emissions from lubricant used in railways. Use of lubricants, except in 2-stroke engines and mixed with motor gasoline is to be reported under the IPPU sector. During the review, Italy explained that all lubricants used for	E.5	According to the review process and to the 2006 IPCC Guidelines emission estimates from lubricants have been reported under IPPU instead of energy	Chapter 3 paragraph 3.5.2

	engines had been included under road transportation (1.A.3.b) and estimated by the COPERT model…. The ERT recommends that the Party exclude the amount of non-combustible use of lubricants in railways from 1.A.3 Transport and include it in the IPPU sector, category 2.D (lubricant use)		except those related to its use in two stroke engines in road transport	
Energy/ 1.A.3.a Domestic aviation – liquid fuels – CH_4 N_2O	During the review, the ERT requested additional explanation from Italy regarding the rationale for the applied N_2O and CH_4 EFs. … The ERT encourages the Party to include information in the NIR to describe the choice of N_2O and CH_4 EFs for aviation fuels, particularly to describe the use of survey data to estimate the CH_4 EF and how the Party ensures times series consistency	E.6	Additional information have been added in the NIR considering also that for many pollutants Eurocontrol methodology and data have been used to estimate emissions from 2005 to 2015.	Chapter 3 paragraph 3.5.1
Energy/ 1.A.3.d Domestic navigation — CO_2, CH_4, N_2O	The ERT requested additional information from the Party regarding the amount of lubricant used in the country, as reported in four groups – maritime bunkers, industrial use, engines in the transport sector, and in the petrochemical industry– and of how it estimated and reported GHG emissions…. The ERT recommends that Italy estimate the amount of non-combustible use of lubricant in domestic navigation, and include its CO_2 emission estimation in category 2.D.3 in order to improve the completeness and comparability of its reporting	E.7	Emission estimates from lubricants have been reported under IPPU instead of energy except those related to its use in two stroke engines in road transport	Chapter 3 paragraph 3.5.4
International navigation – other liquid fuels – CO_2, CH_4, N_2O	In CRF table 1.D, Italy did not specify what was reported under other liquid fuels. The ERT recommends that Italy specify in CRF table 1.D the specific type(s) of liquid fuel consumed to improve transparency	E.8	According to the review process and to the 2006 IPCC Guidelines emission estimates from lubricants have been reported under IPPU instead of energy except those related to its use in two stroke engines in road transport. So there are no more other liquid fuels reported in CRF table 1.D	Chapter 3 paragraph 3.7
Energy/ 1.A.4.a Commercial/ Institutional – other fossil fuels – General	The ERT noted that Italy has reported emissions due to the non-renewable part of wastes used in electricity generation and the amount of fossil waste burned in incinerators with energy recovery under the category commercial/institutional. … Given that the share of municipal solid waste incineration connected to the grid and used for electricity production is increasing, the ERT recommends Italy revise the allocation of these emissions under category 1.A.1.a Public electricity and heat production in order to ensure comparability	E.9	Not implemented. Additional information has been included in the NIR to explain the reason of the allocation used	Chapter 3 paragraph 3.6
Energy/ 1.B.1.b Solid fuel transformatio n – CO_2 and CH_4	The ERT encourages Italy to provide the information on the charcoal production process, specifically when in the time series the modern technology replaced the conventional technology or insert a cross reference in 1.B.1.b Solid fuel transformation in order to improve the overall transparency of the report	E.10	The relevant information has been also included in section 1.B.1.B of the NIR	Chapter 3 paragraph 3.9
Energy/ 1.B.2.c Venting and flaring – Gas – CH4	The ERT noted that the inter-annual change in the CH4 IEF in the category 1.B.2.C.2 flaring – gas between 2013 and 2014 has been large (5,562.0%). … The ERT recommends that the Party revise the value of CH_4 emissions from 1.B.2.C.2 flaring – gas for 2014 to correct the error for flaring in production and processing	E.11	The error has been corrected	Chapter 3 paragraph 3.9
Energy/ 1.B.2.c Venting and flaring – Oil – CO_2, CH_4, N_2O	In CRF table 1.B.2, Italy had entered 4,668.05 kt as the amount of oil produced in 1.B.2.c. flaring – oil production while the amount of oil produced in 2014 was 5,764.93 kt as reported under category 1.B.2.a.2 (oil production) in the same CRF table. … The ERT recommends that Italy report the correct value for the AD for flaring-oil production	E.12	Reporting of activity data in the CRFs has been corrected for the whole time series	Chapter 3 paragraph 3.9

	and improve the QC by introducing a check to ensure the same AD are included for oil production in various parts of the CRF tables			
IPPU/ 2.A Mineral industry – CO_2	The NIR (p.121) states that CO_2 emissions from road paving and asphalt roofing are included in mineral products. … The ERT recommends Italy to correct the error in the NIR in the next annual submission.	I.13	The relevant paragraph has been moved under 2D category description of the NIR	Chapter 4 paragraph 4.5
IPPU/ 2.B.6 Titanium dioxide production – CO_2	In the NIR, Italy states that the AD and CO_2 emission estimates for titanium dioxide production have been provided by the only operator in the country for the entire time series. However, it is not clear from the NIR what methodology was used to provide these estimates. …. Italy explained this facility is in the scope of the EPER/EPRTR legislation; …. The ERT recommends that Italy include a detailed description used to estimate emissions from titanium dioxide in the annual submission. The ERT also recommends that Italy include a description of how EPER/EPRTR and EU ETS methodologies correlate with the 2006 IPCC guidelines for GHG emission estimation	I.14	Additional information has been added in the NIR	Chapter 4 paragraph 4.3
IPPU/ 2.D.2 Paraffin wax use – CO_2	The ERT noted that there was no information in the NIR on the source of AD for paraffin wax use and no rationale for calculating the fraction of entire paraffin consumption ... During the review, Italy provided information on the current data sources and a rationale for extracting 65% of the total paraffin consumption under the assumption that it is used for candle production as the sole known example of paraffin waxes combustion during use. … The ERT recommends that the Party include a description of the AD source for this category in the NIR	I.15	Additional information has been added in the NIR	Chapter 4 paragraph 4.5
IPPU/ 2.E.1 Integrated circuit or semiconductor - HFCs, PFCs, SF_6	Italy estimates the F-gas emissions from semiconductor manufacturing in accordance with the tier2a methodology on the basis of an equation accepted by the World Semiconductor Council. … The ERT noted that this equation is different from the proposed equation in the 2006 IPCC guidelines and it is not clear from the NIR how the different methods correlate. … Italy provided the explanation that the formula reported in the NIR combines the equations 6.2, 6.3, 6.4, 6.5 and 6.6 of the 2006 IPCC Guidelines. The ERT … agrees on the appropriateness of the approach… The ERT recommends that Italy provide information to present the correlation of the formula that is used to calculate the F-gas emissions from semiconductor manufacturing and the proposed Tier 2a method in the 2006 IPCC guidelines	I.16	Additional information has been added in the NIR	Chapter 4 paragraph 4.6
IPPU/ 2.E.1 Integrated circuit or semiconductor - HFCs, SF_6	The ERT noted that the inter-annual change between 1998 and 1999 in the HFC-23 IEF and SF_6 IEF has been identified as large in the time series…. In the NIR Italy explains that the first three years of the time series (1998-2000) are calculated on the basis of consumption data and the following years are calculated on the basis of plant specific parameters, which might imply time-series consistency issues ... Italy explained that for this period, owing to confidentiality problems and consequent lack of specific information, it was impossible ….The ERT recommends that Italy conduct an extrapolation of the estimates after 2001 in order to obtain the emissions for the period 1998-2000 and to include these estimates in the next inventory submission	I.17	Emission estimates have been updated according to additional data collected from industry	Chapter 4 paragraph 4.6

IPPU/ 2.F. Product uses as substitutes for ozone depleting substances – HFCs (35, 2014)	Provide information in the NIR to prove that a significant reduction in the leakage rates for F-gases occurred between 1999 and 2000. In the NIR it is explained that the appropriate leakage rates have been suggested by a pool of experts from several relevant national associations of refrigeration and air conditioning, and these showed a decrease in the leakage rates after 2000. However, Italy Italy did not provide a detailed explanation about the scientific reasons and assumptions behind this significant change (e.g. by providing supporting information on regulations implemented, changes in prices of F-gases or technological improvements, as identified by the previous ERT)	I.8	Additional information has been included in the NIR	Chapter 4 paragraph 4.7
IPPU/ 2.F.1 Refrigeration and air conditioning – HFCs	In NIR table 4.17, p. 160, Italy reported emissions from 2.F.1.a twice. … Italy confirmed that there was an error … The ERT recommends that Italy correct the error in table 4.17…	I.18	The table has been corrected	Chapter 4 paragraph 4.7
IPPU/ 2.F.1 Refrigeration and air conditioning – HFCs	The ERT in the review of the 2013 annual submission of Italy advised Italy to perform a cross-check of the GHG estimations from the top-down and the bottom-up approach…. . In response to a question raised by the ERT …, Italy explained that it is working in order to collect these data in a better way… The ERT welcomes the efforts that Italy undertakes to improve the accuracy and the transparency of the inventory and encourages the Party report on the future improvements related to the use of these two data sets in the next annual submission	I.19	Some comparisons and verification activities have been included in the NIR. Moreover in the 2018 submission emissions from domestic refrigeration have been updated on the basis of appliances produced and placed in the market.	Chapter 4 paragraph 4.7
IPPU/ 2.F.3 Fire protection – HFCs	… After 2010 there are no detailed consumption data for fire extinguishers, but Italy states in the NIR that according to projections the amount of gas was expected to decrease…. During the review, Italy explained that owing to lack of additional data … for the years 2010-2014, it was assumed that emissions are constant at 2010 levels although a reduction in the trend was expected. The ERT noted that there is a discrepancy between the NIR description and the actual manner of emission estimation… The ERT recommends that Italy correct the description in the expected trend … for the years 2010-2014 and explain that for these years the emissions are assumed to be constant and not decreasing	I.20	The relevant text in the NIR has been corrected	Chapter 4 paragraph 4.7
IPPU/ 2.F.4 Aerosols – HFCs	… The ERT noted that Italy changed the methodology and the revised estimates are included in the inventory submission. However, the Party did not provide an explanation of the emission estimation approach in the NIR. The ERT recommends that the Party include a description in the NIR of the methodology used to calculate the emission estimates for this category	I.21	According to the review and the 2006 IPCC Guidelines emission estimates have been updated and the relevant information has been included in the NIR	Chapter 4 paragraph 4.7
Agriculture/ 3.A.1 Cattle – CH_4	Italy uses CH_4 conversion factor (Ym) of 4- 6% for non-dairy cattle … which is one of the lowest compared with other European countries. During the review, Italy explained that the data are based on the Nitrogen Balance Inter-regional Project … The Ym values were calculated as a function of food digestibility ….The ERT recommends Italy to provide more information on Nitrogen Balance Inter-regional Project research results (including breeding performance, food consumption, composition of rations and digestibility) in the NIR	A.4	Additional information has been included in the NIR	Chapter 5 paragraph 5.3

	to confirm country- specific Ym values for non-dairy cattle			
Agriculture/ 3.B Manure management – CH_4	… Italy reported that losses from digesters are equal to 1% of biogas produced. … CH_4 flared has been assumed to be equal to 0. In response to a request by the ERT …, the Party informed that …. The amount of biogas produced was estimated on the basis of the biogas used and information on the average losses of biogas … reported to be about 1% of the total biogas produced. The Party also explained that it is still investigating the biogas flared together with CRPA, which is completing a new survey on the digesters. The ERT … and recommends that the Party include the results of the survey in its submission	A.5	Additional information on the amount of biogas flared has been collected and included in the emission estimates.	Chapter 5 paragraph 5.3
Agriculture/ 3.B Manure management – CH_4	For 1990, N_2O Emissions from Manure Management from Digesters have been reported as NO/NA (CRF table Table3.B(b)). However, in table Table3.B(a)s2 Italy has reported the percentage allocated by digesters for dairy cattle, non -dairy cattle and swine as 0 but the MCF is 1.14. During the review, Italy explained that there is an error in Table3.B(a)s2 and that it will be corrected. The ERT recommends that Italy correct the error in the reporting of a MCF in Table3.B(a)s2 for 1990 and fill the cells with the correct notation keys	A.6	The error has been corrected	Chapter 5 paragraph 5.3
Agriculture/ 3.B.5 Indirect N_2O emissions – N_2O	In CRF table 3(b) Italy reported indirect N_2O emissions from nitrogen leaching/runoff using the notation key IE, indicating that in the cell comment that indirect N_2O emissions … are included … under agricultural soils. During the review, Italy explained that it reports … under agricultural soils because it has a country-specific factor only for nitrogen losses from livestock, due to runoff and leaching which confirms the use of the 2006 IPCC guidelines default factor of 0.30 kg N/kg N of manure and the country-specific factor refers to the phase of the spreading of manure. Additionally, the Party explained that FracLEACH-(H) is comparable with the IPCC default, and therefore it has been decided to apply the IPCC default factor in the overall estimation process, … . The Party explained that a focus on the N losses from leaching and run-off in the storage of manure is currently on going, involving the main national experts. Italy noted that it plans to provide separate estimates and improve the methodological description in the NIR in the next submission. The ERT recommends that Italy make efforts to obtain information on the nitrogen losses due to leaching and run-off during manure storage and improve the accuracy of reporting indirect N_2O emissions from manure management … and improve the methodological description in the NIR	A.7	Separate estimates have been provided and additional information has been included in the NIR	Chapter 5 paragraph 5.3
Agriculture/ 3.D.a.2 Organic N fertilizers – N_2O	Estimates of emissions from animal manure applied to soils in Italy use a default Nbedding from the 2006 IPCC; however, the country specific N amounts in straw for calculating emissions from crop residues are used …. During the review, Italy was asked whether the verification of crop residues information with the calculations of animal manure applied to soils had been completed. … The Party … is still conducting further research to determine whether the 2006 IPCC defaults are appropriate for Italy. The ERT … encourages that Italy continue investigation on the nitrogen amount in bedding materials	A.8	Additional relevant information has been collected and emission estimates have been revised	Chapter 5 paragraph 5.5

Agriculture/ 3.D.b Indirect N_2O emissions from managed soils - N_2O	Italy uses the 2006 IPCC default EF for FracLEACH-(H) of 0.30. During the review, Italy confirmed that the soils meet the criteria indicated in Table 11.3 of the 2006 IPCC Guidelines to use this default value as it has a country-specific factor of nitrogen losses from livestock due to runoff and leaching. Additionally, the Party noted that it is investigating the fulfilment of the criteria set out in the guidelines. The ERT recommends that Italy include information on the value used for Frac LEACH-(H) and encourages the Party to continue to investigate the FrasLEACH-(H) fulfilment of the criteria set out in the IPCC 2006 guidelines	A.9	Additional information has been included in the NIR	Chapter 5 paragraph 5.5
Agriculture/ 3.G Liming – CO_2	In CRF table 3.G-I, Italy reported CO_2 emissions from dolomite using the notation key "IE", indicating in the NIR that there are no national statistics to disaggregate statistics of liming material. … During the review, Italy explained that … the disaggregation between limestone and dolomite used in agriculture showing a share of 55% for limestone and 45% for dolomite; these data will be used in the next submission. … The ERT recommends that Italy estimate emissions from limestone and dolomite application separately to improve the accuracy of reporting liming emissions … and confirm the amount of lime and dolomite for liming	A.10	Additional information has been collected from the industry on the amount of dolomite and limestone applied and the weighted average emission factor has been used to estimate emissions.	Chapter 5 paragraph 5.7
LULUCF General	Review of the use of the notation key so it is clearer what methods are used or if some pools are not estimated	L.3	Notation keys have been changed accordingly	Chapter 6
LULUCF/ 4.A Forest land – CO_2	Provide in the NIR documentation summarising harvest removal from short rotation crops, coppices and high forest categories so that drivers influencing trends in biomass stock changes can be made more evident	L.6	Additional information has been included in the NIR	Chapter 6 paragraph 6.2.4
LULUCF/ 4.A Forest land – CO_2	Provide definition and thresholds for carbon pools in a table in the NIR	L.7	Additional information has been included in the NIR	Chapter 6 paragraph 6.2.4
LULUCF/ 4.A.1 Forest land remaining forest land – CO_2	In response to a recommendation made in the 2013 review report, Italy included plantations in the forest category instead of in the cropland category from the beginning of its 2016 submission. This inclusion can be observed in CRF table 4.A but is not clearly reported in the NIR. The ERT commends the Party for this improvement and recommends it to include information in the NIR indicating that plantations are included in the forest category instead of cropland in order to be consistent with the CRF tables	L.12	Additional information has been included in the NIR	Chapter 6 paragraph 6.2.2
LULUCF/ 4.C.1 Grassland remaining grassland – CO_2	Italy has reported carbon stock change in mineral soils in grazing land management under the KP but has not reported the same pool in GL remaining GL under the Convention …. During the review, Italy explained that improved grazing land … is a subset of the grassland area and that the Party has a planned data collection and model implementation for the soils pool for the grassland area. The ERT welcomes these planned improvements and recommends that the Party include this subset in the CFR tables and the NIR under the Convention while the new information is becoming available	L.14	Data of land subject to grazing land management has been derived from the National System on Organic Farming; quantitative information on the different subcategories, including organic grazing land, is available from the year 1999. Verification activities are currently ongoing to assess the data related to the land subject to the organic grazing land from 1990 to 1998 in order to include this subset (improved grazing land) as a subset of the grassland area, consequently	Chapter 6 paragraph 6.4; Chapter 9, paragraph 9.2

			reporting the relative carbon stock changes in mineral soils.	
LULUCF/ 4.(I) direct N_2O emissions from nitrogen inputs to managed soils	Report direct N2O emissions from nitrogen fertilization as "IE" and transparently explained these emissions are reported under the agriculture sector (with a cross reference to the relevant section in the NIR)	L.10	Notation key has been changed and additional information has been added in the NIR	Chapter 6 paragraph 6.8
KP-LULUCF/ Article 3.4 activities – CO_2	Under the KP, the Party reported 'NA' for the litter pool and 'NO' for dead wood pools for cropland management and also reported 'NO' for Above-ground biomass, Below-ground biomass, Litter and Dead wood for grassland management. During the review week the Party explained that for cropland management a Tier 1 was applied assuming that the dead wood and litter stocks are not present in Cropland or are at equilibrium as in agroforestry systems and orchards and that a Tier 1 value was also applied for the pools in Lands under GM for aboveground and belowground biomass, litter and dead wood pools, assuming that they are at equilibrium. The ERT recommends that the Party include transparent and verifiable information that demonstrates that these pools are not a source, as it is stated in the Annex to Decision 2/CMP.7 and to change the notation key from 'NO' to 'NE'	KL.2	Additional information has been added in the NIR	Chapter 9 paragraph 9.5
KP-LULUCF/ Forest management – CO_2	The ERT notes that Italy has not reported its FMRL in its CRF tables; the NIR correctly references the values presented in the appendix to the annex of decision 2/CMP.7 (–21.182 Mt CO2 eq assuming instantaneous oxidation and –22.166 Mt CO2 eq applying a first order decay function for HWP). The ERT recommends that Italy complete CRF table 4(KP-I)B.1.1 to include the FMRL as included in the appendix to the annex to decision 2/CMP.7	KL.3	CRF Tables have been corrected and completed	Chapter 9 paragraph 9.5.2
KP-LULUCF/ Forest management – CO_2	Italy described … the methodological elements that trigger a methodological inconsistency between the FMRL and FM reporting. It is noted in the NIR that a recommendation was made in the technical assessment of the FMRL in 2011 to make a technical adjustment. However, the Party has not presented the technical correction. … The ERT recommends that the Party report the FMRL correction in the next submission and complete the relevant CFR tables with the current and corrected values	KL.4	The need for the application of a technical correction has been detected. The technical correction has been elaborated and included in the 2018 submission, consistently with the requirements of decision 2/CMP.7, annex, paragraph 14 and guidance of the 2013 KP Supplement (IPCC, 2014, par. 2.7.6.3).	Chapter 9 paragraph 9.5.2
Waste/ 5.A.1 Managed waste disposal sites – CH_4	The Party reported a step function variation for the methane generation constant k (0.463 for 1971 - 1990, 0.362 for 1991 - 2005 and 0.363 for 2006 onwards). This introduces an abrupt change in the time series, especially between 1990 and 1991 …. The ERT recommends that the Party develop a continuous time-series of the (k), instead of using the step function variation over the relevant periods	W.2	K values have been revised for the last years of the time series according to the 2006 IPCC Guidelines and taking into account the changes in climatic conditions occurred in Italy. Additional information has been included in the NIR	Chapter 7 paragraph 7.2
Waste/ 5.A.1 Managed waste disposal sites – CH_4	.. The Party reported having used the default DOC_f value of 0.5 in the NIR. However, the value is different from the value reported in CRF table 5.A of 9.44. … The ERT recommends that the Party make the necessary changes to the DOCf in the CRF table 5A to improve the consistency between the NIR and the CRF tables	W.3	The relevant CRF table has been corrected reporting the DOCf value instead of the DOC	Chapter 7 paragraph 7.2

Waste/ 5.B.1 Composting – CH_4	The Party reported a country specific emission factor of 0.029 g CH_4 / kg for CH_4 emissions from composing. This is less than the 2006 IPCC default value and the IPCC provided range (0.2 to 1.6 g CH_4 / kg). The reported value is also lower than values reported by other Parties and there is no justification or explanation for the choice of the low value. The ERT recommends that the Party provide a detailed explanation for the choice of the EF .., including justification, reference, assumptions made and procedures followed in this choice	W.4	A detailed survey has been conducted and the emission factor has been updated.	Chapter 7 paragraph 7.3
Waste/ 5.A.2 Unmanaged waste disposal sites	The Party reported in the NIR that from the year 2000, waste deposited in unmanaged landfills fell to zero as a result of legal reforms without providing justification for the assumption. During the review, the Party provided more information, including action taken by the Police to halt disposal of waste in unmanaged sites. The ERT recommends that the Party provide information supporting implementation of legal reforms to reduce to zero, the amount of waste deposited in unmanaged landfills, together with an illustration of the trend in the decrease of waste deposited in unmanaged landfills	W.5	Additional information has been included in the NIR	Chapter 7 paragraph 7.2
Waste/ 5.C.1 Waste incineration – CO_2 (66, 2014)	Apply the time-series carbon content as well as fossil carbon fraction in line with the variation of the waste compositions, and report thereon in its next annual submission	W.1	Not implemented	Chapter 7 paragraph 7.4

A12.2 Results of the ESD technical review process

During the last ESD technical review process, some issues were raised which have been taken into account to improve the current submission. Responses to the main issues are described in the following table.

Implementing Regulation Article 9: Reporting on implementation of recommendations and adjustments
2.Member States shall report on the status of implementation of each recommendation listed in the most recent review report pursuant to Article 35(2) in accordance with the tabular format specified in Annex IV.

Member State:	Italy
Reporting year:	2018

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
IT-5A-2017-0001 - 5A Solid waste disposal, CH4, 1990-2015	For category 5.A and gas CH4 for the year 2015, the TERT noted that Italy calculates methane emissions from solid waste disposal using country-specific model parameters that were insufficiently justified. In response to questions raised during the review Italy provided a revised estimate. The TERT disagreed with the revised estimate, because Italy applied IPCC default values for wet, temperate climates, while large part of Italian waste is landfilled under dry, temperate conditions; and also because the amount of methane flared and recovered in the revised estimate was different from the amount reported in the CRF tables. The TERT decided to calculate a technical correction for the year 2015. Italy noted that it does not fully agree with the assumptions made in the technical correction but that it can accept the technical correction, because it is not yet able to provide	2017ESD-FinalReviewReport_IT_30-06-2017.pdf	K values have been revised for the last years of the time series according to the technical correction and 2006 IPCC Guidelines taking in account the distribution of the national territory with dry and wet	Chapter 7 paragraph 7.2

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	a new estimate. The estimates demonstrate that the issue is above the threshold of significance. The TERT recommends that Italy include a revised estimate in its next submission.		temperate climates.	

ANNEX 13: REPORTING UNDER EU REGULATION No 525/2013

A13.1 Article 10 of the EU Regulation

Implementing Regulation Article 10: Reporting on consistency of reported emissions with data from the emissions trading system

1.Member States shall report the information referred to in Article 7(1)(k) of Regulation (EU) No 525/2013 in accordance with the tabular format set out in Annex V to this Regulation.

2.Member States shall report textual information on the results of the checks performed pursuant to Article 7(1)(l) of Regulation (EU) No 525/2013.

Allocation of verified emissions reported by installations and operators under Directive 2003/87/EC to source categories of the national greenhouse gas inventory

Member State:	Italy
Reporting year:	2018

Basis for data: verified ETS emissions and greenhouse gas emissions as reported in inventory submission for the year X-2

Total emissions (CO2 -eq)

Category[1]	Gas	Greenhouse gas inventory emissions [kt CO_2eq][3]	Verified emissions under Directive 2003/87/EC [kt CO2eq][3]	Ratio in % (Verified emissions/ inventory emissions)[3]	Comment[2]
Greenhouse gas emissions (total emissions without LULUCF for GHG inventory and without emissions from 1A3a Civil aviation, total emissions from installations under Article 3h of Directive 2003/87/EC)	Total GHG	425,706.786	154,993.507	36.41%	
CO2 emissions (total CO2 emissions without LULUCF for GHG inventory and without emissions from 1A3a Civil aviation, total emissions from installations under Article 3h of Directive 2003/87/EC)	Total CO_2	348,167.808	154,877.418	44.48%	

CO_2 emissions

Category[1]		Greenhouse gas inventory emissions [kt CO_2eq][3]	Verified emissions under Directive 2003/87/EC [kt CO_2eq][3]	Ratio in % (Verified emissions/ inventory emissions)[3]	Comment[2]
1.A Fuel combustion activities, total	CO_2	332444.216	NA	NA	
1.A Fuel combustion activities, stationary combustion [4]	CO_2	229064.913	138047.123	0.603	
1.A.1 Energy industries	CO_2	103785.133	103785.133	1.000	
1.A.1.a Public electricity and heat production	CO_2	75979.612	75979.612	1.000	
1.A.1.b Petroleum refining	CO_2	21030.396	21030.396	1.000	
1.A.1.c Manufacture of solid fuels and other energy industries	CO_2	6775.125	6775.125	1.000	
Iron and steel total (1.A.1.c, 1.A.2, 1.B,	CO_2	18857.935	17987.268	0.954	

CO_2 emissions					
Category[1]		Greenhouse gas inventory emissions [kt CO_2eq][3]	Verified emissions under Directive 2003/87/EC [kt CO_2eq][3]	Ratio in % (Verified emissions/ inventory emissions)[3]	Comment[2]
2.C.1) [5]					
1.A.2. Manufacturing industries and construction	CO_2	46955.406	33465.784	0.713	
1.A.2.a Iron and steel	CO_2	10609.438	9738.772	0.918	
1.A.2.b Non-ferrous metals	CO_2	1017.868	466.061	0.458	
1.A.2.c Chemicals	CO_2	8492.896	5032.034	0.592	
1.A.2.d Pulp, paper and print	CO_2	4039.490	3945.639	0.977	
1.A.2.e Food processing, beverages and tobacco	CO_2	3473.283	1711.722	0.493	
1.A.2.f Non-metallic minerals	CO_2	11457.679	9579.281	0.836	
1.A.2.g Other	CO_2	7864.753	2992.275	0.380	
1.A.3. Transport	CO_2	103379.303	669.303	0.006	
1.A.3.e Other transportation (pipeline transport)	CO_2	669.303	669.303	1.000	
1.A.4 Other sectors	CO_2	77808.994	796.207	0.010	
1.A.4.a Commercial / Institutional	CO_2	22802.841	796.207	0.035	
1.A.4.c Agriculture/ Forestry / Fisheries	CO_2	7008.039	0	0.000	
1.B Fugitive emissions from Fuels	CO_2	2483.286	2076.609	0.836	
1.C CO2 Transport and storage	CO_2				
1.C.1 Transport of CO2	CO_2				
1.C.2 Injection and storage	CO_2				
1.C:3 Other 2.A Mineral products	CO_2				
2.A Mineral products	CO_2	10606.791	10376.384	0.978	
2.A.1 Cement Production	CO_2	7680.499	7670.555	0.999	
2.A.2. Lime production	CO_2	1660.836	1524.967	0.918	
2.A.3. Glass production	CO_2	512.073	512.073	1.000	
2.A.4. Other process uses of carbonates	CO_2	753.383	668.789	0.888	
2.B Chemical industry	CO_2	1463.479	1997.544	1.365	
2.B.1. Ammonia production	CO_2	642.727	1181.638	1.838	ETS data include emissions from urea production
2.B.3. Adipic acid production (CO2)	CO_2	1.852	1.852	1.000	
2.B.4. Caprolactam, glyoxal and glyoxylic acid production	CO_2				
2.B.5. Carbide production	CO_2	4.568	0	0.000	
2.B.6 Titanium dioxide production	CO_2	35.603	35.603	1.000	
2.B.7 Soda ash production	CO_2	281.794	281.517	0.999	
2.B.8 Petrochemical and carbon black production	CO_2	496.935	496.935	1.000	
2.C Metal production	CO_2	1710.454	1710.454	1.000	
2.C.1. Iron and steel production	CO_2	1473.371	1473.371	1.000	
2.C.2 Ferroalloys production	CO_2				
2.C.3 Aluminium production	CO_2				
2.C.4 Magnesium production	CO_2				
2.C.5 Lead production	CO_2				

CO_2 emissions					
Category[1]		Greenhouse gas inventory emissions [kt CO_2eq][3]	Verified emissions under Directive 2003/87/EC [kt CO_2eq][3]	Ratio in % (Verified emissions/ inventory emissions)[3]	Comment[2]
2.C.6 Zinc production	CO_2	237.083	237.083	1.000	
2.C.7 Other metal production	CO_2				

N_2O emissions					
Category[1]	Gas	Greenhouse gas inventory emissions [kt CO_2eq][3]	Verified emissions under Directive 2003/87/EC [kt CO_2eq][3]	Ratio in % (Verified emissions/ inventory emissions)[3]	Comment[2]
2.B.2. Nitric acid production	N_2O	50.077	50.068	1.000	
2.B.3. Adipic acid production	N_2O	66.022	66.022	1.000	
2.B.4. Caprolactam, glyoxal and glyoxylic acid production	N_2O				

PFC emissions					
Category[1]	Gas	Greenhouse gas inventory emissions [kt CO2eq][3]	Verified emissions under Directive 2003/87/EC [kt CO_2eq][3]	Ratio in % (Verified emissions/ inventory emissions)[3]	Comment[2]
2.C.3 Aluminium production	PFC				

[1] The allocation of verified emissions to disaggregated inventory categories at four digit level must be reported where such allocation of verified emissions is possible and emissions occur. The following notation keys should be used: NO = not occurring IE = included elsewhere C = confidential negligible = small amount of verified emissions may occur in respective CRF category, but amount is < 5% of the category

[2] The column comment should be used to give a brief summary of the checks performed and if a Member State wants to provide additional explanations with regard to the allocation reported. Member States should add a short explanation when using IE or other notation keys to ensure transparency.

[3] Data to be reported up to one decimal point for kt and % values

[4] 1.A Fuel combustion, stationary combustion should include the sum total of the relevant rows below for 1.A (without double counting) plus the addition of other stationary combustion emissions not explicitly included in any of the rows below.

[5] To be filled on the basis of combined CRF categories pertaining to 'Iron and Steel' , to be determined individually by each Member State; e.g. (1.A.2.a+ 2.C.1 + 1.A.1.c and other relevant CRF categories that include emissions from iron and steel (e.g. 1A1a, 1B1))

Notation: x = reporting year

A13.2 Article 12 of the EU Regulation

Implementing Regulation Article 12: Reporting on consistency with energy data
1.Under Article 7(1)(m)(iii) of Regulation (EU) No 525/2013, Member States shall report textual information on the comparison between the reference approach calculated on the basis of the data included in the greenhouse gas inventory and the reference approach calculated on the basis of the data reported pursuant to Article 4 of Regulation (EC) No 1099/2008 of the European Parliament and of the Council (1) and Annex B to that Regulation.
2.Member States shall provide quantitative information and explanations for differences of more than +/– 2 % in the total national apparent fossil fuel consumption at aggregate level for all fossil fuel categories for the year X-2 in accordance with the tabular format set out in Annex VI.

Member State:	ITALY
Reporting year:	2016

FUEL TYPES			Apparent consumption reported in GHG inventory (TJ) (3)	Apparent consumption using data reported pursuant to Regulation (EC) No 1099/2008 (TJ) (3)	Absolute difference (1) (TJ) (3)	Relative difference (2) % (3)	Explanations for differences
Liquid fossil	Primary fuels	Crude oil	2,704,087	2,704,087	0	0.0%	
		Orimulsion					
		Natural gas liquids					
	Secondary fuels	Gasoline	-335,909	-333,388	-2,521	0.8%	
		Jet kerosene	-56,643	-47,977	-8,666	15.3%	
		Other kerosene	431	688	-257	-59.5%	
		Shale oil					
		Gas/diesel oil	-213,391	-204,484	-8,907	4.2%	
		Residual fuel oil	-234,038	-211,258	-22,780	9.7%	
		Liquefied petroleum gases (LPG)	97,498	96,186	1,312	1.3%	
		Ethane					
		Naptha	29,827	32,340	-2,513	-8.4%	
		Bitumen	-41,948	-42,081	133	-0.3%	
		Lubricants	-30,231	-36,246	6,015	-19.9%	
		Petroleum coke	34,820	32,064	2,756	7.9%	
		Refinery feedstocks	343,527	267,700	75,827	22.1%	
		Other oil	-11,583	-19,920	8,337	-72.0%	
	Other liquid fossil						
	Liquid fossil total		2,286,447	2,237,710	48,736	2.1%	
Solid fossil	Primary fuels	Anthracite					
		Coking coal	75,601	75,601	0	0.0%	
		Other bituminous coal	361,633	361,633	0	0.0%	
		Sub-bituminous coal	2,410	2,410	0	0.0%	
		Lignite	21	21	0	0.0%	
		Oil shale and tar sand					
	Secondary fuels	BKB and patent fuel					
		Coke oven/gas coke	19,935	19,935	0	0.0%	
		Coal tar					
	Other solid fossil						
	Solid fossil totals		459,601	459,601	0	0.0%	

FUEL TYPES			Apparent consumption reported in GHG inventory (TJ) (3)	Apparent consumption using data reported pursuant to Regulation (EC) No 1099/2008 (TJ) (3)	Absolute difference (1) (TJ) (3)	Relative difference (2) % (3)	Explanations for differences
Gaseous fossil		Natural gas (dry)	2,431,965	2,431,675	289	0.0%	
Other gaseous fossil							
Gaseous fossil totals			2,431,965	2,431,675	289	0.0%	
	Waste (non-biomass fraction)		36,485	49,536	-13,051	-35.8%	
Other fossil fuels							
Peat							
Total			5,214,498	5,178,523	35,975	0.7%	
(1) Apparent consumption reported in GHG inventory minus apparent consumption using data reported pursuant to Regulation (EC) No 1099/2008							
(2) Absolute difference divided by apparent consumption reported in GHG inventory							
(3) Data to be reported up to one decimal point for kt and % values							

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