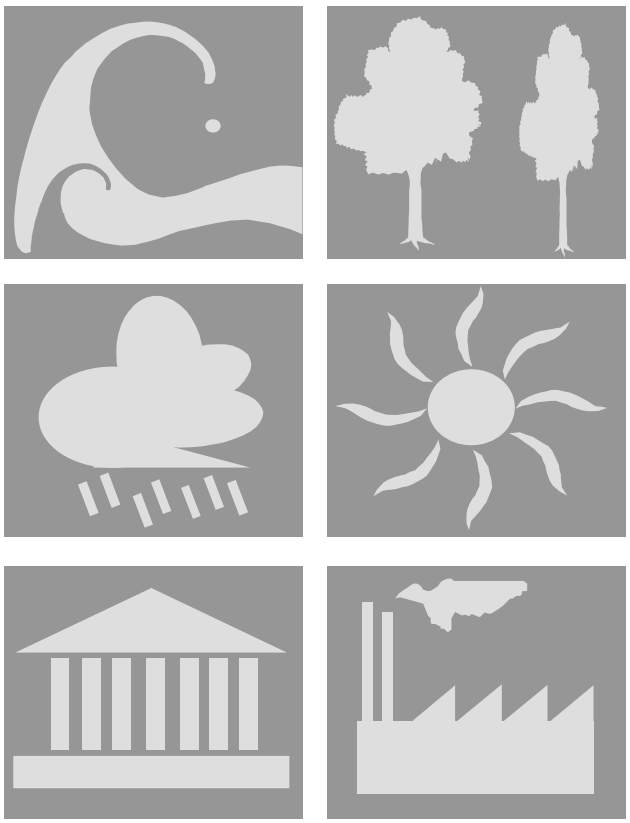
MINISTRY OF ENVIRONMENT, ENERGY AND CLIMATE CHANGE

CLIMATE CHANGE



EMISSIONS INVENTORY

ANNUAL INVENTORY SUBMISSION UNDER THE CONVENTION AND THE KYOTO PROTOCOL FOR GREENHOUSE AND OTHER GASES FOR THE YEARS 1990-2009

APRIL 2011

ANNUAL INVENTORY SUBMISSION
UNDER THE CONVENTION AND
THE KYOTO PROTOCOL
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EXECUTIVE SUMMARY

ES.1 Greenhouse gas inventories and climate change

The present report, prepared by Greece (Ministry of Environment, Energy and Climate Change (Climate Team) in co-operation with the National Technical University of Athens, NTUA – School of Chemical Engineering (Inventory Team)), contains estimates of GHG emissions for the period 1990-2009. **It constitutes Greece's submission both under the Convention and the Kyoto Protocol.** The methodologies applied for the estimation of GHG emissions are discussed and the activity data and emission factors used are presented. The recommendations made by the Expert Review Team (ERT) during the Centralized Review of the GHG inventory submitted in 2010, held from 13 to 18 of September 2010, have been taken into account as described in the present report.

International framework and national commitments

In response to the emerging evidence that climate change could have a major global impact, the United Nations Framework Convention on Climate Change (henceforth the Convention) was adopted on 9 May 1992 and was opened for signature in Rio de Janeiro in June 1992. Greece signed the Convention in Rio and ratified it in 1994 (Law 2205/94).

Recognizing early the need for an effective instrument to provide confidence in addressing the climate change challenge, the Parties at the third meeting of the Conference of the Parties (COP) to the Convention, held in Kyoto (1-11 December 1997), finalised negotiations related to the establishment of such a legal instrument, the Kyoto Protocol on Climate Change (henceforth the Protocol). The Protocol provides a foundation upon which future action can be intensified. It establishes, for the first time, legally binding targets for the reduction of greenhouse gas emissions and it also confirms the capacity of the international community to cooperate in action to deal with a major global environmental problem.

The Protocol calls for legally binding commitments of the developed countries to reduce, individually or jointly, emissions of 6 greenhouse gases (CO_2, CH_4, N_2O, HFC, PFC and SF_6) by more than 5% in the period 2008 to 2012, below their 1990 level. The EU and its Member States agreed to a -8% reduction.

Detailed rules for the implementation of the Protocol were set out at the 7th Conference of the Parties (in Marrakesh) and are described in the Marrakesh Accords adopted in 2001.

The Protocol entered into force on 16 February 2005, after its ratification from 141 Parties including developed countries with a contribution of more than 55% to global CO_2 emissions in 1990.

At the first Conference of the Parties serving as the Meeting of the Parties to the Protocol (COP/CMP) held in Canada (December 2005) the rules for the implementation of the Protocol agreed at COP7 were adopted.

The same COP/CMP established a working group, called the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP), to discuss future commitments for industrialized countries under the Kyoto Protocol.

The Conference of the Parties (COP) in 2007, by its decision 1/CP.13 (the Bali Action Plan) launched a comprehensive process to enable the full, effective and sustained implementation of the Convention through long-term cooperative action, now, up to and beyond 2012, to be conducted under a subsidiary body under the Convention, the Ad Hoc Working Group on Long-Term Cooperative Action under the Convention (AWG-LCA).

Within the framework of the Convention, the Greek government, after taking into consideration both economic and social parameters, agreed that a realistic target for Greece was the restriction of the overall increase of carbon dioxide emissions to 15% ± 3% by 2000 compared to 1990 levels. The measures taken in order to achieve this restriction in the CO_2 emissions were described in the 1st Greek National Action Plan for the abatement of CO_2 and other greenhouse gases emissions (MINENV / NTUA 1995).

With respect to the EU target under the Kyoto Protocol (i.e. reduction of emissions at 8% for the period 2008-2012), EU has stated that this will be achieved jointly by EU Member-States under the provisions of Article 4 of the Protocol. The Burden-Sharing agreement between all Member States was finalised during the Environment Council in June 1998 and entered into force with Decision 2002/358/EC concerning the approval, on behalf of the European Community, of the Kyoto Protocol. According to this agreement, Greece is committed to limit its GHG emissions increase for the period 2008 – 2012 to +25% compared to base year emissions (1990 for CO_2, CH_4 and N_2O emissions – 1995 for F - gases). Greece ratified the Protocol in 2002 (Law 3017/2002) and adopted the 2nd National Programme for Climate Change (MINENV, 2002) for achieving the above-mentioned commitment by a decision of the Council of Ministers (DCM5/2003).

Greenhouse gas emissions inventories

Annual inventories of greenhouse and other gases emissions form an essential element of each national environmental policy-making process. They can be used to derive information on emissions trends, with reference to a pre-selected base year, and can assist in monitoring the progress of existing abatement measures for the reduction of greenhouse gases emissions and the fulfilment of the KP target.

Reporting requirements and guidelines under the Convention are defined by relevant decisions of the Conference of the Parties (Decisions 18/CP.8, 13/CP.9, 14/CP.11). In order to ensure transparency, consistency, comparability, completeness and accuracy in national greenhouse gas emissions inventories the use of (a) the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, (b) the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories and (c) the IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry was adopted. However, it should be mentioned that Parties are encouraged to

apply country specific methodologies provided that compliance with the above-mentioned references can be proven.

Institutional arrangements and inventory preparation

In article 5, paragraph 1 of the Protocol, it is specified that "Each Party included in Annex I shall have in place, no later than one year prior to the start of the first commitment period, a national system for the estimation of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol". A national system includes all institutional, legal and procedural arrangements made within an Annex I Party of the Convention that is also a Party to the Protocol for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, and for reporting and archiving inventory information.

The Ministry of Environment, Energy and Climate Change, MEECC (former Ministry for the Environment, Physical Planning and Public Works) is the governmental body responsible for the development and implementation of environmental policy in Greece, as well as for the provision of information concerning the state of the environment in compliance with relevant requirements defined in international conventions, protocols and agreements. Moreover, the MEECC is responsible for the co-ordination of all involved ministries, as well as any relevant public or private organization, in relation to the implementation of the provisions of the Kyoto Protocol, according to the Law 3017/2002 with which Greece ratified the Kyoto Protocol.

In this context, the MEECC has the overall responsibility for the national GHG inventory, and the official consideration and approval of the inventory prior to its submission. (Contact person: Afroditi Kotidou, Address: Villa Kazouli, Kifisias 241, Athens, Greece, e-mail: a.kotidou@ekpaa.minenv.gr, tel.: +30210 8089275, fax: +30210 8089239).

An overview of the organizational structure of the National Inventory System is presented in ***Figure 1.1***. The participating entities are:

- The **Ministry of Environment, Energy and Climate Change (MEECC)** designated as the national entity responsible for the national inventory, which keeps the overall responsibility, but also plays an active role in the inventory planning, preparation and management.
- The **National Technical University of Athens (NTUA) / School of Chemical Engineering**, which has the technical and scientific responsibility for the compilation of the annual inventory.
- **Governmental ministries and agencies** through their appointed focal persons, ensure the data provision.

International or national associations, along with individual private industrial companies contribute to data providing and development of methodological issues as appropriate.

The compilation of the inventory is completed in three main stages, as follows:

Stage 1: The first stage consists of data collection and check for all source/sink categories. The main data sources used are the Hellenic Statistical Authority (ElStat), the national energy balance, the government ministries/agencies involved and large private enterprises, along with the verified reports from installations under the EU ETS.

Quality control of activity data include the comparison of the same or similar data from alternative data sources (e.g. Hellenic Statistical Authority and ETS reports) as well as time-series assessment in order to identify changes that cannot be explained. In cases where problems and/or inconsistencies are identified, the agency's representative, responsible for data providing, is called to explain the inconsistency and/or help solving the problem.

Stage 2: Once the reliability of input data is checked and certified, emissions/removals per source/sink category are estimated. Emissions estimates are then transformed to the format required by the CRF Reporter. This stage also includes the evaluation of the emission factors used and the assessment of the consistency of the methodologies applied in relation to the provisions of the IPCC Guidelines, the IPCC Good Practice Guidance and the LULUCF Good Practice Guidance. Regarding LULUCF (UNFCCC scope) and Article 3.3 and 3.4 activities (KP LULUCF), the General Directorate for the Development and Protection of Forests of MEECC prepares the NIR and CRF tables for the above mentioned activities, which are incorporated by the inventory team to the NIR and CRF tables submitted to the MEECC Climate team for approval and submission.

Quality control checks, when at this stage, are related to time-series assessment as well as to the identification and correction of any errors / gaps while estimating emissions / removals and filling in the CRF Reporter.

Stage 3: The last stage involves the compilation of the NIR and its internal (i.e. within NTUA) check. The official approval procedure follows for one month period of interactions between the Inventory Team (NTUA) and the Climate Team (MEECC), starting on the 1st of February of the year of submission. During this period, the NTUA Inventory Team has to revise the report according to the observations and recommendations of the Climate Team. On the basis of this interaction process, the final version of the report is compiled. The General Director for the Environment of MEECC, who supervises the National System, approves the inventory and then the MEECC submits the NIR to the European Commission and to the UNFCCC Secretariat.

The information that is related to the annual GHG emissions inventory is kept at the Centralized Inventory File.

ES.2 Emissions trends for aggregated greenhouse gas emissions

The GHG emissions trends (CO_2, CH_4, N_2O, HFC, PFC and SF_6) for the period 1990 - 2009 are presented in ***Table ES.1*** (in kt CO_2 eq).

It is noted that according to the IPCC Guidelines, emissions estimates for international marine and aviation bunkers were not included in the national totals, but are reported separately as memo items.

Base year GHG emissions for Greece (1990 for CO_2, CH_4, and N_2O - 1995 for F-gases) were estimated at 106.52 Mt CO_2 eq. Given that *LULUCF* was a net sink of GHG emissions in 1990 (and for the rest of the reporting period) the relevant emissions / removals are not considered in estimating base year emissions for Greece.

In 2009, GHG emissions (without *LULUCF*) amounted to 122.54 Mt CO_2 eq showing an increase of 15.05 % compared to base year emissions and of 17.42% compared to 1990 levels. If emissions / removals from *LULUCF* were to be included then the increase would be 17.33 % (from 101.87 Mt CO_2 eq in 1990 to 119.52 Mt CO_2 eq in 2009).

Carbon dioxide emissions accounted for 85.13% of total GHG emissions in 2009 (without *LULUCF*) and increased by approximately 25.28% from 1990. Methane emissions accounted for 10.46% of total GHG emissions in 2009 and decreased by 10.46% from 1990, while nitrous oxide emissions accounted for 5.60 % of the total GHG emissions in 2009 and decreased by 32.21% from 1990. Finally, F-gases emissions that accounted for 2.13% of total GHG emissions in 2009, decreased by 22.12% from 1995 (base year for F-gases), due to cease of HCFC-22 production.

Table ES.1a Total GHG emissions in Greece (in kt CO_2 eq) for the period 1990-2000

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
A. GHG emissions per gas (excluding LULUCF)											
CO_2	83274.33	82990.95	84692.44	84039.09	86314.82	86775.84	88893.98	93741.14	98652.37	98054.10	103198.78
CH_4	9761.78	9731.51	9796.85	9778.83	9929.49	9957.62	10158.38	10013.09	10215.30	10030.40	9941.83
N_2O	10127.58	9817.48	9668.50	8788.73	8617.84	8898.00	9144.20	8922.83	8817.17	8744.93	8432.69
HFC	935.06	1106.82	908.39	1606.64	2143.91	3262.03	3772.29	4036.07	4531.22	5343.13	4274.52
PFC	263.38	264.27	258.36	156.56	96.05	85.78	73.61	169.64	208.53	135.49	151.70
SF_6	3.07	3.16	3.26	3.35	3.45	3.59	3.68	3.73	3.78	3.87	3.99
Total	104365.21	103914.19	105327.80	104373.21	107105.57	108982.85	112046.14	116886.51	122428.37	122311.92	126003.50
B. GHG emissions/removals from LULUCF											
CO_2	-2523.60	-2606.27	-2908.76	-3257.25	-2880.01	-3218.91	-2801.77	-2862.20	-3178.60	-3333.17	-2934.75
CH_4	24.96	16.03	48.00	37.76	37.25	18.34	14.97	26.77	62.79	5.74	89.21
N_2O	2.53	1.63	4.87	3.83	3.78	1.86	1.52	2.72	6.37	0.58	9.05
Total	-2496.11	-2588.62	-2855.89	-3215.66	-2838.98	-3198.71	-2785.28	-2832.71	-3109.44	-3326.85	-2836.48
C. GHG Emissions from International Transport											
CO_2	10475.30	9478.60	10665.71	12212.33	13251.52	13862.55	12399.31	12343.16	13595.02	12685.32	13857.13
CH_4	5.91	5.68	6.90	7.72	8.41	9.53	8.02	8.10	8.45	7.85	8.62
N_2O	90.22	81.51	91.53	104.27	113.65	118.07	106.04	105.86	116.42	110.00	118.84
Total	10571.43	9565.79	10764.14	12324.33	13373.58	13990.15	12513.38	12457.12	13719.89	12803.17	13984.59

Table ES.1b Total GHG emissions in Greece (in kt CO_2 eq) for the period 2001-2009

	2001	2002	2003	2004	2005	2006	2007	2008	2009
A. GHG emissions per gas (excluding LULUCF)									
CO_2	105552.29	105201.72	109335.78	109622.92	113363.10	111908.74	114444.97	110107.59	104326.51
CH_4	9590.69	9500.94	9342.28	9375.23	9173.68	9183.53	8993.82	8796.97	8740.74
N_2O	8225.05	8152.61	8077.34	8085.81	7782.67	7550.97	7787.66	7078.92	6865.96
HFC	3978.19	4210.49	4036.66	4221.57	3957.12	2032.02	2098.19	2482.95	2568.96
PFC	93.42	90.66	80.01	73.22	73.05	62.43	60.19	76.08	36.13
SF_6	4.06	4.25	4.25	4.47	6.45	8.37	9.92	7.53	5.02
Total	127443.70	127160.69	130876.32	131383.21	134356.07	130746.06	133394.76	128550.03	122543.32
B. GHG emissions/removals from LULUCF									
CO_2	-3119.27	-3221.88	-2907.66	-3080.30	-3056.58	-3148.67	-3109.16	-3100.23	-3043.40
CH_4	14.74	2.43	3.31	8.29	4.70	9.04	159.33	19.03	22.55
N_2O	1.50	0.25	0.34	0.84	0.48	0.92	16.17	1.93	2.29
Total	-3103.04	-3219.20	-2904.01	-3071.17	-3051.40	-3138.71	-2933.66	-3079.27	-3018.56
C. GHG Emissions from International Transport									
CO_2	13351.40	12214.71	13150.47	13327.28	11464.10	12661.37	12935.62	12808.67	10909.12
CH_4	7.78	7.03	6.87	6.79	5.66	6.02	5.96	5.73	5.09
N_2O	114.50	105.13	114.16	115.77	95.93	106.38	108.63	108.02	92.01
Total	13473.67	12326.87	13271.51	13449.84	11565.69	12773.77	13050.21	12922.42	11006.22

ES.3 Emissions trends per sector

GHG emissions trends by sector for the period 1990 - 2008 are presented in ***Table ES.2***.

- Emissions from *Energy* in 2009 accounted for 81.95% of total GHG emissions (without LULUCF) and increased by approximately 29.79% compared to 1990 levels.

  The living standards improvement due to the economic growth of the period 1990 – 2008, the important growth of the services sector, the introduction of natural gas in the Greek energy system and the economic recession starting in 2009 represent the basic factors affecting emissions trends from *Energy*.

  The evolution of GHG emissions from *Energy* can be distinguished into five periods that are related to economic development and the penetration of natural gas. At first (1990 – 1995) GHG emissions increased with an average annual rate of 0.9% while Gross Domestic Product (GDP) increased with an annual rate of 1.7%. Then and up to 2000, GHG emissions increased with an annual rate of 3.8% which is higher than the rate of increased of GDP for the same period (3.4%). The average annual rate of emissions increase for the period 2000 – 2004 was 1.9% while GDP increased with higher rate (approximately 4%). For the period 2005-2008, a stabilization of the emission levels is observed, although the GDP increased with an annual rate of 3.3%. Finally, after 2008 a reduction of emission is observed by 3.7%, higher than the respective decrease of GDP (2.3%) due to economic recession.

  The majority of GHG emissions (54.6%) in 2009 derived from energy industries, while the contribution of transport, manufacturing industries and construction and other sectors is estimated at 25.6%, 7.4% and 10.9% respectively. The rest 1.5% of total GHG emissions from *Energy* derived from fugitive emissions from fuels.

  The substantial increase of GHG emissions from road transport is directly linked to the increase of vehicles fleet but also to the increase of transportation activity. The renewal of the passenger car fleet and the implied improvement of energy efficiency limit the increase of GHG emissions. The implemented, adopted and planned measures for the improvement of public transport means and is expected to moderate the high use of passenger cars.

- Emissions from *Industrial processes* in 2009 accounted for 7.48% of the total emissions (without *LULUCF*) and decreased by approximately 9.88% compared to 1990 levels. The deep decrease in this sector (mainly depicted in the CO_2 emissions) that took place in 2009 is attributed to economic recession. The intense fluctuation observed in the rest years of the time series is highly dependent on the HCFC-22 production until 2006 when the respective production has ceased. Emissions in 2009 are significantly lower than emissions of 2008, with a decrease of 18.80%.

- The contribution of the *Solvents and other products use* sector to total GHG emissions is minor (0.26% of the total emissions) and has slightly increased compared to 1990 level of emissions.

- Emissions from *Agriculture* that accounted for 7.29% of total emissions in 2009 (without *LULUCF*), decreased by approximately 22.15% compared to 1990 levels. Emissions reduction is mainly due to the reduction of N_2O emissions from agricultural soils, because of the

reduction in the use of synthetic nitrogen fertilizers. The changes of the rest determining parameters of GHG emissions from the sector (e.g. animal population, crops production etc.) have a minor effect on GHG emissions trend.

- Emissions from the *Waste* Sector (3.01% of the total emissions, without *LULUCF*), decreased by approximately 26.52% from 1990. Greenhouse gases emissions from solid waste disposal on land present an increasing trend, while, on the contrary, emissions from wastewater handling are gradually decreasing. The decrease is mostly noticeable since 1999 because of the constant increase of wastewater volume treated under aerobic conditions, while since 2002 the rate of increase is slowing down.
- The *Land Use, Land Use Change and Forestry* sector was a net sink of greenhouse gases during the period 1990 – 2009. During this period, the LULUCF sector offset about 3% of the total national emissions (without LULUCF). The magnitude of this sink increased from approximately 2.5 Mt CO_2 eq in 1990, to 3.0 Mt CO_2 eq in 2009, i.e. an increase of 21%. This upward trend in the net removals from the Forest Land is attributed mainly to the reduction in fellings and the afforestation programmes started in 1994.

Table ES.2a Total GHG emissions (in kt CO_2 eq) by sector for the period 1990-2000

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy	77377.25	77196.22	78934.79	78576.53	80916.32	80890.74	83128.82	87903.01	92770.71	92175.83	97019.35
Industrial processes	10174.31	10075.99	9947.71	10194.14	10654.41	12272.03	12898.98	13233.79	13761.30	14566.86	13811.46
Solvents	308.34	315.54	314.37	312.95	307.39	299.82	298.22	300.20	300.40	308.73	306.61
Agriculture	11483.24	11322.87	11086.56	10220.26	10035.38	10336.87	10480.53	10334.71	10347.17	10194.17	9956.34
Waste	5022.07	5003.57	5044.37	5069.33	5192.06	5183.39	5239.60	5114.79	5248.79	5066.33	4909.74
Total [1)]	104365.21	103914.19	105327.80	104373.21	107105.57	108982.85	112046.14	116886.51	122428.37	122311.92	126003.50
LULUCF	-2496.11	-2588.62	-2855.89	-3215.66	-2838.98	-3198.71	-2785.28	-2832.71	-3109.44	-3326.85	-2836.48
Index per sector											
Energy	100.00	99.77	102.01	101.55	104.57	104.54	107.43	113.60	119.89	119.13	125.38
Industrial processes	100.00	99.03	97.77	100.19	104.72	120.62	126.78	130.07	135.26	143.17	135.75
Solvents	100.00	102.33	101.95	101.49	99.69	97.24	96.72	97.36	97.42	100.13	99.44
Agriculture	100.00	98.60	96.55	89.00	87.39	90.02	91.27	90.00	90.11	88.77	86.70
Waste	100.00	99.63	100.44	100.94	103.38	103.21	104.33	101.85	104.51	100.88	97.76
Total [2)]	100.00	99.57	100.92	100.01	102.63	104.42	107.36	112.00	117.31	117.20	120.73

1) Emissions / removals from *Land Use, Land Use Change and Forestry* are not included in national totals

2) *Land Use, Land Use Change and Forestry* is not included

Table ES.2b Total GHG emissions (in kt CO_2 eq) by sector for the period 2001-2009

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Energy	99422.93	99252.98	103227.63	103498.79	106701.05	105424.87	108038.79	104251.20	100429.67
Industrial processes	13347.38	13456.96	13383.52	13557.15	13794.26	11512.54	11506.03	11291.46	9168.59
Solvents	304.28	305.13	305.93	306.75	309.29	311.92	313.41	314.13	315.60
Agriculture	9859.75	9828.56	9764.65	9847.87	9555.08	9388.59	9645.67	8974.94	8939.50
Waste	4509.36	4317.07	4194.59	4172.66	3996.39	4108.14	3890.87	3718.29	3689.96
Total [1)]	127443.70	127160.69	130876.32	131383.21	134356.07	130746.06	133394.76	128550.03	122543.32
LULUCF	-3103.04	-3219.20	-2904.01	-3071.17	-3051.40	-3138.71	-2933.66	-3079.27	-3018.56
Index per sector									
Energy	128.49	128.27	133.41	133.76	137.90	136.25	139.63	134.73	129.79
Industrial processes	131.19	132.26	131.54	133.25	135.58	113.15	113.09	110.98	90.12
Solvents	98.68	98.96	99.22	99.48	100.31	101.16	101.64	101.88	102.36
Agriculture	85.86	85.59	85.03	85.76	83.21	81.76	84.00	78.16	77.85
Waste	89.79	85.96	83.52	83.09	79.58	81.80	77.48	74.04	73.47
Total [2)]	122.11	121.84	125.40	125.89	128.74	125.28	127.82	123.17	117.42

1) Emissions / removals from *Land Use, Land Use Change and Forestry* are not included in national totals

2) *Land Use, Land Use Change and Forestry* is not included

ES.4 Emissions trends for indirect greenhouse gases and sulphur dioxide

The present report contains also estimates of nitrogen oxides (NOx), carbon monoxide (CO), non-methane organic volatile compounds (NMVOC) and sulphur dioxide (SO_2) emissions for the period 1990-2009.

The key features of emissions trends for indirect greenhouse gases and SO_2 are the following:

- NO_x emissions increased by 13.49% from 1990 to 2009. Energy sector accounts for the high majority of emissions (99.32%). The decrease in NO_x emissions from transport after 1998 is attributed to the substitution of old technology vehicles by new catalytic ones (NO_x emissions from this category account for the 51.64% of total NO_x emissions in 2009). Emissions from *Industrial processes* decreased by 49.5% from 1990 due to reductions in the production of nitric acid.
- The transport sector is the main source of CO emissions. Due to the substitution of old technology vehicles by new and more efficient ones, CO emissions from transport decreased by 56.13% from 1990 to 2009 and as a result total CO emissions in 2009 decreased by 52.07%. Emissions from industrial processes in 2009 decreased by 19.93% compared to 1990 levels. The variation of CO emissions from *LULUCF* is related to the intensity and number of forest fires. In 2009 emissions from LULUCF accounted for 1.57% of total CO emissions (incl LULUCF), and are by 9.67% lower than emissions of 1990.
- NMVOC emissions decreased by 24.24% from 1990 to 2009. Emissions from transport (28.29% of total NMVOC emissions in 2009), decreased by 56.98% compared to 1990 levels, while emissions from *Energy* decreased by 42.04% from 1990 to 2009. The significant increase of NMVOC emissions from *Industrial processes* (approximately 62.93% from 1990 to 2009) is attributed to the non-energy use of bitumen in the construction sector. Emissions from Solvents and other products use decreased by 4.26% compared to 1990 levels.
- SO_2 emissions decreased by 10.5% from 1990 to 2009. Emissions from energy, which is the main source of SO_2 emissions in Greece (98.68 % of total SO_2 emissions for 2009), decreased with a mean annual rate of increase of 0.52% for the period 1990 – 2009. The operation of desulphurisation plants at large installations for electricity generation since 1998 resulted in the restriction of the increase of SO_2 emissions from electricity generation. Reductions with respect to the sulphur content of liquid fossil fuels and the introduction of natural gas in the Greek energy system resulted in a reduction of SO_2 emissions from manufacturing industry 87% for the period 1990 – 2009. Emissions from *Industrial processes* decreased by 41% from 1990 due to decrease of sulphuric acid industrial production.

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1. Introduction

1.1 Background information on greenhouse gas inventories, climate change and supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

The impact of all human activities on the climate of earth has been recognized as the greatest global environmental challenge involving the whole international community. The mitigation of the effects of this problem requires responses from governments, economic sectors and all societal actors working together.

Naturally occurring greenhouse gases (GHG) include water vapour, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3). In the last few years, a new category of greenhouse gases has emerged that includes hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulphur hexafluoride (SF_6). These gases are man-made and are mainly used in a number of industrial activities in replacement of CFCs. Other naturally occurring gases, which do not contribute directly to the greenhouse effect, are carbon monoxide (CO), oxides of nitrogen (NOx), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO_2).

1.1.1 Background information on climate change

United Nations Framework Convention on Climate Change

In response to the emerging evidence that climate change could have a major global impact, the United Nations Framework Convention on Climate Change (henceforth the Convention) was adopted on 9 May 1992 and was opened for signature in Rio de Janeiro in June 1992. Greece signed the Convention in Rio and ratified it in 1994 (Law 2205/94).

The ultimate objective of the Convention is the stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The Convention recognizes that the developed countries should take the lead in combating climate change and calls these countries to:

- Adopt policies and measures to mitigate climate change.
- Return, individually or jointly, to 1990 levels of carbon dioxide and other greenhouse gas by the year 2000
- Provide technology transfer and financial resources to help developing countries so as to confront climate change impacts and to develop, ensuring at the same time the environmental protection through the restraint of GHG emissions.

Kyoto Protocol

Recognizing early the need for an effective instrument to provide confidence in addressing the climate change challenge, the Parties at the third meeting of the Conference of the Parties (COP) to the Convention, held in Kyoto (1-11 December 1997), finalised negotiations related to the establishment of such a legal instrument, the Kyoto Protocol on Climate Change (henceforth the Protocol). The Protocol provides a foundation upon which future action can be intensified. It establishes, for the first time, legally binding targets for the reduction of greenhouse gas emissions and it also confirms the capacity of the international community to cooperate in action to deal with a major global environmental problem.

The Protocol calls for legally binding commitments of the developed countries to reduce, individually or jointly, emissions of 6 greenhouse gases (CO_2, CH_4, N_2O, HFC, PFC and SF_6) by more than 5% in the period 2008 to 2012, below their 1990 level. The EU and its Member States agreed to a -8% reduction.

For the achievement of these targets, the Protocol provides for the use of the following:

- Adoption of national policies and measures,
- Establishment of an emissions trading regime,
- Establishment of the joint implementation mechanism,
- Establishment of a clean development mechanism and
- Protection and promotion of sinks to enhance CO_2 removals.

Detailed rules for the implementation of the Protocol were set out at the 7th Conference of the Parties (in Marrakesh) and are described in the Marrakesh Accords adopted in 2001.

The Protocol entered into force on 16 February 2005, after its ratification from 141 Parties including developed countries with a contribution of more than 55% to global CO_2 emissions in 1990.

At the first Conference of the Parties serving as the Meeting of the Parties to the Protocol (COP/CMP) held in Canada (December 2005) the rules for the implementation of the Protocol agreed at COP7 were adopted.

The same COP/CMP established a working group, called the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP), to discuss future commitments for industrialized countries under the Kyoto Protocol.

The Conference of the Parties (COP) in 2007, by its decision 1/CP.13 (the Bali Action Plan) launched a comprehensive process to enable the full, effective and sustained implementation of the Convention through long-term cooperative action, now, up to and beyond 2012, to be conducted under a subsidiary body under the Convention, the Ad Hoc Working Group on Long-Term Cooperative Action under the Convention (AWG-LCA).

National commitments

Within the framework of the Convention, the Greek government, after taking into consideration both economic and social parameters, agreed that a realistic target for Greece was the restriction of the overall increase of carbon dioxide emissions to 15% ± 3% by 2000 compared to 1990 levels. The measures taken in order to achieve this restriction in the CO_2 emissions were described in the 1st Greek National Action Plan for the abatement of CO_2 and other greenhouse gases emissions (MINENV / NTUA 1995).

With respect to the EU target under the Kyoto Protocol (i.e. reduction of emissions at 8% for the period 2008-2012), EU has stated that this will be achieved jointly by EU Member-States under the provisions of Article 4 of the Protocol. The Burden-Sharing agreement between all Member States was finalised during the Environment Council in June 1998 and entered into force with Decision 2002/358/EC concerning the approval, on behalf of the European Community, of the Kyoto Protocol. According to this agreement, Greece is committed to limit its GHG emissions increase for the period 2008 – 2012 to +25% compared to base year emissions (1990 for CO_2, CH_4 and N_2O emissions – 1995 for F - gases). Greece ratified the Protocol in 2002 (Law 3017/2002) and adopted the 2nd National Programme for Climate Change (MINENV, 2002) for achieving the above-mentioned commitment by a decision of the Council of Ministers (DCM5/2003).

1.1.2 Background information on greenhouse gas inventories

Annual inventories of greenhouse and other gases emissions form an essential element of each national environmental policy-making process. They can be used to derive information on emissions trends, with reference to a pre-selected base year, and can assist in monitoring the progress of existing abatement measures for the reduction of greenhouse gases emissions and the fulfilment of the KP target.

According to Article 4 of the Convention, Annex I Parties have the obligation to submit national inventories of GHG emissions and removals. At COP2, the annual submission of inventories was decided (Decision 9/CP.2), while the use of the "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories" (henceforth IPCC Guidelines) was adopted with Decision 2/CP.3. In order to enhance the transparency of the GHG inventories submitted and improve comparability across sectors and different countries, the use of Common Reporting Format (CRF) tables for the submission of the emissions/removals estimates per source/sink category was adopted at COP5 (Decision 3/CP.5).

At the 12th session of the Subsidiary Body for Scientific and Technological Advice (SBSTA), the use of the IPCC "Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories" (henceforth IPCC Good Practice Guidance) for inventories due in 2003 and beyond was decided. The IPCC Good Practice Guidance is considered as an elaboration of the IPCC Guidelines.

New reporting guidelines, together with a structure of the National Inventory Report (NIR) were adopted at COP8 (Decision 18/CP.8) for use in reporting annual inventories due in 2004 and beyond. Overall annual national inventories submissions include the submission of both the Common Reporting Format tables and the National Inventory Report by the 15th of April.

At COP9 the use of the IPCC "Good Practice Guidance for Land Use, Land Use Change and Forestry" (henceforth LULUCF Good Practice Guidance) for inventories due in 2005 and beyond was adopted (Decision 13/CP.9). Moreover, new Common Reporting Format tables for LULUCF, to be used for a trial period covering inventory submissions due in 2005, were adopted with the same decision.

The Conference of the Parties (COP), by its decision 14/CP.11, adopted the tables of the common reporting format and their notes for reporting on land use, land-use change and forestry (LULUCF) sector, to be used for the purpose of submission of the annual inventory due in and after 2007.

Greece, as an Annex I signatory Party to the Convention, has to comply with the above-mentioned reporting requirements.

Parallel commitments also exist under the European Council Decision 280/2004/EC concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol.

With the present report, which contains estimates of GHG emissions for Greece for the years 1990-2009, and the mandatory supplementary information required for the 2011 submission under the Kyoto Protocol, the above obligations are addressed.

1.1.3 Background information on supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

Greece, as an Annex I Party that is also Party to the Kyoto Protocol is also required to report supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol, with the inventory submission due under the Convention, in accordance with paragraph 3(a) of decision 15/CMP.1. Part II of this report (Chapters 10-14) provides information on activities under Article 3, paragraph 3 (Afforestation, Reforestation, Deforestation) and the elected activity under Article 3, paragraph 4 (Forest Management), on accounting of Kyoto units, on changes in the national system and the national registry and information on the minimization of adverse impacts of climate change in accordance with Articles 3.14.

1.1.4 Structure of the report

The present NIR consists of 14 chapters and 6 annexes. **Chapter 1** contains (a) a presentation of the institutional, legal and procedural arrangements for inventory planning and preparation, (b) a brief description of basic methodological issues and (c) an overview of the completeness of the inventory.

Emissions trends (including other gases) per gas and per sector for the period 1990 – 2008 are discussed in **Chapter 2**, while comprehensive information regarding methodologies used for the estimation of GHG emissions per source category are presented in **Chapters 3 – 8**. In **Chapter 9** an overview of the recalculations made since the 2008 submission and the future improvements planned is presented. The **Chapters 10-14** of part II of this report contain supplementary information required under article 7, paragraph 1. **Chapter 10** provides information on activities under Article 3, paragraph 3 (Afforestation, Reforestation, Deforestation) and the elected activity under Article 3, paragraph 4 (Forest Management), and **Chapters 11-14** provide information on on accounting of Kyoto units, changes in national system, changes in national registry, minimization of adverse impacts in accordance with Article 3, paragraph 14, respectively.

As concerns the annexes, in **Annex I** the methodology for the determination of key categories is described, while in **Annexes II** and **III** the methodology for the estimate of carbon dioxide emissions from the energy sector is discussed (sectoral and reference approach respectively). The calculations made for the assessment of uncertainty are presented in **Annex IV**, while **Annex V** provides information with regard to the emissions of oxides of nitrogen, carbon monoxide, non-methane volatile organic compounds and sulphur dioxide per sector. **Annex VI** shows sources of GHGs that are not estimated in the Greek GHG inventory, and the reasons for those sources being omitted.

1.2 A description of the institutional arrangements for inventory preparation, including the legal and procedural arrangements for inventory planning, preparation and management

1.2.1 Overview of institutional, legal and procedural arrangements for compiling GHG inventory and supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

In article 5, paragraph 1 of the Protocol, it is specified that "Each Party included in Annex I shall have in place, no later than one year prior to the start of the first commitment period, a national system for the estimation of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol". A national system includes all institutional, legal and procedural arrangements made within an Annex I Party of the Convention that is also a Party to the Protocol for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, and for reporting and archiving inventory information.

The Ministry of Environment, Energy and Climate Change, MEECC (former Ministry for the Environment, Physical Planning and Public Works) is the governmental body responsible for the development and implementation of environmental policy in Greece, as well as for the provision of information concerning the state of the environment in Greece in compliance with relevant requirements defined in international conventions, protocols and agreements. Moreover, the MEECC is responsible for the co-ordination of all involved ministries, as well as any relevant public or private organization, in relation to the implementation of the provisions of the Kyoto Protocol, according to the Law 3017/2002 with which Greece ratified the Kyoto Protocol.

In this context, the MEECC has the overall responsibility for the national GHG inventory, and the official consideration and approval of the inventory prior to its submission. (Contact person: Afroditi Kotidou, Address: Villa Kazouli, Kifisias 241, Athens, Greece, e-mail: a.kotidou@ekpaa.minenv.gr, tel.: +30210 8089275, fax: +30210 8089239).

Figure 1.1 provides an overview of the organizational structure of the National Inventory System. The entities participating in it are:

- The **MEECC** designated as the national entity responsible for the national inventory, which keeps the overall responsibility, but also plays an active role in the inventory planning, preparation and management.
- The **National Technical University of Athens (NTUA) / School of Chemical Engineering**, which has the technical and scientific responsibility for the compilation of the annual inventory.
- **Governmental ministries and agencies** through their appointed focal persons, ensure the data provision.

International or national associations, along with individual public or private industrial companies cotribute to data providing and development of methodological issues as appropriate.

The legal framework defining the roles-responsibilities and the co-operation between the MEECC Climate team, the NTUA Inventory team and the designated contact points of the competent Ministries was formalized by circular 918/21-4-08 released by MEECC (former MINENV) entitled "Structure and operation of the National Greenhouse Gases Inventory System- Roles and Responsibilities". The above-mentioned circular includes a description of each entity's responsibilities, concerning the inventory preparation, data providing or other relative information. This formal framework has improved the collaboration between the entities involved, assuring the timely collection and quality of the activity data required and solving data access restriction problems raised due to confidentiality issues.

According to the Presidential Decree No 189 dated 5th November 2009 the new Ministry of Environment, Energy and Climate change retains the responsibilities regarding the Environment, and Physical Planning of the former Ministry for the Environment, Physical Planning and Public Works. Furthermore, the General Directorate of Energy and Natural Resources, previously belonging to the Ministry of Development as well as the General Directorate of Forest Development and Protection and Natural Resources, previously belonging to the Ministry of Rural Development and Food, are transferred to the Ministry of Environment, Energy and Climate Change. The Public Works General Secretariat was transferred to the new Ministry of Infrastructure, Transport and Networks.

Accordingly, there is a restructuring of the roles of the ministries in the national inventory system, as described in section 1.2.2.

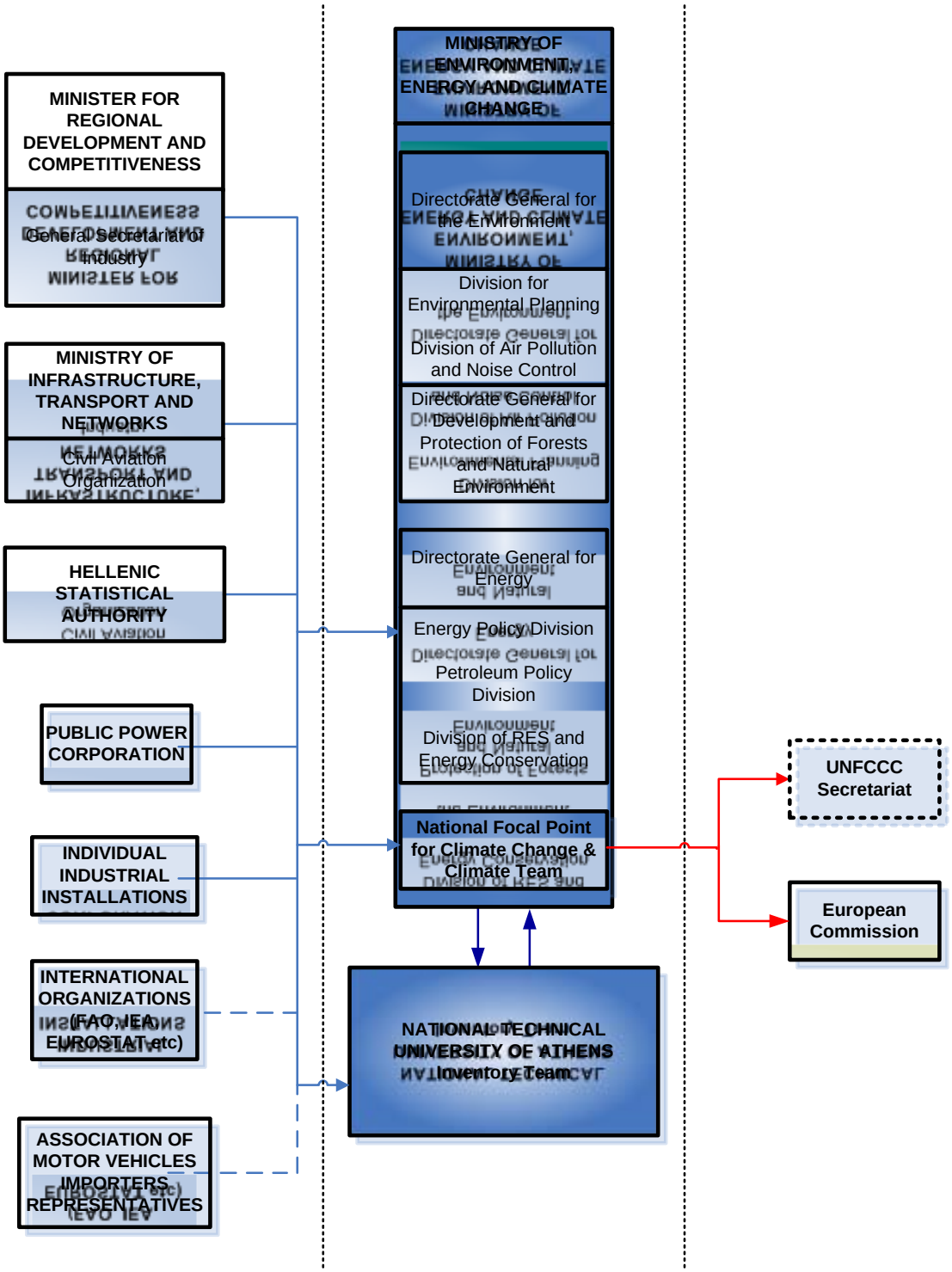

Figure 1.1 Organizational Structure of the National Inventory System

1.2.2 Roles and Responsibilities

1.2.2.1 Ministry of Environment, Energy and Climate Change

The Ministry of Environment, Energy and Climate Change, MEECC, has the overall responsibility, as the national entity, for the national GHG inventory. Among its responsibilities are the following:

- The co-ordination of all ministries and governmental agencies involved, as well as any relevant public or private organization. In this context, it oversees the operation of the National System and decides on the necessary arrangements to ensure compliance with relevant decisions of the COP and the COP/CMP.
- The official consideration and approval of the inventory prior to its submission.
- The response to any issues raised by the inventory review process under Article 8 of the Kyoto Protocol, in co-operation with the technical consultant (NTUA Inventory Team), who has the technical and scientific responsibility for the inventory planning, preparation and management of all sectors, as mentioned above.
- The timely submission of the GHG inventory to the European Commission and to the UNFCCC Secretariat.
- The keeping of the Centralised Inventory File, which is delivered to the institute which has the technical responsibility for the inventory planning, preparation and management (currently NTUA) at the beginning of each inventory cycle. The Centralised Inventory File is kept at the premises of the MEECC.
- The administration of the National Registry. Greece cooperates with the Member States of the European Union and with the supplementary transaction log and the registry of the European Community by maintaining the national registries in a consolidated system. The administration of the registry is assigned to the National Center for the Environment and Sustainable Development, which reports to the Ministry of Environment, Energy and Climate Change and operates under the authority of the latter.
- The supervision of Quality Assurance/Quality Control Plan (QA/QC)

As it appears from the above description, the role of the MEECC is not narrowed to the co-ordination of the entities involved in the inventory process and to facilitate the activity data transfer from the data providers to the NTUA's Inventory Team. MEECC has an active role in monitoring and overseeing the inventory process through continuous communication and frequent scheduled and / or ad-hoc meetings with the Inventory Team of NTUA and the competent ministries or other agencies involved.

For the fulfilment of the above-mentioned roles and responsibilities of the Ministry, a Climate Team is established within the MEECC (Climate Team), comprising the following experts:

1. Afroditi Kotidou, National UNFCCC focal point, *Co-ordinator*
2. Eirini Nikolaou

3. Angeliki Tsaxali

4. Stavros Vellidis

For each inventory sector, a member of the MEECC's Climate team has been assigned as responsible for overseeing NTUA's inventory work and communication with other ministries and other data providing agencies.

Furthermore, for expanding the overseeing role of MEECC in the inventory process, the supervision of QA/QC system is performed by the QA/QC responsible, an expert from the National Center for the Environment and Sustainable Development (NCESD), which is supervised by MEECC. The QA/QC responsible is not involved in the day-to-day inventory preparation and compilation. In co-operation with the scientific responsible of NTUA team and the NTUA inventory sector experts, he is responsible for the sound performance of the QA/QC system.

1.2.2.2 National Technical University of Athens (NTUA) - School of Chemical Engineering

The Ministry of Environment, Energy and Climate Change has assigned, on a contract basis, the National Technical University of Athens (NTUA) / School of Chemical Engineering as the national institution that has the technical and scientific responsibility for the planning, preparation and management of the annual national inventory. In this framework, NTUA (Inventory Team) has the following responsibilities / tasks to fulfil for the GHG inventory preparation:

1. Data collection (activity data and emission factors) for all source categories that are Energy, Industrial Processes, Solvents and Other Product Use, Agriculture, and Waste.
2. Reliability check of input data through
   - ✓ the comparison of the same or similar data from alternative data sources and
   - ✓ time-series assessment in order to identify changes that cannot be explained.
3. Selection of the appropriate methodologies according to IPCC guidelines, preparation of GHG emissions estimates by applying the methodologies and models having been selected.
4. Data processing and archiving.
5. Assessment of the consistency of the methodologies applied, inventory improvement – recalculations.
6. Reliability check of results.
7. Key categories analysis.
8. Uncertainty assessment.
9. Preparation of Common Reporting Format (CRF) tables.
10. Preparation of National Inventory Report (NIR).
11. Reporting of the required information according to Article 3 of the Decision 280/2004/EC of the European Parliament and of the Council.

12. Preparation and keeping of annual Centralised Inventory File. At the end of each cycle of the inventory preparation, all inventory related information is handled to the MEECC's employee responsible for keeping the Centralised Inventory File (member of the Climate Team), who in turn gives the latest version of all relevant files to the NTUA inventory team at the beginning of the next inventory cycle.
13. Development of QA/QC procedures.
14. Implementing the QA/QC procedures under the supervision of MEECC.
15. Training the representatives of data providing agencies on inventory issues.

The NTUA co-operates with a number of government agencies and other entities for the preparation of the inventory (see next section). It should be mentioned that this co-operation is not restricted to data collection but it also concerns methodological issues as appropriate. However, the technical consultant (NTUA) is responsible for the final decision concerning methodological issues.

NTUA is also responsible in co-operation with MEECC's Climate Team to perform greenhouse gas balance projections in terms of sources and sinks as a minimum for the years 2010, 2015 and 2020, organized by gas and by sector, according to the national policies and measures adopted.

The names and contact details of the NTUA inventory team follows:

1. Prof. Ioannis Ziomas, Scientific responsible
   Address: National Technical University of Athens, School of Chemical Engineering, Heroon Polytechniou 9, Zografos, 157 80 Athens, Greece.
   E-mail: ziomas@chemeng.ntua.gr
   Tel: +30 210 772 2358
   FAX: +30 210 772 3155

2. Ioannis Sempos (Sebos), Chemical Engineer, MBA, Research and Technical Associate
   E-mail: isebos@mail.ntua.gr
   Tel: +30 210 772 3240
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3. Athina Progiou, Dr Mechanical Engineer
   E-mail: athenaproyou@axonenviro.gr
   Tel: +30 210 8223083
   Fax: +30 210 8238604

4. Spyridoula Ntemiri, Dr Chemical Engineer, NTUA
   E-mail: spyrdem@chemeng.ntua.gr
   Tel: +30 210 772 3149
   FAX: +30 210 772 3155

5. Leonidas Kallinikos, Dr Chemical Engineer, NTUA
   E-mail: leokalls@central.ntua.gr
   Tel: +30 210 772 3240
   FAX: +30 210 772 3155

It should be mentioned that, whenever necessary, the above mentioned NTUA's Inventory Team is ad hoc supported by experts either from the NTUA or other institutions.

1.2.2.3 Government Ministries/ Government agencies

The following government agencies and ministries, develop and maintain, within their terms of operation, data sets and emission methodology information necessary for the estimation of GHG emissions / removals. Most of these institutes have been used as sources of data since the first submission of greek GHG national inventory. However, new sources of information are being sought both for further inventory development and improvement (higher Tier methodology usage) and quality control issues.

The co-operation with the following government agencies and other entities for the preparation of the inventory is indispensable, as those agencies and entities develop and maintain statistical data necessary for the estimation of GHG emissions / removals.

Each of the following ministries/agencies, has appointed focal persons responsible for data provision, included in the above mentioned circular:

- The Ministry of Environment, Energy and Climate Change (Contact Persons: Chatzigianakis Konstantinos, Macheras Ioannis, Panagiotis Drougas) provides
  - annual data for energy consumption and production (more specifically: Energy policy division – Solid fuels and electricity; Petroleum policy division – Liquid and gaseous fuels; Division of RES and energy conservation – Renewable energy sources), data for NO_X and SO_2 emissions (Division of Air pollution and Noise control)
  - data for solid waste management (Department of Solid Waste Management) data for wastewater treatment (Cental Water Agency)
  - activity data and emissions for the installations included in the Emissions Trading system (Emissions Trading Office)
  - data for f-gases use (Division of Air pollution and Noise control)
  - emissions / removals from LULUCF activities (UNFCCC scope), along with emissions / removals from activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol (KP). The above-mentioned KP activities are afforestation, reforestation and deforestation, which are mandatory according to Article 3.3,

along with the elected one forest land management, according to Article 3.4. (General Directorate for the Development and Protection of Forests and Natural Environment). Moreover, the General Directorate for the Development and Protection of Forests prepares the NIR and CRF tables for the above mentioned activities (UNFCCC and KP LULUCF), which are incorporated by the inventory team to the NIR and CRF tables submitted to the MEECC Climate team for approval and submission.

- The Hellenic Statistical Authority (Contact persons: Ioanna Papanagnou and Konstantina Katartzi) represents the main source of information for the estimation of emissions / removals from most of the IPCC source / sink categories.

- The Ministry of Economy, Competitiveness and Shipping (Contact person: Xarikleia Piperopoulou, General Secretariat of Industry) provides industry data

- The Ministry of Rural Development and Food provides information and data (through the Hellenic Statistical Authority which processes primary data collected by the Ministry) for the main indices and parameters of rural economy (e.g. animal population, cultivated areas, crops production, etc.).

- The Ministry of Infrastructure, Transport and Networks (Contact person: Tselikas Panagiotis) provides information and data for the vehicle fleet and its technical characteristics. The Civil Aviation Organization (Contact person: Kokkinos Anastasios), supervised by the same Ministry provides information on Landing and Take-off cycles for both domestic and international aviation.

Data are also obtained from International Organizations as the United Nations Food and Agricultural Organization (FAO) from which data on the annual consumption of fertilizers are collected, the EUROSTAT, the International Iron and Steel Institute, the International Energy Association. These data are supplementary to the data collected from the aforementioned data providers.

Furthermore, other government organisations, associations, and individual public and private industrial companies contribute to data providing and development of methodological issues as appropriate. For example, data is provided from the National Oganization for Medicines, while data from the Association of Motor Vehicles Importers Representatives or the Hellenic Association of Fertilizer professionals and traders are supplementary to the official data and are used in cases where official data are temporarily not available. Individual industrial companies / installations, either public or private, as Power Public Corporation, cement plants, etc, constitute an additional

data source for the GHG inventory preparation. However, these data are used as supplementary to the official data (e.g. for QC).

1.3 Inventory planning and preparation

1.3.1 GHG inventory, data collection, processing and storage

The preparation of the Greek GHG emissions inventory is based on the application of the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, as elaborated by the IPCC good practice guidance.

The compilation of the inventory is completed in three main stages (***Figure 1.2***), while the timetable for the completion of those stages in the annual inventory cycle is presented in ***Figure 1.3.***

Stage 1: The first stage consists of data collection and check for all source/sink categories. The main data sources used are the Hellenic Statistical Authority, the national energy balance, the government ministries/agencies involved and large private enterprises, along with the verified reports from installations under the EU ETS.

Quality control of activity data include the comparison of the same or similar data from alternative data sources (e.g. Hellenic Statistical Authority and ETS reports) as well as time-series assessment in order to identify changes that cannot be explained. In cases where problems and/or inconsistencies are identified, the agency's representative, responsible for data providing, is called to explain the inconsistency and/or help solving the problem.

Stage 2: Once the reliability of input data is checked and certified, emissions/removals per source/sink category are estimated. Emissions estimates are then transformed to the format required by the CRF Reporter. This stage also includes the evaluation of the emission factors used and the assessment of the consistency of the methodologies applied in relation to the provisions of the IPCC Guidelines, the IPCC Good Practice Guidance and the LULUCF Good Practice Guidance. Regarding LULUCF (UNFCCC scope) and Article 3.3 and 3.4 activities (KP LULUCF), the General Directorate for the Development and Protection of Forests of MEECC prepares the NIR and CRF tables for the above mentioned activities, which are incorporated by the inventory team to the NIR and CRF tables submitted to the MEECC Climate team for approval and submission.

Quality control checks, when at this stage, are related to time-series assessment as well as to the identification and correction of any errors / gaps while estimating emissions / removals and filling in the CRF Reporter.

Stage 3: The last stage involves the compilation of the NIR and its internal (i.e. within NTUA) check. The official approval procedure follows for one month period of interactions between the Inventory Team (NTUA) and the Climate Team (MEECC), starting on the 1st of February of the year of submission. During this period, the NTUA Inventory Team has to revise the report according to the observations and recommendations of the

Climate Team. On the basis of this interaction process, the final version of the report is compiled. The General Director for the Environment of MEECC, who supervises the National System, approves the inventory and then the MEECC submits the NIR to the European Commission and to the UNFCCC Secretariat.

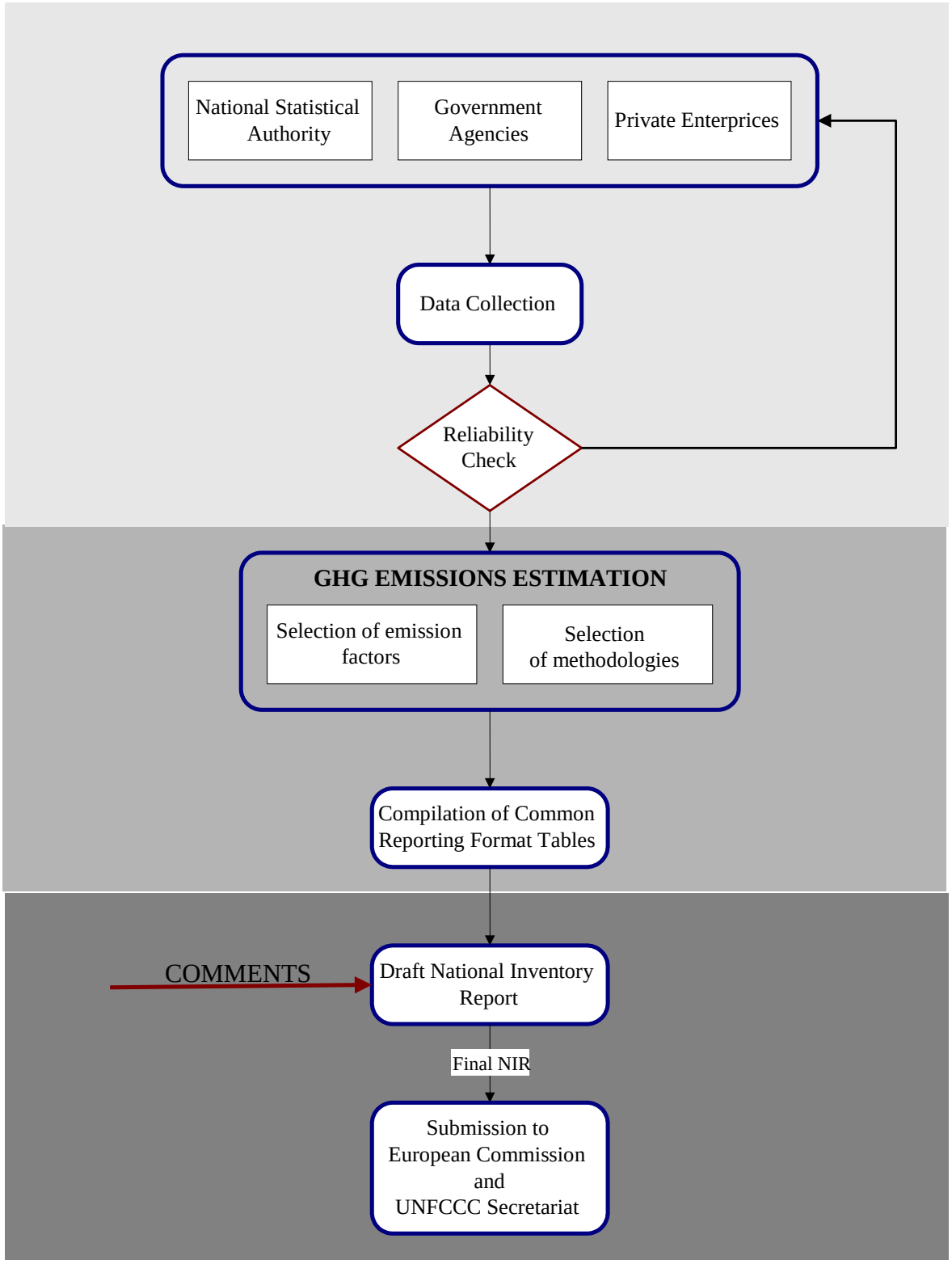


Figure 1.2 GHG emissions inventory preparation process in Greece

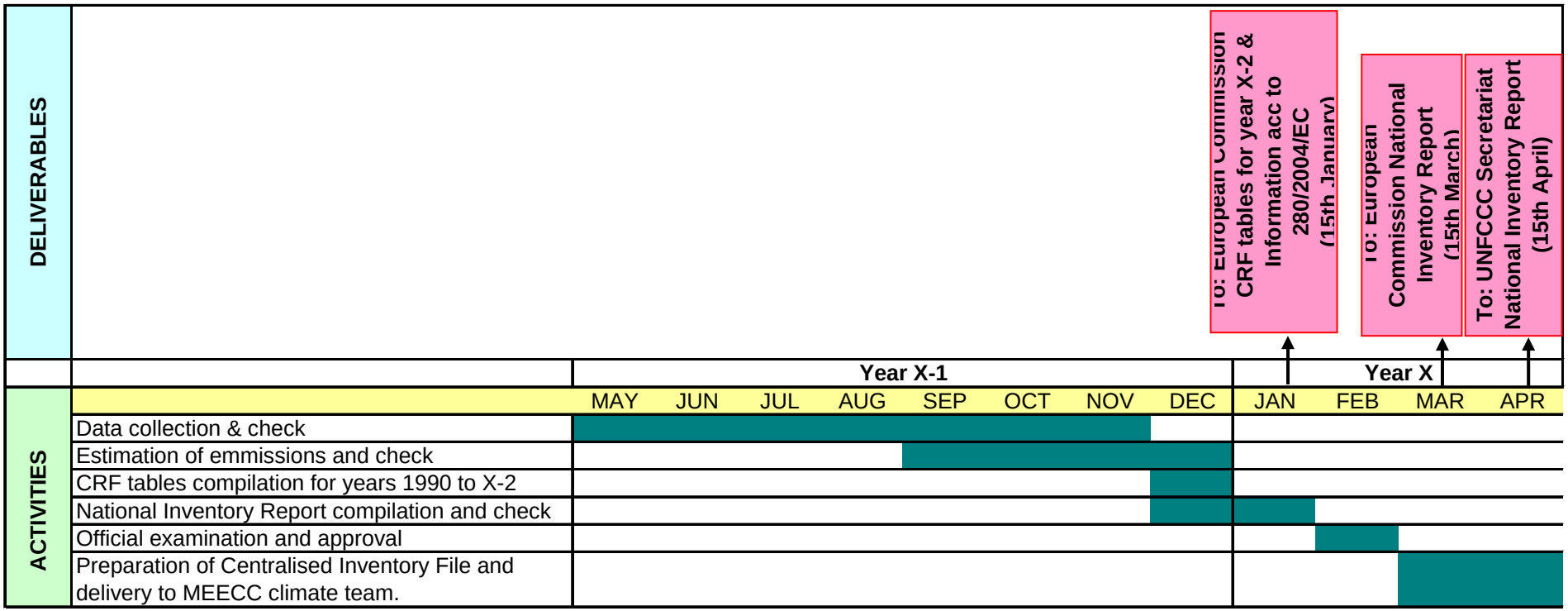


Figure 1.3 Timetable for the preparation and submission of GHG emissions/removals inventory in Greece

As shown in the timetable, the government ministries and agencies and the individual private or public industrial companies referred previously should have collected and delivered to the MEECC Climate Team and the NTUA Inventory Team the respective activity data needed for the inventory (for year X-2) and any changes in activity data for the period 1990 to year X-2, within the time period of May to November of year X-1 (X is the submission year of CRF tables and NIR referred to X-2 GHG emissions inventory).

The information that is related to the annual GHG emissions inventory (activity data, emission factors, analytic results, compilation in the required analysis level of the CRF tables) is stored in MS Excel spreadsheets. Moreover, the final results (NIR and CRF tables) are available in the MEECC web site (http://www.ypeka.gr/Default.aspx?tabid=470&language=el-GR).

In addition, and within the context of the Quality Assurance/Quality Control system developed, two master files have been organized aiming at the systematic and safe archiving of inventory information: the Input Data File and the Centralised Inventory File.

- The Input Data File contains (in electronic format and/or hard copy) all input data and parameters that are necessary for the estimation of GHG emissions/removals. Data are stored in files by sector and reference year.
- The Centralised Inventory File includes all information relevant to the GHG emissions/removals inventory. At the end of each cycle of the inventory preparation, all inventory related information is handed by the NTUA Inventory Team to the person responsible for keeping the Centralised Inventory File (member of the Climate Team) in MEECC, who in turn provides the latest version of all relevant files (calculation files and NIR) to the Inventory Team at the beginning of the next inventory cycle.

More specifically the information stored in the Centralised Inventory Files includes:

- A list of the reports, the input data files and the calculation/estimation files.
- The members of the Inventory Team.
- Final versions, in electronic format and hard copy, of the NIR.
- CRF tables in electronic format and a hard copy of the CRF tables for the last year covered by each submission.
- XML file and database of CRF reporter
- Calculation files, including the uncertainty estimation files.
- Expert review reports.
- Any comments from the public review of the inventory.
- Documentation derived from the implementation of the QA/QC procedures.

1.3.2 Quality assurance / quality control (QA / QC) procedures and extensive review of GHG inventory

Information pertaining to this section can be found in section 1.6.

1.4 Brief general description of methodologies and data sources used

1.4.1 GHG inventory and KP-LULUCF inventory

1.4.1.1 Emission factors

The estimation of GHG emissions / removals per source / sink category is based on the methods described in the IPCC Guidelines, the IPCC Good Practice Guidance, the LULUCF Good Practice Guidance and the CORINAIR methodology[1]. The emission factors used derive from the above-mentioned methodological sources and special attention was paid in selecting the emission factors that better describe practices in Greece. Furthermore, emission factors were obtained from plant specific information contained in EU ETS reports. An overview of the methods applied for the calculation of emissions / removals is presented in ***Table 1.1***.

The key categories analysis (see Paragraph 1.5) constitutes the basic tool for methodological choice and for the prioritisation of the necessary improvements. In addition, the results of the various review processes (at national and international level) represent key input information for the identification of possible improvements. It should be mentioned however, that data availability as well as availability of resources (both human and financial) also have to be considered.

- Data availability could become a significant restrictive parameter when selecting an estimation methodology. The accuracy and the consistency of the emissions estimated depend on the availability of the data needed for the correct application of the selected methodology.
- Availability of resources needs also to be considered as the searching for and the collection of the necessary data in order to apply a detailed methodology for a source category should not affect the completeness and the on-time preparation of an inventory submission.

[1] Emissions estimates from road transport presented in this inventory derive from the implementation of the COPERT IV model (COmputer Program to calculate Emissions from Road Transport), developed for the Commission of the European Communities in the framework of the CORINAIR methodology.

Table 1.1 Overview of methods applied for the calculation of GHG emissions / removals

	CO2		CH4		N2O		F-gases	
	Method	Emission factor	Method	Emission factor	Method	Emission factor	Method	Emission factor
1. Energy								
A. Fuel combustion								
1. Energy industries	CR, T2	CS,D,PS	T2	D	T2	D		
2. Manufacturing industries and Construction	CR,T2	CS,D,PS	T2	D	T2	D		
3. Transport	CR,T1,T2	D	CR,M,T1,T2	CR,D,M	CR,M,T1,T2	CR,D,M		
4. Other sectors	CR,T2	CS,D	T2	D	T2	D		
B. Fugitive emissions from fuels								
1. Solid fuels	NA	NA	T1	D	NA	NA		
2. Oil and Natural gas	T1	D	T1	D	T1	D		
2. Industrial processes								
A. Mineral products	CS,T1	CS, D, OTH, PS	NA	NA	NA	NA		
B. Chemical industry	NA, T1a	NA,CS	T1, NA	D, NA	D	D		
C. Metal production	CR, CS, T1	CR, CS, PS	CR	CR	NA	NA	T3	PS
E. Production of halocarbons and SF_6							T1, NA	D, NA
F. Consumption of halocarbons and SF_6							NA, T2 , CS	NA, D, CS
3. Solvents and other products use	CR	CR			OTH	OTH		
4. Agriculture								
A. Enteric fermentation			T1,T2	CS,D				
B. Manure management			T1,T2	CS,D	D	D		
C. Rice cultivation			D	D				

	CO2		CH4		N2O		F-gases	
	Method	Emission factor	Method	Emission factor	Method	Emission factor	Method	Emission factor
D. Agricultural soils			NA	NA	D,T1a,T1b	CS,D		
F. Field burning of agricultural residues			D	D	D	D		
5. Land Use, Land Use Change and Forestry								
A. Forest land	T1,T2	CS,D	T1	D	T1	D		
B. Cropland	T1,T2	CS,D	NA	NA	NA	NA		
C. Grassland	T2, NA	CS, NA	T1	D	T1	D		
D. Wetlands	T2, NA	CS, NA	NA	NA	NA	NA		
E. Settlements	T2, NA	CS, NA	NA	NA	NA	NA		
F. Other Land	T2	CS	NA	NA	NA	NA		
6. Waste								
A. Solid waste disposal on land	NA	NA	T2	D, CS				
B. Wastewater handling			D	D, CS	D	D, CS		
C. Waste incineration	D	D	D	CS	D	CS		
KP-LULUCF								
KP.A.1. Afforestation - Reforestation	T1	D	NA	NA	NA	NA		
KP.A.2. Deforestation	T2	CS	NA	NA	NA	NA		
KP.B.1. Forest Management	T2	CS	T1	CS, D	T1	CS, D		

CR = CORINAIR, CS = Country Specific, PS = Plant Specific

NE = Not Estimated, NA= Not Applicable, NO= Not Observed, OTH= Other

T1, T1a, T1b, T2, T2a, T3b = IPCC T1, T1a, T1b, T2, T2a, T3b methodology respectively

D = Default IPCC methodology and emission factor

IE = Included Elsewhere

M = Copert IV model

1.4.1.2 Activity data

Data collection, processing and check constitute the activity with the longest duration in the annual inventory cycle. The duration of this activity is related to the amount of the necessary data and the number of the entities involved. The on-time and successful completion of this activity has a major effect on the timeliness preparation and submission of the inventory as well as on its accuracy, completeness and consistency.

Table 1.2 gives an overview of the main data sets used for the estimation of GHG emissions / removals. Data from international organizations and databases are supplementary to the data collected from the above data providers.

It should be noted that information and data collected (through questionnaires developed according to the guidelines described in the Commission Decision 2004/156/EC) in the framework of the formulation of the National Allocation Plan (NAP) for the period 2005 – 2007, according to the EU Directive 2003/87/EC (and its transposition to the national Law, JMD 2004) along with the data from the verified reports from installations under the EU ETS for years 2005-2009 constituted a significant source of information and an additional quality control check.

Table 1.2 Data sources and data sets per IPCC sector, source category

SECTOR		STATISTICAL DATA	DATA SOURCES
1.A1	Electricity generation	Fuel consumption	• Public Power Corporation • Ministry of Environment, Energy and Climate Change • ETS verified reports
1.A2	Manufacturing industry and construction	Fuel consumption	• Ministry of Environment, Energy and Climate Change • ETS verified reports
1.A3	Transport	Number of vehicles	• Ministry of Infrastructure, Transport and Networks • Hellenic Statistical Authority • Association of Greek Auto Importers
		Aircraft landing and take off cycles	• Civil Aviation Organization
1.A4	Residential / Tertiary sector / Agriculture	Fuel consumption	• Ministry of Environment, Energy and Climate Change
1.B	Fugitive emissions from fuels	Amount of fuels Transmission/distribution pipelines length	• Ministry of Environment, Energy and Climate Change
2	Industrial processes	Industrial production	• Hellenic Statistical Authority • Industrial units • ETS verified reports • Market surveys • National Association of Refrigerating and Cooling Technicians • Hellenic Aerosol Association • Public Power Corporation • National Organization of Medicines • Private companies
3	Solvents and other products use	Amount of solvents/other products use	• Hellenic Statistical Authority • Ministry of Environment, Energy and Climate Change
4	Agriculture	Cultivated areas Agricultural production Livestock population	• Hellenic Statistical Authority • Ministry of Rural Development and Food
		Fertilizer use	• UN Food and Agricultural Organisation • Pan-Hellenic Association of Professional Fertilizers Producers & Dealers
5	Land Use, Land Use Change and Forestry / KP-LULUCF	Area and wood stocks of managed forests Forest and grassland area affected by wildfires Afforestation and Deforestation areas Cultivated areas and areas of other land uses	• Ministry of Environment, Energy and Climate Change • Hellenic Statistical Authority
6	Waste	Quantities - composition of solid waste generated Recycling Population Industrial production	• Ministry of Environment, Energy and Climate Change • Association of Communities and Municipalities in the Attica Region (ACMAR) • Hellenic Statistical Authority • UN Food and Agricultural Organisation

1.4.1.3 Global warming potential

Emissions from anthropogenic activities affect the concentration and distribution of greenhouse gases in the atmosphere. These changes can potentially produce a radiative forcing of the Earth's surface and lower atmosphere, by changing either the reflection or absorption of solar radiation or the emissions and absorption of long-wave radiation.

A simple measure of the relative radiative effects of the emissions of various greenhouse gases is the Global Warming Potential (GWP) index. This index is defined as the cumulative radiative forcing between the present and some chosen time-horizon caused by a unit mass of gas emitted now, expressed relative to that for some reference gas. The values for GWP for some of the most potent greenhouse gases are given in ***Table 1.3***.

Corresponding values of GWP for other gases (NOx, CO, NMVOC) are not given by the IPCC (nor by other sources for this purpose), since at present it is impossible to calculate the indirect results of these gases, as the scientific knowledge on their chemical reactions taking place in the atmosphere is not sufficient.

Table 1.3 Global Warming Potential (in t of CO_2 eq) for the 100-year horizon

Gas	GWP
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310
Hydrofluorocarbons (HFC)	
HFC-23	11700
HFC-32	650
HFC-125	2800
HFC-134a	1300
HFC-143a	3800
HFC-152a	140
HFC-227ea	2900
HFC-236fa	6300
HFC-4310mee	1300
Perfluorocarbons (PFC)	
CF_4	6500
C_2F_6	9200
C_4F_{10}	7000
C_6F_{14}	7400
Sulphur hexafluoride (SF_6)	23900

1.5 Brief description of key categories

1.5.1 GHG inventory

The IPCC Good Practice Guidance defines procedures (in the form of decision trees) for the choice of estimation methods within the context of the IPCC Guidelines. Decision trees formalize the choice of the estimation method most suited to national circumstances considering at the same time the need for accuracy and the available resources (both financial and human). Generally, inventory uncertainty is lower when emissions are estimated using the most rigorous methods, but due to finite resources, this may not be feasible for every source category. Therefore it is good practice to identify those source categories (key source categories) that have the greatest contribution to overall inventory uncertainty in order to make the most efficient use of available resources.

In that context, a *key source category* is one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of direct greenhouse gases in terms of the absolute level of emissions (level assessment) or/and to the trend of emissions (trend assessment). As far as possible, key source categories should receive special consideration in terms of two important inventory aspects:

1. The use of source category-specific good practice methods is preferable, unless resources are unavailable.
2. The key source categories should receive additional attention with respect to quality assurance (QA) and quality control (QC).

As a result of the adoption of the LULUCF Good Practice Guidance (Decision 13/CP.9) the concept of key sources has been expanded in order to cover LULUCF emissions by sources and removals by sinks. Therefore the term key category is used in order to include both sources and sinks.

The determination of the key categories for the Greek inventory system is based on the application of the Tier 1 methodology (see Annex I for an analytic presentation of calculations) described in the IPCC Good Practice Guidance, adopting the categorization of sources that is presented in table 7.1 of the IPCC Good Practice Guidance.

Tier 1 methodology for the identification of key categories assesses the impacts of various source categories on the level and the trend of the national emissions inventory. Key categories are those which, when summed together in descending order of magnitude, add up to over 95% of total emissions (level assessment) or the trend of the inventory in absolute terms.

It should be mentioned that:

- Source category uncertainty estimates are not taken into consideration.
- Base year estimates were calculated considering 1990 as base year.

The key categories for the Greek inventory system (without *LULUCF*) and for the year 2009 are presented in ***Table 1.4.*** There are important differences compared to the results of the analysis

presented in the previous submissions. These differences refer to the number and the identity of the key categories and are closely connected to the breaking up of larger categories in the Energy and the Agriculture Sectors, following the suggestions of the ERT during the 2010 centralised review.

Thirteen key source categories are found in the energy sector and eight in the IP sector in 2009 (without *LULUCF*).

Table 1.4 Key categories for the Greek inventory system without LULUCF for 2009

Source categories	Gas	Criteria
Energy		
Energy industries – Solid fuels	CO_2	Level
Energy industries– Liquid fuels	CO_2	Level, Trend
Energy industries – Gaseous fuels	CO_2	Level, Trend
Manufacturing Industries & Construction – Solid fuels	CO_2	Trend
Manufacturing Industries & Construction – Liquid fuels	CO_2	Level, Trend
Manufacturing Industries & Construction – Gaseous fuels	CO_2	Level, Trend
Transport – Road transport	CO_2	Level, Trend
Transport – Navigation	CO_2	Level, Trend
Transport - Aviation	CO_2	Level, Trend
Coal mining and handling	CH_4	Level
Other Sectors - Liquid fuels	CO_2	Level
Other Sectors – Liquid fuels	N_2O	Trend
Other Sectors – Gaseous fuels	CO_2	Level, Trend
Industrial processes		
Cement production	CO_2	Level, Trend
Lime production	CO_2	Trend
Limestone and dolomite use	CO_2	Trend
Nitric acid production	N_2O	Trend
Ferroalloys production	CO_2	Trend
Aluminium production	PFC	Trend
HFC-23 emissions from HCFC-22 manufacture	HFC	Trend
Ozone depleting substances substitutes	F-gases	Level, Trend
Agriculture		
Enteric fermentation – Sheep	CH_4	Level, Trend
Enteric fermentation - Other	CH_4	Level
Agricultural soils – Direct emissions	N_2O	Level, Trend
Agricultural soils – Animal production	N_2O	Level, Trend
Agricultural soils – Indirect emissions	N_2O	Level, Trend
Waste		
Solid waste disposal on land	CH_4	Level, Trend
Wastewater handling	CH_4	Level, Trend

The methodology applied for the determination of the key categories with *LULUCF* is similar to the one presented above. The key categories identified for the year 2009 are presented in ***Table 1.5***

(see Annex I for an analytic presentation of calculations). The comparison of the results of the analysis with and without *LULUCF* reveals no major differences in the source categories identified (apart from the categories from the LULUCF sector).

Table 1.5 Key categories for the Greek inventory system with LULUCF for 2009

Source categories	Gas	Criteria
Energy		
Energy industries – Solid fuels	CO_2	Level, Trend
Energy industries – Liquid fuels	CO_2	Level
Energy industries – Gaseous fuels	CO_2	Level, Trend
Manufacturing Industries & Construction – Liquid fuels	CO_2	Level, trend
Manufacturing Industries & Construction – Gaseous fuels	CO_2	Level, Trend
Transport – Road transport	CO_2	Level, Trend
Transport – Navigation	CO_2	Level, Trend
Transport - Aviation	CO_2	Level, Trend
Coal mining and handling	CH_4	Level
Other Sectors – Liquid fuels	CO_2	Level, Trend
Othe Sectors – Gaseous fuels	CO_2	Level, Trend
Industrial processes		
Cement production	CO_2	Level, Trend
Limestone & dolomite use	CO_2	Trend
Nitric acid production	N_2O	Trend
Ferroalloys production	CO_2	Trend
Aluminium production	PFC	Trend
HFC-23 emissions from HCFC-22 manufacture	HFC	Trend
Ozone depleting substances substitutes	F-gases	Level, Trend
Agriculture		
Enteric fermentation – Non dairy cattle	CH_4	Level
Enteric fermentation – Sheep	CH_4	Level, Trend
Enteric fermentation – Other	CH_4	Level
Agricultural soils – Direct emissions	N_2O	Level, Trend
Agricultural soils – Animal production	N_2O	Level, Trend
Agricultural soils – Indirect emissions	N_2O	Level, Trend
Waste		
Solid waste disposal on land	CH_4	Level, Trend
Wastewater handling	CH_4	Level, Trend
LULUCF		
Forest land remaining forest land	CO_2	Level, Trend
Cropland remaining cropland	CO_2	Level, Trend
Conversion to forestland	CO_2	Trend

The results of the analysis for the previous years are presented in Table 7 of each year's CRF excel file. There are some differences (inclusions and exclusions of sub-categories) throughout the time

series, usually due to the flunctuation of the emissions (this is mostly the case in the industrial processes sector and is justified by the fact that in many cases there is a limited number of plants for each sub-category and the flunctuation of one plant's emissions cannot be easily counterbalanced by the production of the rest).

1.5.2 KP-LULUCF inventory

In accordance with the GPG LULUCF, the assessment of key categories under article 3.3 and 3.4 of Kyoto Protocol was based on the assessment made for the UNFCCC inventory. In the cases where there is a clear correspondence between the UNFCCC categories and the Kyoto Protocol Activities (i.e. Afforestation/ Reforestation and Forest Management), a Kyoto Protocol activity was considered as key when the associated category was identified as key in the UNFCCC inventory.

The Kyoto Protocol activity of Deforestation encompasses the UNFCCC subcategories 5.B.2.1, 5.C.2.1, 5.D.2.1, 5.E.2.1 and 5.F.2.1 (Forest land converted to other land uses). The sum of these subcategories is much smaller than the smallest UNFCCC key category. Moreover, none of the categories 5.B.2, 5.C.2, 5.D.2, 5.E.2 and 5.F.2 has been identified as key, and hence Deforestation is not identified as a key category.

Table 1.6 Key categories under Kyoto Protocol art. 3.3 and 3.4

Key category	Gas	Criteria	Associated key category in UNFCCC inventory
KP-LULUCF			
Afforestation / Reforestation	CO_2	Trend	Land converted to Forest Land
Forest Management	CO_2	Level, Trend	Forest Land remaining Forest Land

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

1.6.1 QA/QC procedures and verification activities

The development and the implementation of an inventory Quality Assurance / Quality Control (QA/QC) plan represents a key tool for meeting the objectives of National Systems under Article 5 Paragraph 1 of the Protocol as described in Decision 20/CP.7.

With the Protocol's application, the pressure upon national GHG emissions inventories increases and therefore quality management is essential in order to comply with the requirements of (a) producing transparent, consistent, comparable, complete and accurate emissions estimates, (b) establishing a reliable central archiving system concerning all necessary information for GHG emissions inventories development and (c) compiling national reports according to the provisions of the adopted decisions.

In this framework, a QA/QC system is being implemented since April 2004. For the implementation of the QA/QC system the National Technical University of Athens is responsible in close co-operation with the Ministry of Environment, Energy and Climate Change. The system is based on the ISO 9001:2000 standard and its quality objectives, as stated in the quality management handbook, are the following:

1. Compliance with the IPCC guidelines and the UNFCCC reporting guidelines while estimating and reporting emissions/removals.
2. Continuous improvement of GHG emissions/removals estimates.
3. Timely submission of necessary information in compliance with relevant requirements defined in international conventions, protocols and agreements.

The accomplishment of the above-mentioned objectives can only be ensured by the implementation, from all the members of the Inventory Team (see ***Figure 1.4*** for the flow chart of activities concerning emissions inventory within the NTUA), of the QA/QC procedures included in the plan for:

- data collection and processing,
- applying methods consistent with IPCC Good Practice Guidance and LULUCF Good Practice Guidance for calculating / recalculating emissions or removals,
- making quantitative estimates of inventory uncertainty,
- archiving information and record keeping and
- compiling national inventory reports.

The QA/QC system developed covers the following processes (see ***Table 1.7*** for the list of procedures within each process and ***Figure 1.5*** for the relationship between the processes and the activities of the inventory team):

- **QA/QC system management**, comprising all activities that are necessary for the management and control of the inventory agency in order to ensure the accomplishment of the above-mentioned quality objectives.
- **Quality control,** that is directly related to the estimation of emissions. The process includes activities related to (a) data inquiry, collection and documentation, (b) methodological choice in accordance with IPCC Good Practice Guidance, (c) quality control checks for data from secondary sources and (d) record keeping.
- **Archiving inventory information**, comprising activities related to centralised archiving of inventory information and the compilation of the national inventory report.
- **Quality assurance**, comprising activities related to the different levels of review processes including the review of input data from experts, if necessary, and comments from the public
- **Estimation of uncertainties**, defining procedures for estimating and documenting uncertainty estimates per source / sink category and for the whole inventory.
- **Inventory improvement**, that is related to the preparation and the justification of any recalculations made.

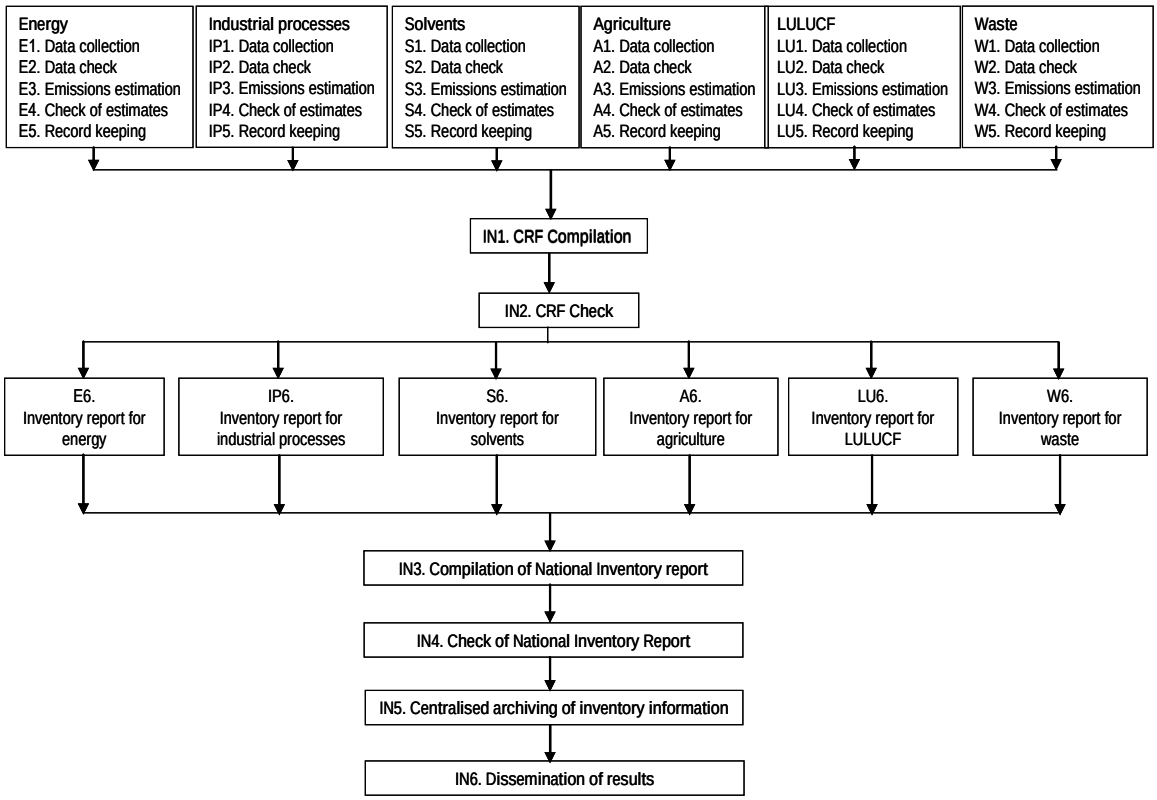


Figure 1.4 Flow chart activities concerning the GHG emissions inventory

Table 1.7 Quality assurance / quality control procedures for the Greek GHG emissions inventory

Process	Procedure code	Procedures
Quality management	QM 01	System review
	QM 02	System improvement
	QM 03	Training
	QM 04	Record keeping
	QM 05	Internal reviews
	QM 06	Non compliance – Corrective and preventive actions
	QM 07	Supplies
	QM 08	Quality management system
	QM 09	Documents control
	QM 10	Internal communication
Quality control	QC 01	Data collection
	QC 02	Estimation of emissions / removals
	QC 03	Data quality control check
	QC 04	Input data record keeping
Archiving of inventory information	AI 01	Centralised archiving of inventory information
	AI 02	Compilation of reports
Quality assurance	QA 01	Expert review of input data and parameters
	QA 02	Expert review of GHG emissions / removals inventory
	QA 03	Review from public
Estimation of uncertainties	EU 01	Uncertainty analysis
Inventory improvement	II 01	Recalculations management

The implementation of the plan started in April 2004 and the first internal review was carried out in June 2004, following procedures and manuals (available only in Greek) developed by in house staff and outside consultants. The current in use version of the QA/QC manual was revised in May 2008. All the procedures described there, are followed by both the MEECC and the NTUA staff members.

Moreover, as described in the next chapters and in the sections entitled "Source-specific QA/QC and verification", source-specific Tier 2 QC procedures are applied in the majority of source categories for quality control and verification purposes.

Furthermore, annual internal audits take place by MEECC/NTUA between September and November of each year and audits by independent local experts are planned and implemented.

The most important results of these audits and the main recommendations of the ERT 2010 Centralised Review are presented in ***Table 1.8***. As described in the next chapters these findings were addressed in this submission.

According to procedure QM 03 of the Greek Quality System, training procedures have taken place during 2010 (as well as in the previous years). The training sessions have been held in the Ministry of Environment, Energy & Climate Change and took place in November 2010. The first part of the

sessions included presentations of the Inventory Team (NTUA) to the Climate Team (MEECC), followed by personal meetings between the sectoral experts. As a part of the QM 03 Procedure, the Inventory Team has also participated in meetings and/or long-distance training sessions with experts from other Ministries and Governmental Agencies (i.e. Hellenic Statistical Authority, Public Power Corporation), as well as with individual industry plants (i.e. Aluminium of Greece, LARCO, BFL SA etc) in order to improve the data provision and to explore the possibilities to improve the methodologies used to estimate emissions. This kind of training is on-going and is based on the specific needs identified by the Inventory Team and/or other reviewers of the Greek inventory system.

Table 1.8 Findings and recommendations from reviews / audits of GHG inventory system

Sector	Areas of Further Improvement
General	1. Disaggregation of important categories while performing the Key Categories Analysis 2. Provide additional information for the use of additional information, following the QA/QC procedures. 3. Provide information of training activities in the NIR.
Energy	4. Information to be reported in the NIR to confirm whether the EU ETS data have been prepared and incorporated in the inventory submission in line with the IPCC good practice guidance. 5. AD (e.g. on aviation gasoline used for civil aviation) and disaggregated AD (e.g. vehicle population by class and rate of fuel consumption to be included in NIR. 6. Since gas work gas is a secondary solid fuel to be reallocated from gaseous to solid fuels. 7. Estimates for the non-estimated GHG emissions from international marine to be estimated and reported. 8. Alternative fuels to be reallocated from solid fuels to other fuels of the same source category. 9. Reference approach to be improved. 10. Through the comparison of Sectoral .vs. Reference approach, an error was located concerning the activity data used in calculations in Public electricity and heat production (CRF Source Category 1.A.1.a) – gaseous fuels 11. Improve the consistency between the energy sector and the IP sector (ammonia and hydrogen production in refineries)
Industrial Processes	12. Improve lime production data – Check IEFs 13. Properly describe emissions estimation process in the calculation of emissions from magnesia production (limestone & dolomite use) 14. Clarify and properly describe ammonia production trends. Check data availability 15. Correct PFCs emissions from Aluminium production, following the change of methodology as described and reported by the plant. 16. Include additional and more detailed information in the NIR with regards to the factors used in refrigeration and a/c equipment. 17. Check for data from GIS installation in order to estimate SF_6 emissions
Agriculture	18. Use T2 methodology for the estimation of CH_4 emissions from enteric fermentation of other dairy cattle and dairy cattle. 19. Recalculation of CH_4 emissions from enteric fermentation of sheep in order to estimations be consistent with the IPCC GPG. 20. Improvement of transparency of the NIR in relation to the characterization of sheep population. 21. Disaggregation of emissions from enteric fermentation by the significant animal types cattle when undertaking the key category analysis 22. Use T2 approach for the estimation of methane emissions from manure management of dairy cattle, other cattle and sheep. 23. Use of western Europe values for the Nex of dairy cattle, other cattle and buffalo. 24. Use of adjustment factors for the estimation of Nex values of young animals (other cattle, sheep)

	25. Improve and properly describe the methodology used to estimate CH_4 emissions from industrial sludge. 26. Improve information provided in the NIR regarding the assumptions performed for the estimations of AD used on the estimation of emissions from SWDS.
Waste	27. Improve uncertainty estimations of AD used on the estimation of emissions from SWDS 28. Estimation of N2O emissions from industrial wastewater and sludge 29. Revision of the figure of DOC_F for managed and unmanaged SWDS 30. Revision of the figure of MCF for unmanaged SWDS.

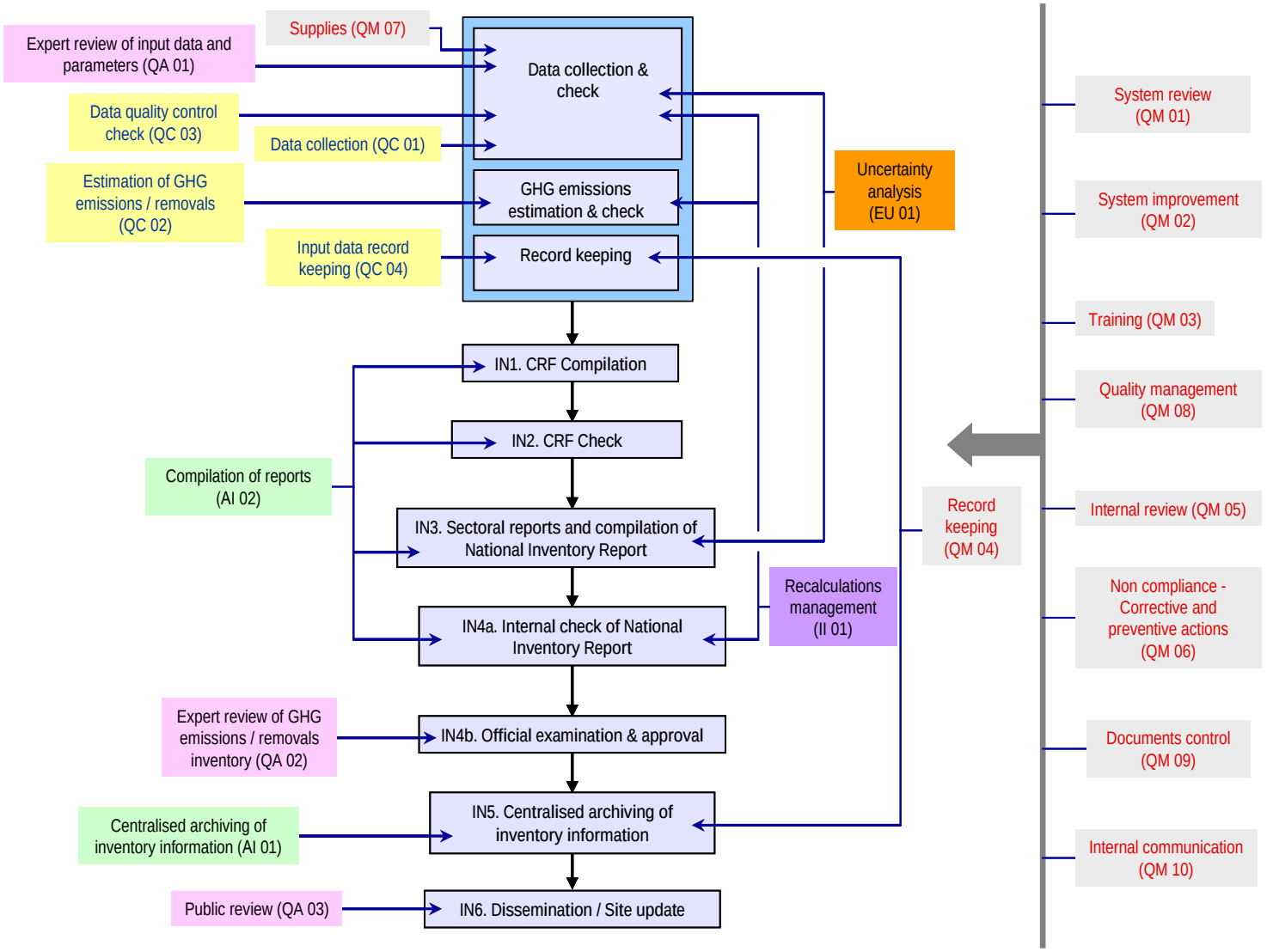


Figure 1.5 QA/QC processes and procedures and inventory related activities

1.6.2 Treatment of confidentiality issues

Confidentiality issues concern mainly the Industrial Processes sector in cases were the activity data relate directly to the production activity of one plant. This is the case in a number of categories of the industrial processes sector.

The provision of data that are concerned as confidential is quite difficult, since these data are not published in the national statistics. In the past, therefore, the only possible way to collect such information was by communicating directly to the respective plants.

In the recent years, the organisation of the new inventory system accommodates this kind of situation, enabling the operation of new procedures of confidential data exchange between the inventory team and the Hellenic Statistics Authority (El.Stat). More specifically, the cooperation established under the new system contributed to the confidentiality waiver that was decided by the relevant committee of the Service in 2008. The newly received data have been entered in Greece's QA/QC input file and are constantly used as primary data or in QA/QC checks (see also Chapter 4: Industrial Processes). Moreover, whenever a confidentiality issue arrises, the inventory system is working in close cooperation with the Prodcom Section of the El. Stat. throughout all the stages of the inventory preparation and during the reviews if necessary. It should be also mentioned that in any case, the El. Stat. provides the inventory team with all the information regarding the plant's id, information that has also been considered as confidential in the past. This enables the resolve of any sub-category completeness issues.

Finally, it should be noted, that in a number of cases activity data are reported as confidential in the inventory files. This happens in cases when the inventory team has not received an official approval by the corresponding industry in order to publish direct activity data. It should be noted, however, that in any case the activity data are kept in the Input File of the inventory and are made available at any request during the review processes. For example, this has been the case for aluminium production and for ferroalloys productions, when the only plants operating in Greece have not granted permission to publish the reported production data.

1.7 General uncertainty evaluation

1.7.1 GHG inventory

In order to evaluate the accuracy of an emissions inventory, an uncertainty analysis has to be carried out for both annual estimates of emissions and emissions trends over time.

The estimated uncertainty of emissions from individual sources (e.g. power plants, motor vehicles) is either a function of instrument characteristics, calibration and sampling frequency of direct measurements, or (more often) a combination of the uncertainties in the emission factors for typical sources and the corresponding activity data.

- Emission factors reported in the literature usually derive from measurements at specific installations, the characteristics of which are judged to be typical for a set of similar installations. The validity of this assumption given the national circumstances represents the crucial factor determining uncertainty.
- Activity data are more closely linked to economic activity than are emission factors. Therefore, there are often well established incentives requirements for accurate accounting. As a result activity data tend to have lower uncertainties and lower correlation between years. Data availability at the level of analysis required for the estimation of GHG emissions / removals as well as the definitions used by the statistical agencies represent some of the parameters affecting the uncertainty of activity data.

Detailed explanation regarding the choice of the uncertainty values on the activity data and emission factors estimations is presented in Annex IV.

The uncertainty analysis for the Greek GHG inventory is based on Tier 1 methodology described in the IPCC Good Practice Guidance and the LULUCF Good Practice Guidance, with 1990 as base year for CO_2, CH_4, N_2O and F-gases emissions.

- For the estimation of uncertainties per gas, a combination of the information provided by the IPCC and critical evaluation of information from indigenous sources was applied.
- The uncertainty analysis was carried out both without and with the *LULUCF* sector.

Table 1.9 presents the uncertainty estimates by source category and by gas (without *LULUCF*), while the detailed calculations are presented in Annex IV.

The uncertainty estimates for GHG emissions per gas in 2009, were estimated at:

3.6% for CO_2 emissions

51.7% for CH_4 emissions

88.4% for N_2O emissions and

246.1% for the F-gases emissions.

Table 1.9 Uncertainty estimates per source category and gas (without LULUCF)

Source categories	Gas	Uncertainty (%)
Stationary combustion – Solid fuels	CO_2	7.1
Stationary combustion – Liquid fuels		7.1
Stationary combustion – Gaseous fuels		7.1
Stationary combustion – Other fuels		7.1
Mobile combustion – Road transport		7.1
Mobile combustion – Navigation		7.1
Mobile combustion – Aviation		7.1
Mobile combustion – Railway		7.1
Pipeline transport		7.1
Fugitive – Oil and Natural gas		300.0
Cement production		2.8
Lime production		7.8
Limestone & Dolomite Use		11.2
Glass Production		5.8
Ammonia Production		6.7
Iron & steel production		7.1
Ferroalloys		9.9
Aluminium Production		5.8
Solvent and other product use		300.0
Waste incineration		100.1
Total CO_2		3.6
Fuel combustion	CH_4	100.1
Mobile combustion – Road transport		40.2
Mobile combustion – Navigation		100.1
Mobile combustion – Aviation		100.1
Mobile combustion – Railway		100.1
Pipeline transport		100.1
Fugitive – Oil and Natural gas		300.0
Fugitive – Coal mining and handling		300.0
Other Chemicals (Organic chemicals production)		7.1
Iron and Steel Production		6.4
Enteric fermentation		30.4
Manure management		50.2
Rice cultivation		40.0
Field burning of agricultural residues		28.3
Managed solid waste disposal on land		44.7
Unmanaged solid waste disposal on land		74.7
Municipal Sludge Disposal on Land		44.7
Wastewater handling		104.4
Waste incineration		100.1

Table 1.9(cont.) Uncertainty estimates per source category and gas (without LULUCF)

Source categories	Gas	Uncertainty (%)
Total CH_4		51.7
Fuel combustion	N_2O	300.0
Mobile combustion – Road transport		50.2
Mobile combustion – Navigation		300.0
Mobile combustion – Aviation		300.0
Mobile combustion – Railway		300.0
Pipeline transport		300.0
Oil and Natural gas		300.0
Nitric acid production		20.1
Solvent and other product use		300.0
Manure management		111.8
Agricultural soils – Animal production		111.8
Agricultural soil – Direct emissions		400.5
Agricultural soil – Indirect emissions		53.9
Field burning of agricultural residues		28.3
Wastewater handling		11.2
Waste incineration		100.1
Total N_2O		88.4
HFC-23 emissions from production of HCFC-22	F-gases	70.7
Ozone depleting substances substitutes		250
PFC from Aluminium production		6.7
SF6 from electrical equipment		111.8
Total F-gases		246.1
Total uncertainty (%)		8.67

In general, the uncertainties associated with CO_2 are very low, while the least accurate estimations are those for N_2O and F-gases. This difference is mainly due to the uncertainty in emissions factors. For example, in the sector of marine transport the emission factor for CO_2 depends only on the type of fuel, while CH_4 and N_2O factors depend heavily on the technology of the engine used. As a result, the uncertainty in emissions factors for marine transport is 5% for CO_2 and an order of magnitude for CH_4 and N_2O.

Total uncertainty is 8.67% (without *LULUCF*), while the uncertainty that carried over into the GHG emissions trend is 11.25%. To be mentioned that the uncertainty analysis is based on the 100% of emissions. The results of the uncertainty analysis for the *LULUCF* sector are presented in ***Table 1.10***.

The uncertainty estimates for GHG emissions per gas, with LULUCF, in 2009, were estimated at (the detailed calculations are presented in Annex IV):

- 3.8% for CO_2 emissions,
- 51.6% for CH_4 emissions,

- 88.4% for N_2O emissions and
- 246.1% for the F-gases emissions.

Total uncertainty is 8.92%, while the uncertainty that carried over into the GHG emissions trend is 11.53%.

Table 1.10 Uncertainty analysis for the LULUCF sector

Source / Sink categories	Gas	Uncertainty (%)
Forest Land remaining Forest Land	CO_2	34
Conversion to Forest Land	CO_2	113
Cropland remaining Cropland	CO_2	54
Conversion to Cropland	CO_2	51
Conversion to Grassland	CO_2	51
Land converted to Wetlands	CO_2	51
Conversion to Settlements	CO_2	51
Conversion to Other Land	CO_2	51
Forest Land remaining Forest Land	CH_4	71
Grassland remaining Grassland	CH_4	71
Forest Land remaining Forest Land	N_2O	71
Grassland remaining Grassland	N_2O	71

1.7.2 KP-LULUCF inventory

Since there is a clear correspondence between the Kyoto Protocol activities 'Afforestation / Reforestation' and 'Forest Management', and the UNFCCC categories 'Conversion to Forest land' and 'Forest land remaining Forest land', uncertainty levels of the net emissions/removals are the same for both inventories. The uncertainty of emissions from units of land under 'Deforestation' is estimated to be 51%.

Table 1.11 Uncertainty analysis for the KP-LULUCF activities

Art. 3.3 & 3.4 Activities	Gas	Uncertainty (%)
Afforestation / Reforestation	CO_2	112.8
Deforestation	CO_2	51.0
Forest Management	CO_2	34.0
Forest Management	CH_4	70.9
Forest Management	N_2O	70.9

1.8 General assessment of the completeness

1.8.1 GHG inventory

In the present inventory report, which supersedes all previous ones, estimates of GHG emissions in Greece for the years 1990-2009 are presented. Emissions estimates included in the CRF tables submitted and discussed in the present report, cover the whole territory of Greece. All major sources are reported including emissions estimates for indirect greenhouse gases and SO_2.

Completeness gaps in the present inventory submission that will be discussed in more details in the relevant chapters include:

- CO_2 from *organic chemicals production* and *asphalt roofing-road paving with asphalt* are not estimated due to lack of emission factors in the IPCC GPG.
- *Potential emissions* of F-gases are not estimated, as, for the time being, imports/exports of the relative chemical compounds are not recorded separately.
- N_2O emissions from industrial wastewater handling due to lack of IPPC methodology.

Annex VI provides in detail the sources of GHGs that are not estimated in the Greek GHG inventory, and the reasons for those sources being omitted.

2. Trends in greenhouse gas emissions

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

The GHG emissions trends (CO_2, CH_4, N_2O, HFC, PFC and SF_6) for the period 1990 - 2009 are presented in ***Table 2.1*** (in kt CO_2 eq). The GWP values used for the conversion of emissions estimates into the common unit of carbon dioxide equivalent are those presented in Table 1.3.

It is noted that according to the IPCC Guidelines, emissions estimates for international marine and aviation bunkers were not included in the national totals, but are reported separately as memo items.

Base year GHG emissions for Greece (1990 for CO_2, CH_4, and N_2O - 1995 for F-gases) were estimated at 106.52 Mt CO_2 eq. Given that *LULUCF* was a net sink of GHG emissions in 1990 (and for the rest of the reporting period) the relevant emissions / removals are not considered in estimating base year emissions for Greece.

In 2009, GHG emissions (without *LULUCF*) amounted to 122.54 Mt CO_2 eq showing an increase of 15.05 % compared to base year emissions and of 17.42% compared to 1990 levels. If emissions / removals from *LULUCF* were to be included then the increase would be 17.33 % (from 101.87 Mt CO_2 eq in 1990 to 119.52 Mt CO_2 eq in 2009).

Carbon dioxide emissions accounted for 85.13% of total GHG emissions in 2009 (without *LULUCF*) and increased by approximately 25.28% from 1990. Methane emissions accounted for 10.46% of total GHG emissions in 2009 and decreased by 10.46% from 1990, while nitrous oxide emissions accounted for 5.60 % of the total GHG emissions in 2009 and decreased by 32.21% from 1990. Finally, F-gases emissions that accounted for 2.13% of total GHG emissions in 2009, decreased by 22.12% from 1995 (base year for F-gases), due to cease of HCFC-22 production.

Table 2.1a Total GHG emissions in Greece (in kt CO_2 eq) for the period 1990-2000

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
A. GHG emissions per gas (excluding LULUCF)											
CO_2	83274.33	82990.95	84692.44	84039.09	86314.82	86775.84	88893.98	93741.14	98652.37	98054.10	103198.78
CH_4	9761.78	9731.51	9796.85	9778.83	9929.49	9957.62	10158.38	10013.09	10215.30	10030.40	9941.83
N_2O	10127.58	9817.48	9668.50	8788.73	8617.84	8898.00	9144.20	8922.83	8817.17	8744.93	8432.69
HFC	935.06	1106.82	908.39	1606.64	2143.91	3262.03	3772.29	4036.07	4531.22	5343.13	4274.52
PFC	263.38	264.27	258.36	156.56	96.05	85.78	73.61	169.64	208.53	135.49	151.70
SF_6	3.07	3.16	3.26	3.35	3.45	3.59	3.68	3.73	3.78	3.87	3.99
Total	104365.21	103914.19	105327.80	104373.21	107105.57	108982.85	112046.14	116886.51	122428.37	122311.92	126003.50
B. GHG emissions/removals from LULUCF											
CO_2	-2523.60	-2606.27	-2908.76	-3257.25	-2880.01	-3218.91	-2801.77	-2862.20	-3178.60	-3333.17	-2934.75
CH_4	24.96	16.03	48.00	37.76	37.25	18.34	14.97	26.77	62.79	5.74	89.21
N_2O	2.53	1.63	4.87	3.83	3.78	1.86	1.52	2.72	6.37	0.58	9.05
Total	-2496.11	-2588.62	-2855.89	-3215.66	-2838.98	-3198.71	-2785.28	-2832.71	-3109.44	-3326.85	-2836.48
C. GHG Emissions from International Transport											
CO_2	10475.30	9478.60	10665.71	12212.33	13251.52	13862.55	12399.31	12343.16	13595.02	12685.32	13857.13
CH_4	5.91	5.68	6.90	7.72	8.41	9.53	8.02	8.10	8.45	7.85	8.62
N_2O	90.22	81.51	91.53	104.27	113.65	118.07	106.04	105.86	116.42	110.00	118.84
Total	10571.43	9565.79	10764.14	12324.33	13373.58	13990.15	12513.38	12457.12	13719.89	12803.17	13984.59

Table 2.1b Total GHG emissions in Greece (in kt CO_2 eq) for the period 2001-2009

	2001	2002	2003	2004	2005	2006	2007	2008	2009
A. GHG emissions per gas (excluding LULUCF)									
CO_2	105552.29	105201.72	109335.78	109622.92	113363.10	111908.74	114444.97	110107.59	104326.51
CH_4	9590.69	9500.94	9342.28	9375.23	9173.68	9183.53	8993.82	8796.97	8740.74
N_2O	8225.05	8152.61	8077.34	8085.81	7782.67	7550.97	7787.66	7078.92	6865.96
HFC	3978.19	4210.49	4036.66	4221.57	3957.12	2032.02	2098.19	2482.95	2568.96
PFC	93.42	90.66	80.01	73.22	73.05	62.43	60.19	76.08	36.13
SF_6	4.06	4.25	4.25	4.47	6.45	8.37	9.92	7.53	5.02
Total	127443.70	127160.69	130876.32	131383.21	134356.07	130746.06	133394.76	128550.03	122543.32
B. GHG emissions/removals from LULUCF									
CO_2	-3119.27	-3221.88	-2907.66	-3080.30	-3056.58	-3148.67	-3109.16	-3100.23	-3043.40
CH_4	14.74	2.43	3.31	8.29	4.70	9.04	159.33	19.03	22.55
N_2O	1.50	0.25	0.34	0.84	0.48	0.92	16.17	1.93	2.29
Total	-3103.04	-3219.20	-2904.01	-3071.17	-3051.40	-3138.71	-2933.66	-3079.27	-3018.56
C. GHG Emissions from International Transport									
CO_2	13351.40	12214.71	13150.47	13327.28	11464.10	12661.37	12935.62	12808.67	10909.12
CH_4	7.78	7.03	6.87	6.79	5.66	6.02	5.96	5.73	5.09
N_2O	114.50	105.13	114.16	115.77	95.93	106.38	108.63	108.02	92.01
Total	13473.67	12326.87	13271.51	13449.84	11565.69	12773.77	13050.21	12922.42	11006.22

2.2 Description and interpretation of emission trends by category

GHG emissions trends by sector for the period 1990 - 2009 are presented in ***Table 2.2***.

- Emissions from *Energy* in 2009 ***(Figure 2.1)*** accounted for 81.95% of total GHG emissions (without LULUCF) and increased by approximately 29.79% compared to 1990 levels.

  The living standards improvement due to the economic growth of the period 1990 – 2008, the important growth of the services sector, the introduction of natural gas in the Greek energy system and the economic recession starting in 2009 represent the basic factors affecting emissions trends from *Energy*.

  The evolution of GHG emissions from *Energy* can be distinguished into five periods that are related to economic development and the penetration of natural gas. At first (1990 – 1995) GHG emissions increased with an average annual rate of 0.9% while Gross Domestic Product (GDP) increased with an annual rate of 1.7%. Then and up to 2000, GHG emissions increased with an annual rate of 3.8% which is higher than the rate of increased of GDP for the same period (3.4%). The average annual rate of emissions increase for the period 2000 – 2004 was 1.9% while GDP increased with higher rate (approximately 4%). For the period 2005-2008, a stabilization of the emission levels is observed, although the GDP increased with an annual rate of 3.3%. Finally, after 2008 a reduction of emission is observed by 3.7%, higher than the respective decrease of GDP (2.3%) due to economic recession.

  The majority of GHG emissions (54.6%) in 2009 derived from energy industries, while the contribution of transport, manufacturing industries and construction and other sectors is estimated at 25.6%, 7.4% and 10.9% respectively. The rest 1.5% of total GHG emissions from *Energy* derived from fugitive emissions from fuels.

  The substantial increase of GHG emissions from road transport is directly linked to the increase of vehicles fleet but also to the increase of transportation activity. The renewal of the passenger car fleet and the implied improvement of energy efficiency limit the increase of GHG emissions. The implemented, adopted and planned measures for the improvement of public transport means and is expected to moderate the high use of passenger cars.

- Emissions from *Industrial processes* in 2009 accounted for 7.48% of the total emissions (without *LULUCF*) and decreased by approximately 9.88% compared to 1990 levels. The deep decrease in this sector (mainly depicted in the CO_2 emissions) that took place in 2009 is attributed to economic recession. The intense fluctuation observed in the rest years of the time series are highly dependent on the HCFC-22 production until 2006 when the respective production has ceased. Emissions in 2009 are significantly lower than emissions of 2008, with a decrease of 18.80%.

- The contribution of the *Solvents and other products use* sector to total GHG emissions is minor (0.26% of the total emissions) and has slightly increased compared to 1990 level of emissions.

- Emissions from *Agriculture* that accounted for 7.29% of total emissions in 2009 (without *LULUCF*), decreased by approximately 22.15% compared to 1990 levels. Emissions reduction

is mainly due to the reduction of N_2O emissions from agricultural soils, because of the reduction in the use of synthetic nitrogen fertilizers. The changes of the rest determining parameters of GHG emissions from the sector (e.g. animal population, crops production etc.) have a minor effect on GHG emissions trend.

- Emissions from the *Waste* Sector (3.01% of the total emissions, without *LULUCF*), decreased by approximately 26.52% from 1990. Greenhouse gases emissions from solid waste disposal on land present an increasing trend, while, on the contrary, emissions from wastewater handling are gradually decreasing. The decrease is mostly noticeable since 1999 because of the constant increase of wastewater volume treated under aerobic conditions, while since 2002 the rate of increase is slowing down.
- The *Land Use, Land Use Change and Forestry* sector was a net sink of greenhouse gases during the period 1990 – 2009. During this period, the LULUCF sector offset about 3% of the total national emissions (without LULUCF). The magnitude of this sink increased from approximately 2.5 Mt CO_2 eq in 1990, to 3.0 Mt CO_2 eq in 2009, i.e. an increase of 21%. This upward trend in the net removals from the Forest Land is attributed mainly to the reduction in fellings and the afforestation programmes started in 1994.

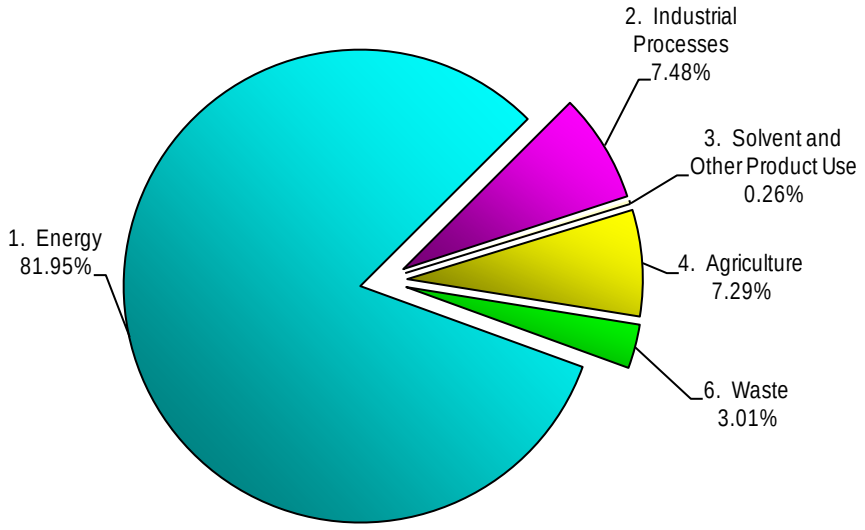


Figure 2.1 Relative contribution of activity sectors to total GHG emissions (without LULUCF) in 2009

Table 2.2a Total GHG emissions (in kt CO_2 eq) by sector for the period 1990-2000

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy	77377.25	77196.22	78934.79	78576.53	80916.32	80890.74	83128.82	87903.01	92770.71	92175.83	97019.35
Industrial processes	10174.31	10075.99	9947.71	10194.14	10654.41	12272.03	12898.98	13233.79	13761.30	14566.86	13811.46
Solvents	308.34	315.54	314.37	312.95	307.39	299.82	298.22	300.20	300.40	308.73	306.61
Agriculture	11483.24	11322.87	11086.56	10220.26	10035.38	10336.87	10480.53	10334.71	10347.17	10194.17	9956.34
Waste	5022.07	5003.57	5044.37	5069.33	5192.06	5183.39	5239.60	5114.79	5248.79	5066.33	4909.74
Total [1)]	104365.21	103914.19	105327.80	104373.21	107105.57	108982.85	112046.14	116886.51	122428.37	122311.92	126003.50
LULUCF	-2496.11	-2588.62	-2855.89	-3215.66	-2838.98	-3198.71	-2785.28	-2832.71	-3109.44	-3326.85	-2836.48
Index per sector											
Energy	100.00	99.77	102.01	101.55	104.57	104.54	107.43	113.60	119.89	119.13	125.38
Industrial processes	100.00	99.03	97.77	100.19	104.72	120.62	126.78	130.07	135.26	143.17	135.75
Solvents	100.00	102.33	101.95	101.49	99.69	97.24	96.72	97.36	97.42	100.13	99.44
Agriculture	100.00	98.60	96.55	89.00	87.39	90.02	91.27	90.00	90.11	88.77	86.70
Waste	100.00	99.63	100.44	100.94	103.38	103.21	104.33	101.85	104.51	100.88	97.76
Total [2)]	100.00	99.57	100.92	100.01	102.63	104.42	107.36	112.00	117.31	117.20	120.73

1) Emissions / removals from *Land Use, Land Use Change and Forestry* are not included in national totals

2) *Land Use, Land Use Change and Forestry* is not included

Table 2.2b Total GHG emissions (in kt CO_2 eq) by sector for the period 2001-2009

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Energy	99422.93	99252.98	103227.63	103498.79	106701.05	105424.87	108038.79	104251.20	100429.67
Industrial processes	13347.38	13456.96	13383.52	13557.15	13794.26	11512.54	11506.03	11291.46	9168.59
Solvents	304.28	305.13	305.93	306.75	309.29	311.92	313.41	314.13	315.60
Agriculture	9859.75	9828.56	9764.65	9847.87	9555.08	9388.59	9645.67	8974.94	8939.50
Waste	4509.36	4317.07	4194.59	4172.66	3996.39	4108.14	3890.87	3718.29	3689.96
Total [1)]	127443.70	127160.69	130876.32	131383.21	134356.07	130746.06	133394.76	128550.03	122543.32
LULUCF	-3103.04	-3219.20	-2904.01	-3071.17	-3051.40	-3138.71	-2933.66	-3079.27	-3018.56
Index per sector									
Energy	128.49	128.27	133.41	133.76	137.90	136.25	139.63	134.73	129.79
Industrial processes	131.19	132.26	131.54	133.25	135.58	113.15	113.09	110.98	90.12
Solvents	98.68	98.96	99.22	99.48	100.31	101.16	101.64	101.88	102.36
Agriculture	85.86	85.59	85.03	85.76	83.21	81.76	84.00	78.16	77.85
Waste	89.79	85.96	83.52	83.09	79.58	81.80	77.48	74.04	73.47
Total [2)]	122.11	121.84	125.40	125.89	128.74	125.28	127.82	123.17	117.42

1) Emissions / removals from *Land Use, Land Use Change and Forestry* are not included in national totals

2) *Land Use, Land Use Change and Forestry* is not included

2.3 Description and interpretation of emission trends by gas

2.3.1 Carbon dioxide

The trend of carbon dioxide emissions from 1990 to 2009 by source category is presented in ***Table 2.3***. Total CO_2 emissions increased from 83.27 Mt in 1990 to 104.33 Mt in 2009 (without LULUCF). The increase of 25.28 % from 1990 to 2009 is mainly attributed to the increased electricity production as well as to the increased energy consumption in the residential and transport sectors. The decrease in 2009 is mainly attributed to economic crisis. Other reasons are the increased share of natural gas in energy mix and RES technologies.

CO_2 emissions from *Energy* increase, from 75.25 Mt in 1990 to 97.97 Mt in 2009, presenting a total increase of 30.21% from 1990 to 2009. Carbon dioxide emissions from *Industrial processes* in 2009 decreased by 21.3% compared to 1990 levels and from *Solvents and other products use* decreased by 4.9% compared to 1990 levels. Finally, emissions from *Waste* in 2009 show a continuous increase from 1990. (***Figure 2.2***).

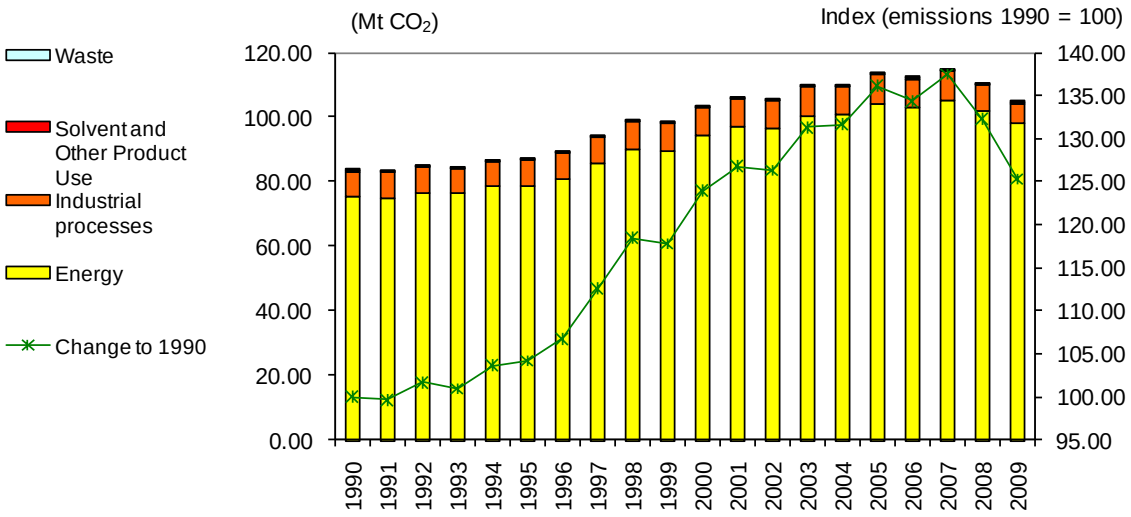


Figure 2.2 CO_2 emissions by sector (in Mt) for the years 1990 – 2009 (without LULUCF)

Table 2.3a CO_2 *emissions / removals by sector for the period 1990-2000 (in kt)*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total (with LULUCF)	80,750.73	80,384.68	81,783.68	80,781.83	83,434.81	83,556.93	86,092.21	90,878.95	95,473.77	94,720.92	100,264.03
Total (without LULUCF)	83,274.33	82,990.95	84,692.44	84,039.09	86,314.82	86,775.84	88,893.98	93,741.14	98,652.37	98,054.10	103,198.78
1. Energy	75,241.44	75,028.43	76,698.67	76,350.04	78,624.04	78,579.71	80,696.29	85,445.50	90,207.94	89,563.12	94,431.58
A. Fuel combustion	75,171.21	74,957.53	76,640.47	76,302.71	78,578.82	78,540.98	80,652.69	85,406.35	90,180.76	89,561.67	94,407.43
1. Energy industries	42,992.74	41,850.29	44,131.81	44,030.08	46,006.63	44,769.81	43,948.69	47,468.36	50,078.31	50,259.91	54,629.23
2. Man. Industry and Construction	9,566.03	9,467.36	8,828.86	8,527.17	8,452.07	9,215.80	9,769.38	9,974.00	10,030.91	8,979.19	9,721.62
3. Transport	14,486.54	15,218.73	15,620.29	15,826.75	16,141.96	16,503.89	16,981.63	17,746.03	19,506.31	19,931.29	19,059.72
4. Other sectors	8,125.91	8,421.16	8,059.51	7,918.71	7,978.16	8,051.48	9,952.98	10,217.96	10,565.23	10,391.28	10,996.86
B. Fugitive emissions	70.23	70.90	58.20	47.33	45.22	38.73	43.60	39.15	27.18	1.44	24.15
2. Industrial processes	7,863.03	7,786.59	7,820.78	7,518.78	7,527.41	8,041.33	8,045.38	8,142.42	8,291.90	8,330.87	8,609.72
A. Mineral products	6,675.86	6,596.67	6,669.17	6,625.74	6,594.53	7,072.62	7,063.10	7,145.91	7,191.57	7,177.06	7,380.34
B. Chemical production	240.28	229.59	218.32	140.72	NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	177.48	283.96	275.90
C. Metal production	946.89	960.32	933.29	752.32	932.87	968.71	982.28	996.52	922.85	869.85	953.48
3. Solvents	169.71	175.78	172.84	170.12	163.22	154.65	152.16	153.07	152.39	159.96	157.33
5. LULUCF	-2,523.60	-2,606.27	-2,908.76	-3,257.25	-2,880.01	-3,218.91	-2,801.77	-2,862.20	-3,178.60	-3,333.17	-2,934.75
6. Waste	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
International transport [1)]	10,475.30	9,478.60	10,665.71	12,212.33	13,251.52	13,862.55	12,399.31	12,343.16	13,595.02	12,685.32	13,857.13
Aviation	2,447.55	2,110.50	2,201.85	2,343.60	2,781.45	2,608.20	2,497.95	2,416.05	2,535.75	2,847.60	2,497.95
Marine	8,027.75	7,368.10	8,463.86	9,868.73	10,470.07	11,254.35	9,901.36	9,927.11	11,059.27	9,837.72	11,359.18

1) Emissions from International transport are not included in national totals.

Table 2.3b CO_2 emissions / removals by sector for the period 2001-2009 (in kt)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total (with LULUCF)	102,433.02	101,979.85	106,428.12	106,542.62	110,306.52	108,760.07	111,335.82	107,007.36	101,283.11
Total (without LULUCF)	105,552.29	105,201.72	109,335.78	109,622.92	113,363.10	111,908.74	114,444.97	110,107.59	104,326.51
1. Energy	96,774.10	96,518.95	100,493.16	100,756.12	103,992.18	102,780.31	105,383.91	101,641.21	97,970.97
A. Fuel combustion	96,757.05	96,501.10	100,481.54	100,744.65	103,982.72	102,771.20	105,376.95	101,635.88	97,963.45
1. Energy industries	55,149.40	54,581.87	55,823.30	57,144.79	57,973.55	55,786.98	59,251.16	57,618.91	54,619.70
2. Man. industry and Construction	9,894.81	9,444.31	9,133.51	8,491.51	10,170.76	10,383.78	10,102.46	9,255.42	7,411.93
3. Transport	19,868.72	20,088.77	21,240.09	21,620.79	21,708.53	22,574.35	23,365.59	22,378.03	25,322.12
4. Other sectors	11,844.13	12,386.16	14,284.64	13,487.56	14,129.89	14,026.09	12,657.74	12,383.52	10,609.70
B. Fugitive emissions	17.04	17.85	11.62	11.47	9.46	9.11	6.96	5.33	7.52
2. Industrial processes	8,623.37	8,527.24	8,686.34	8,709.95	9,211.36	8,966.52	8,897.65	8,302.08	6,190.64
A. Mineral products	7,429.63	7,202.01	7,233.91	7,244.62	7,737.80	7,474.37	7,335.86	6,957.66	5,314.86
B. Chemical production	135.77	155.94	272.40	289.46	263.30	292.59	299.16	230.37	187.61
C. Metal production	1,057.98	1,169.30	1,180.03	1,175.87	1,210.26	1,199.57	1,262.64	1,114.06	688.17
3. Solvents	154.67	155.12	155.50	155.87	157.70	159.64	160.34	160.68	161.38
5. LULUCF	-3,119.27	-3,221.88	-2,907.66	-3,080.30	-3,056.58	-3,148.67	-3,109.16	-3,100.23	-3,043.40
6. Waste	0.15	0.41	0.79	0.98	1.87	2.26	3.06	3.61	3.53
International transport [1)]	13,351.40	12,214.71	13,150.47	13,327.28	11,464.10	12,661.37	12,935.62	12,808.67	10,909.12
Aviation	2,321.47	2,321.55	3,021.87	3,106.36	2,385.19	2,860.89	2,923.94	3,040.47	2,615.19
Marine	11,029.93	9,893.16	10,128.61	10,220.92	9,078.91	9,800.48	10,011.69	9,768.20	8,293.93

1) Emissions from International transport are not included in national totals.

2.3.2 Methane

The trend of methane emissions from 1990 to 2009 by source category is presented in ***Table 2.4*** and in ***Figure 2.3***.

Agriculture represents the largest anthropogenic source of methane emissions in Greece since 2005 (with enteric fermentation being the main source category in the sector), accounting for 42.85% of total methane emissions in 2009 (without *LULUCF*). Methane emissions from *Agriculture* in 2009 increased by 0.84% compared to 1990 levels. Methane emissions from *Waste* in 2009 accounted for 37.8% of total methane emissions and decreased by 29.63% from 1990. Methane emissions from the *Energy sector* (mainly fugitive emissions from coal mining and production, processing, and distribution of liquid fuels and natural gas) account for almost the remaining 19.8% of the total methane emissions. Finally the contribution of CH_4 emissions from *Iron and* Steel *Production* can be considered negligible.

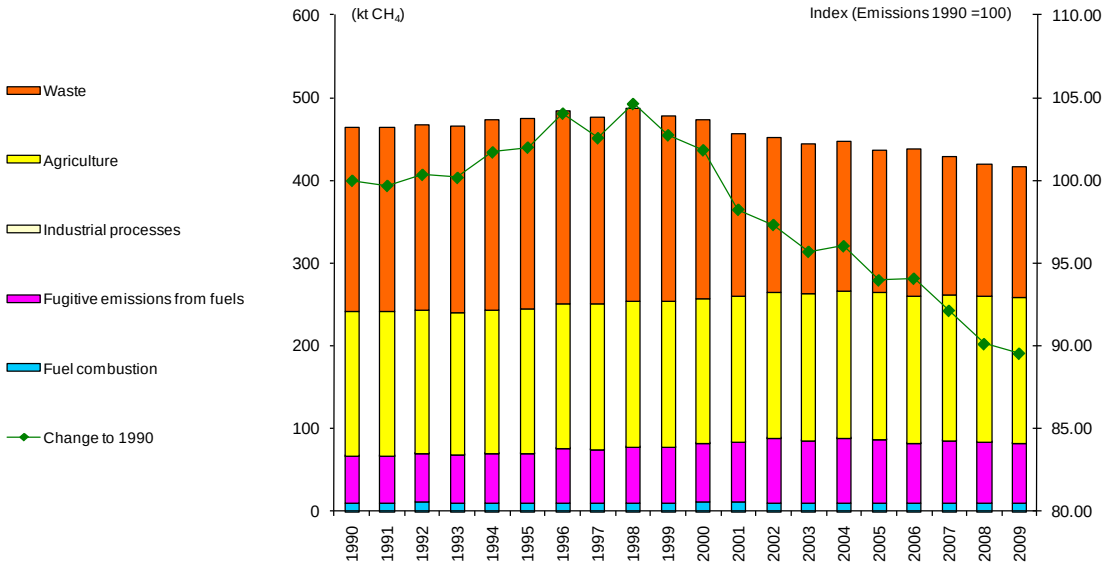


Figure 2.3 CH_4 emissions by sector (in kt) for the period 1990 – 2009 (without LULUCF)

Table 2.4a CH_4 emissions by source category for the period 1990-2000 (in kt)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total (with LULUCF)	466.04	464.17	468.80	467.46	474.61	475.05	484.44	478.09	489.43	477.91	477.67
Total (without LULUCF)	464.85	463.41	466.52	465.66	472.83	474.17	483.73	476.81	486.44	477.64	473.42
1. Energy	66.07	66.78	69.42	68.08	69.33	70.12	74.91	74.13	76.93	77.73	81.80
A. Fuel combustion	9.55	9.60	10.35	9.98	9.56	9.53	9.68	9.55	9.60	10.25	11.05
1. Energy industries	0.60	0.61	0.62	0.63	0.64	0.65	0.65	0.67	0.70	0.71	0.79
2. Manufacturing industry and Construction	0.43	0.43	0.43	0.42	0.40	0.42	0.44	0.45	0.44	0.42	0.48
3. Transport	4.52	4.55	4.49	4.55	4.53	4.56	4.58	4.64	4.79	4.89	5.00
4. Other sectors	4.00	4.01	4.81	4.39	3.98	3.90	4.01	3.78	3.68	4.23	4.79
B. Fugitive emissions from fuels	56.52	57.18	59.07	58.10	59.77	60.59	65.23	64.58	67.33	67.48	70.75
1. Solid fuels	52.16	52.96	55.33	55.09	56.96	57.95	60.08	59.14	61.19	62.36	64.21
2. Oil and natural gas	4.36	4.23	3.74	3.01	2.82	2.64	5.15	5.44	6.14	5.12	6.54
2. Industrial processes	0.03	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.02
4. Agriculture	175.23	174.25	173.12	172.37	173.11	174.20	176.25	176.41	176.92	176.41	175.50
A. Enteric fermentation	154.58	153.49	152.63	150.85	150.81	151.58	153.12	153.16	154.29	154.42	154.31
B. Manure management	16.07	16.00	16.08	16.07	16.03	15.96	16.00	16.01	16.04	16.00	15.81
C. Rice cultivation	3.29	2.95	2.94	4.05	4.74	5.22	5.72	5.82	5.25	4.67	3.98
F. Field burning of agricultural residues	1.29	1.81	1.47	1.41	1.53	1.44	1.41	1.43	1.34	1.32	1.39
5. LULUCF	1.19	0.76	2.29	1.80	1.77	0.87	0.71	1.27	2.99	0.27	4.25
6. Waste	223.51	222.34	223.95	225.17	230.36	229.81	232.53	226.24	232.56	223.48	216.10
A. Solid waste disposal on land	88.49	91.15	92.49	95.04	97.81	100.70	103.74	106.99	109.25	106.89	110.67
B. Wastewater handling	135.02	131.19	131.46	130.13	132.55	129.11	128.80	119.25	123.31	116.58	105.44
C. Waste Incineration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
International Transport [1)]	0.28	0.27	0.33	0.37	0.40	0.45	0.38	0.39	0.40	0.37	0.41
Aviation	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
Marine	0.26	0.25	0.30	0.34	0.37	0.42	0.35	0.35	0.37	0.33	0.37

[1)] Emissions from International Transport are not included in national totals

Table 2.4b CH_4 emissions by source category for the period 2001-2009 (in kt)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total (with LULUCF)	457.40	452.54	445.03	446.83	437.07	437.74	435.86	419.81	417.30
Total (without LULUCF)	456.70	452.43	444.87	446.44	436.84	437.31	428.28	418.90	416.23
1. Energy	84.01	87.15	85.27	87.62	86.23	82.15	84.07	83.24	82.21
A. Fuel combustion	10.73	9.76	9.76	10.23	9.59	9.89	9.65	9.26	8.80
1. Energy industries	0.78	0.78	0.80	0.80	0.83	0.84	0.90	0.89	0.79
2. Manufacturing industry and Construction	0.47	0.48	0.41	0.42	0.49	0.46	0.45	0.49	0.42
3. Transport	5.12	5.06	5.02	5.05	4.81	4.72	4.51	4.22	3.95
4. Other sectors	4.37	3.45	3.52	3.97	3.46	3.87	3.79	3.66	3.64
B. Fugitive emissions from fuels	73.27	77.39	75.51	77.38	76.64	72.26	74.42	73.98	73.41
1. Solid fuels	66.68	70.82	68.64	70.39	69.74	64.84	66.80	66.05	65.22
2. Oil and natural gas	6.60	6.57	6.87	6.99	6.90	7.42	7.62	7.93	8.19
2. Industrial processes	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02
4. Agriculture	175.53	177.28	177.50	177.83	178.33	177.67	177.18	176.92	176.71
A. Enteric fermentation	154.18	155.83	156.06	156.12	156.48	156.17	155.32	154.78	154.07
B. Manure management	15.70	15.60	15.65	15.75	15.80	15.73	15.58	15.59	15.56
C. Rice cultivation	4.22	4.48	4.52	4.55	4.62	4.46	5.00	5.00	5.60
F. Field burning of agricultural residues	1.42	1.38	1.27	1.42	1.43	1.32	1.28	1.54	1.48
5. LULUCF	0.70	0.12	0.16	0.39	0.22	0.43	7.59	0.91	1.07
6. Waste	197.15	187.98	182.08	180.97	172.26	177.46	167.00	158.71	157.29
A. Solid waste disposal on land	114.61	115.47	119.32	119.06	118.15	123.02	119.11	117.64	117.33
B. Wastewater handling	82.54	72.50	62.76	61.91	54.11	54.45	47.89	41.07	39.96
C. Waste Incineration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
International Transport [1)]	0.37	0.33	0.33	0.32	0.27	0.29	0.28	0.27	0.24
Aviation	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03
Marine	0.33	0.30	0.29	0.28	0.24	0.26	0.25	0.24	0.21

[1)] Emissions from International Transport are not included in national totals

2.3.3 Nitrous oxide

The trend of nitrous oxide emissions from 1990 to 2009 by source category is presented in ***Table 2.5*** and in ***Figure 2.4***.

Agriculture represents the largest anthropogenic source of nitrous oxide emissions in Greece (76.15% approximately of the total nitrous oxide emissions in 2009, without *LULUCF*). Emissions from this sector decreased by 33.0 % since 1990, mainly because of new agricultural practices applied, affecting the use of synthetic nitrogen fertilizers.

Nitrous oxide is also produced from the reaction between nitrogen and oxygen during fossil fuel combustion. Nitrous oxide emissions from fossil fuels combustion (accounting for 10.67% of total nitrous oxide emissions in 2009) decreased by 2.12% from 1990. Emissions from the *Energy* sector tend to decrease mainly due to the penetration of natural gas in electricity production.

Production of nitric acid is the major source of N_2O emissions from *Industrial processes* and accounts for 5.35% of total N_2O emissions in 2009. Nitrous oxide emissions from this source decreased by 66.87% from 1990, due to the reduction of nitric acid production in Greece.

N_2O emissions from *Waste* in 2009 (5.58% of total emissions without *LULUCF*) increased by 16.79% compared to 1990 levels.

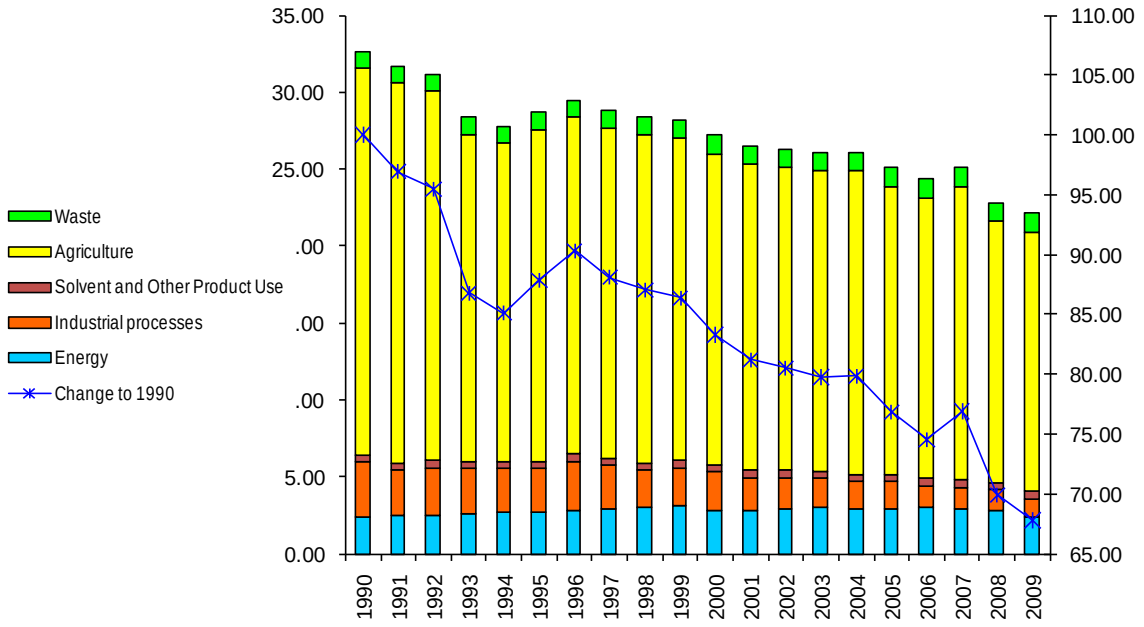


Figure 2.4 N_2O emissions by sector (in kt) for the period 1990 – 2009 (without LULUCF)

Table 2.5a N_2O emissions by source category for the period 1990-2000 (in kt)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total (with LULUCF)	32.68	31.67	31.20	28.36	27.81	28.71	29.50	28.79	28.46	28.21	27.23
Total (without LULUCF)	32.67	31.67	31.19	28.35	27.80	28.70	29.50	28.78	28.44	28.21	27.20
1. Energy	2.41	2.47	2.51	2.57	2.70	2.70	2.77	2.91	3.06	3.16	2.81
A. Fuel combustion	2.41	2.47	2.51	2.57	2.70	2.70	2.77	2.91	3.06	3.16	2.81
1. Energy industries	0.50	0.48	0.51	0.51	0.53	0.51	0.50	0.54	0.57	0.56	0.60
2. Man. industry and Construction	0.14	0.15	0.15	0.15	0.15	0.16	0.16	0.17	0.18	0.16	0.17
3. Transport	0.54	0.57	0.64	0.74	0.85	0.93	0.98	1.07	1.19	1.31	0.88
4. Other sectors	1.23	1.27	1.21	1.17	1.17	1.10	1.13	1.12	1.12	1.13	1.15
B. Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Industrial processes	3.58	2.95	3.08	2.93	2.85	2.83	3.24	2.84	2.34	2.43	2.49
4. Agriculture	0.45	0.45	0.46	0.46	0.47	0.47	0.47	0.47	0.48	0.48	0.48
B. Manure management	25.17	24.72	24.04	21.29	20.65	21.54	21.87	21.39	21.39	20.93	20.23
D. Agricultural soils	1.10	1.08	1.07	1.00	0.97	0.95	0.98	0.97	0.97	0.96	0.95
F. Field burning of agr. residues	24.04	23.59	22.93	20.26	19.63	20.56	20.85	20.38	20.39	19.94	19.24
5. LULUCF	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03
6. Waste	0.01	0.01	0.02	0.01	0.01	0.01	0.00	0.01	0.02	0.00	0.03
International transport [1)]	1.06	1.08	1.10	1.10	1.14	1.15	1.15	1.17	1.18	1.20	1.20
Aviation	0.29	0.26	0.30	0.34	0.37	0.38	0.34	0.34	0.38	0.35	0.38
Marine	0.09	0.07	0.08	0.08	0.10	0.09	0.09	0.09	0.09	0.10	0.09

2) Emissions from International transport are not included in national totals

Table 2.5b N_2O emissions by source category for the period 2001-2009 (in kt)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total (with LULUCF)	26.54	26.30	26.06	26.09	25.11	24.36	25.17	22.84	22.16
Total (without LULUCF)	26.53	26.30	26.06	26.08	25.11	24.36	25.12	22.84	22.15
1. Energy	2.85	2.92	3.04	2.91	2.90	2.97	2.87	2.78	2.36
A. Fuel combustion	2.85	2.92	3.04	2.91	2.90	2.97	2.87	2.78	2.36
1. Energy industries	0.61	0.60	0.61	0.63	0.63	0.59	0.62	0.60	0.59
2. Man. industry and Construction	0.17	0.16	0.15	0.14	0.15	0.15	0.15	0.15	0.13
3. Transport	0.91	0.91	0.93	0.96	0.93	0.98	0.98	0.95	0.86
4. Other sectors	1.16	1.24	1.35	1.18	1.19	1.24	1.12	1.08	0.78
B. Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Industrial processes	2.09	2.01	1.86	1.77	1.76	1.43	1.42	1.36	1.19
4. Agriculture	0.48	0.48	0.49	0.49	0.49	0.49	0.49	0.49	0.50
B. Manure management	19.91	19.70	19.47	19.72	18.74	18.25	19.11	16.97	16.87
D. Agricultural soils	0.94	0.95	0.97	0.98	1.00	1.00	0.99	0.98	0.97
F. Field burning of agr. residues	18.94	18.71	18.47	18.70	17.71	17.22	18.09	15.95	15.85
5. LULUCF	0.04	0.03	0.03	0.04	0.04	0.03	0.03	0.04	0.04
6. Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.01	0.01
International transport [1)]	1.19	1.19	1.19	1.20	1.22	1.22	1.23	1.23	1.24
Aviation	0.37	0.34	0.37	0.37	0.31	0.34	0.35	0.35	0.30
Marine	0.09	0.09	0.11	0.11	0.08	0.09	0.09	0.10	0.08

1) Emissions from International transport are not included in national totals

2.3.4 Halocarbons and sulphur hexafluoride

HFC and PFC are chemical substances, the production of which aims mainly to the substitution of ozone depleting substances (see Montreal Protocol – 1987). HFC and PFC are not harmful to the stratospheric ozone layer and thus their emissions are not controlled by the above-mentioned Protocol. However, many of these substances, as well as SF_6, are powerful greenhouse gases; in addition, apart from being characterized by a high Global Warming Potential (GWP), these gases have extremely long atmospheric lifetimes, resulting in their essentially irreversible accumulation in the atmosphere. Especially sulphur hexafluoride is the most potent greenhouse gas according to the IPCC evaluation.

Emission estimates of these gases presented in ***Table 2.6*** originate from:

- The production of HCFC-22 (emissions of HFC-23) and aluminium production (emissions of CF_4 and C_2F_6). HFC-23 emissions have been increasing steadily up to 1999 due to an equivalent increase in the production of HCFC-22, while PFC emissions from aluminium have dropped due to the control/reduction of the "anode effect" during the production process, since 1990 (with the exception of the period 1997 – 2000). HFC-23 emissions are reported as not occurring since 2006, due to the closure of the plant producing HCFC-22.
- Manufacturing, operation and maintenance of refrigeration and air conditioning equipment. HFC emissions increased significantly since 1995 (base year), mainly due to the increase of air conditioning equipment in the residential sector, the increasing trend of emissions from the commercial refrigeration and the introductionof new passenger cars with air-conditioning systems, but also due to the implementation of the Montreal Protocol, leading to an increase in the number of equipment operating with f-gases.
- Use of f-gases (mainly HFC-134a) in aerosol products. The main application regards the use of HFC-134a in metered dose inhalers, as provided by the National Organization of Medicines and plants of the sector. The trend is generally increasing and emissions show a peak in 2009. Other aerosol applications regard the use of HFC-134a by one company in Greece, according to data received by the Hellenic Aerosol Association.
- Use of HFC-134a and HFC-152a in foam blowing since 2001, as reported by the four plants of the sector. Emissions show a peak in 2006, resulting from the use of f-gases by three of the plants in that particular year.
- The use of SF_6 in the electricity transmission / distribution system of the Public Power Corporation of Greece. Emissions mainly derive from the use of SF_6 in the transmission system, as the equipment used by the distribution system and by the medium voltage Greek clients refers to sealed pressure systems, minimizing the possibility of SF_6 leakages.
- Finally, the emissions from fire extinguishers, which follow a continous increasing trend in the inventory years.

Table 2.6 Actual F-gases emissions for the period 1990-2009 (in kt CO_2 eq)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
HFC	935.06	1,106.82	908.39	1,606.64	2,143.91	3,262.03	3,772.29	4,036.07	4,531.22	5,343.13
HFC-23	935.06	1,106.82	908.39	1,606.64	2,143.91	3,253.07	3,746.34	3,960.22	4,359.89	5,023.04
HFC-32										
HFC-125										
HFC-134a						8.97	25.95	75.85	171.33	315.91
HFC-152a										
HFC-227ea										4.18
PFC	263.38	264.27	258.36	156.56	96.05	85.78	73.61	169.64	208.53	135.49
SF_6	3.07	3.16	3.26	3.35	3.45	3.59	3.68	3.73	3.78	3.87
Total	1,201.52	1,374.25	1,170.01	1,766.56	2,243.41	3,351.40	3,849.58	4,209.44	4,743.53	5,482.50

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
HFC	4,274.52	3,978.19	4,210.49	4,036.66	4,221.57	3,957.12	2,032.02	2,098.19	2,482.95	2,568.96
HFC-23	3,735.11	3,181.46	3,194.57	2,661.05	2,550.60	2,157.48				
HFC-32	2.37	4.16	8.46	14.08	19.60	26.08	36.66	41.84	52.91	60.24
HFC-125	11.05	19.44	39.49	65.74	91.46	121.67	171.07	195.09	246.60	280.58
HFC-134a	520.01	763.69	927.40	1,241.63	1,506.76	1,591.92	1,751.21	1,788.04	2,107.31	2,153.72
HFC-152a		1.67	30.40	40.90	35.19	37.69	46.73	41.22	40.91	35.88
HFC-227ea	5.97	7.75	10.17	13.26	17.96	22.28	26.36	32.01	35.22	38.54
PFC	151.70	93.42	90.66	80.01	73.22	73.05	62.43	60.19	76.08	36.13
SF_6	3.99	4.06	4.25	4.25	4.47	6.45	8.37	9.92	7.53	5.02
Total	4,430.21	4,075.67	4,305.40	4,120.93	4,299.25	4,036.62	2,102.81	2,168.30	2,566.56	2,610.11

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

The role of carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane organic volatile compounds (NMVOC) is important for climate change as these gases act as precursors of tropospheric ozone. In this way, they contribute to ozone formation and alter the atmospheric lifetimes of other greenhouse gases. For example, CO interacts with the hydroxyl radical (OH), the major atmospheric sink for methane, to form carbon dioxide. Therefore, increased atmospheric concentration of CO limits the number of OH compounds available to destroy methane, thus increasing the atmospheric lifetime of methane.

These gases are generated through a variety of anthropogenic activities. Emissions trends for indirect greenhouse gases and SO_2 are presented in ***Table 2.7***, while more information on the emissions of indirect greenhouse gases and SO_2 is provided in Annex V.

- NO_x emissions increased by 13.49% from 1990 to 2009. Energy sector accounts for the high majority of emissions (99.32%). The decrease in NO_x emissions from transport after 1998 is attributed to the substitution of old technology vehicles by new catalytic ones (NOx emissions from this category account for the 51.64% of total NO_x emissions in 2009). Emissions from *Industrial processes* decreased by 49.5% from 1990 due to reductions in the production of nitric acid.
- The transport sector is the main source of CO emissions. Due to the substitution of old technology vehicles by new and more efficient ones, CO emissions from transport decreased by 56.13% from 1990 to 2009 and as a result total CO emissions in 2009 decreased by 52.07%. Emissions from industrial processes in 2009 decreased by 19.93% compared to 1990 levels. The variation of CO emissions from *LULUCF* is related to the intensity and number of forest fires. In 2009 emissions from LULUCF accounted for 1.57% of total CO emissions (incl LULUCF), and are by 9.67% lower than emissions of 1990.
- NMVOC emissions decreased by 24.24% from 1990 to 2009. Emissions from transport (28.29% of total NMVOC emissions in 2009), decreased by 56.98% compared to 1990 levels, while emissions from *Energy* decreased by 42.04% from 1990 to 2009. The significant increase of NMVOC emissions from *Industrial processes* (approximately 62.93% from 1990 to 2009) is attributed to the non-energy use of bitumen in the construction sector. Emissions from Solvents and other products use decreased by 4.26% compared to 1990 levels.
- SO_2 emissions decreased by 10.5% from 1990 to 2009. Emissions from energy, which is the main source of SO_2 emissions in Greece (98.68 % of total SO_2 emissions for 2009, decreased with a mean annual rate of increase of 0.52% for the period 1990 – 2009. The operation of desulphurisation plants at large installations for electricity generation since 1998 resulted in the restriction of the increase of SO_2 emissions from electricity generation. Reductions with respect to the sulphur content of liquid fossil fuels and the introduction of natural gas in the Greek energy system resulted in a reduction of SO_2 emissions from manufacturing industry

87% for the period 1990 – 2009. Emissions from *Industrial processes* decreased by 41% from 1990 due to decrease of sulphuric acid industrial production.

Table 2.7a Emissions trends for indirect greenhouse gases and SO_2 (in kt) for the period 1990-2000

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
NOx	330.91	340.74	347.79	345.28	353.33	332.93	336.95	350.24	372.95	370.05	364.11
1. Energy	327.56	337.32	344.22	341.96	350.00	329.90	333.88	347.11	369.62	367.37	360.33
Transport	183.97	186.29	187.79	188.79	191.40	181.54	178.84	186.55	205.72	206.23	185.99
Other energy sectors	143.59	151.04	156.43	153.17	158.60	148.36	155.04	160.56	163.90	161.14	174.34
2. Industrial processes	1.88	1.64	1.68	1.60	1.53	1.54	1.62	1.52	1.38	1.42	1.47
4. Agriculture	1.17	1.58	1.32	1.27	1.36	1.27	1.28	1.30	1.20	1.19	1.25
5. LULUCF	0.30	0.19	0.57	0.45	0.44	0.22	0.18	0.32	0.74	0.07	1.06
CO	1,250.52	1,231.81	1,185.90	1,183.80	1,168.32	1,069.01	1,061.90	1,068.39	1,087.89	1,061.20	1,054.14
1. Energy	1,190.15	1,164.42	1,112.85	1,117.92	1,101.82	1,012.51	1,007.27	1,008.38	1,011.93	1,007.74	964.63
Transport	878.86	849.89	800.96	806.31	788.42	701.38	694.99	691.91	693.75	690.84	642.01
Other energy sectors	311.29	314.53	311.89	311.61	313.41	311.13	312.28	316.47	318.17	316.90	322.62
2. Industrial processes	22.91	22.78	22.19	20.60	18.75	18.61	18.74	18.89	21.67	23.45	23.13
4. Agriculture	27.06	37.93	30.86	29.54	32.23	30.26	29.65	29.97	28.13	27.62	29.21
5. LULUCF	10.40	6.68	20.00	15.73	15.52	7.64	6.24	11.15	26.16	2.39	37.17
NMVOC	279.24	281.15	276.91	276.26	274.84	269.13	269.37	271.23	277.40	279.29	273.87
1. Energy	195.63	194.11	189.83	189.42	188.94	179.75	180.10	181.05	182.31	180.94	170.91
Transport	139.09	137.50	132.78	133.48	131.47	120.67	120.00	119.95	120.54	120.08	106.90
Other energy sectors	56.54	56.61	57.05	55.93	57.47	59.08	60.10	61.10	61.77	60.85	64.01
2. Industrial processes	26.97	28.77	29.62	30.68	31.60	37.74	38.21	38.75	43.72	44.60	49.76
3. Solvents	56.65	58.27	57.45	56.16	54.31	51.64	51.05	51.43	51.36	53.75	53.20
SO_2	477.43	518.40	535.37	532.14	523.14	541.05	530.97	529.79	537.44	556.27	497.12
1. Energy	467.86	509.30	527.08	524.27	515.09	532.26	522.34	520.87	528.36	546.92	488.64
Transport	39.04	39.04	41.34	38.59	43.05	32.32	30.88	37.94	52.75	56.58	21.58
Other energy sectors	428.82	470.26	485.74	485.68	472.05	499.94	491.46	482.93	475.62	490.34	467.06
2. Industrial processes	9.57	9.10	8.29	7.87	8.05	8.78	8.63	8.92	9.08	9.35	8.48

Table 2.7b Emissions trends for indirect greenhouse gases and SO_2 (in kt) for the period 2001-2009

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
NOx	385.73	386.67	396.32	402.36	419.18	415.49	418.72	395.06	375.53
1. Energy	382.91	383.94	393.72	399.56	416.34	412.80	414.25	392.04	372.96
Transport	197.48	191.91	191.09	196.62	189.98	195.53	191.05	181.90	193.93
Other energy sectors	185.43	192.03	202.63	202.94	226.36	217.27	223.20	210.14	179.03
2. Industrial processes	1.36	1.45	1.37	1.39	1.45	1.35	1.38	1.34	0.95
4. Agriculture	1.29	1.25	1.19	1.31	1.33	1.23	1.21	1.45	1.36
5. LULUCF	0.17	0.03	0.04	0.10	0.06	0.11	1.89	0.23	0.27
CO	1,020.21	975.09	932.80	922.99	722.54	740.86	748.00	630.12	599.34
1. Energy	961.72	922.27	881.07	865.96	667.01	685.90	630.93	566.62	540.53
Transport	639.25	599.96	579.01	566.75	501.22	519.17	455.38	405.77	385.56
Other energy sectors	322.47	322.31	302.06	299.20	165.79	166.72	175.55	160.84	154.97
2. Industrial processes	22.44	22.89	23.66	23.78	23.47	23.56	23.74	23.15	18.34
4. Agriculture	29.91	28.91	26.69	29.80	30.09	27.64	26.94	32.43	31.08
5. LULUCF	6.14	1.01	1.38	3.45	1.96	3.77	66.39	7.93	9.39
NMVOC	271.38	268.15	256.03	255.65	221.82	231.71	220.61	228.42	211.56
1. Energy	169.26	163.83	158.63	152.53	134.33	133.90	129.08	119.14	113.39
Transport	105.57	99.11	94.04	90.04	79.43	76.99	70.22	61.78	59.84
Other energy sectors	63.69	64.72	64.59	62.49	54.90	56.92	58.86	57.36	53.54
2. Industrial processes	49.78	51.84	44.79	50.39	34.44	44.12	37.63	55.27	43.94
3. Solvents	52.35	52.49	52.61	52.73	53.05	53.68	53.90	54.01	54.24
SO_2	505.06	516.34	554.62	549.00	528.30	534.44	539.18	446.39	427.31
1. Energy	496.71	507.81	546.02	540.28	518.24	526.78	531.43	439.00	421.66
Transport	28.89	25.26	26.83	31.86	27.98	30.63	27.67	23.54	46.99
Other energy sectors	467.81	482.55	519.19	508.42	490.26	496.15	503.77	415.47	374.67
2. Industrial processes	8.35	8.54	8.60	8.72	10.06	7.67	7.74	7.39	5.65

2.5 Description and interpretation of emission trends for KP-LULUCF inventory in aggregate and by activity, and by gas

Since 1990, land areas afforested were 33270 ha, land areas deforested were 3880 ha and land areas under forest management were 1167124 ha. In 2009 net removals from ARD activities was 350.63 kt CO_2 eq. and from Forest Management activities 1944.71 Kt CO_2 eq. GHG emissions and removals from KP-LULUCF activities are reported for first time in 2010 submission, hence trends are not yet available.

However, since there is a clear correspondence between the Kyoto Protocol activities 'Afforestation / Reforestation' and 'Forest Management', and the UNFCCC categories 'Conversion to Forest land' and 'Forest land remaining Forest land', the description and interpretation of emission / removal trends for the associated UNFCCC categories can be found in Chapter 7.

The Kyoto Protocol activity of Deforestation encompasses the UNFCCC subcategories 5.B.2.1, 5.C.2.1, 5.D.2.1, 5.E.2.1 and 5.F.2.1 (Forest land converted to other land uses). In figure 2.5 emissions from these subcategories during the period 1990-2008 are summed up in order to illustrate the effect of deforestation.

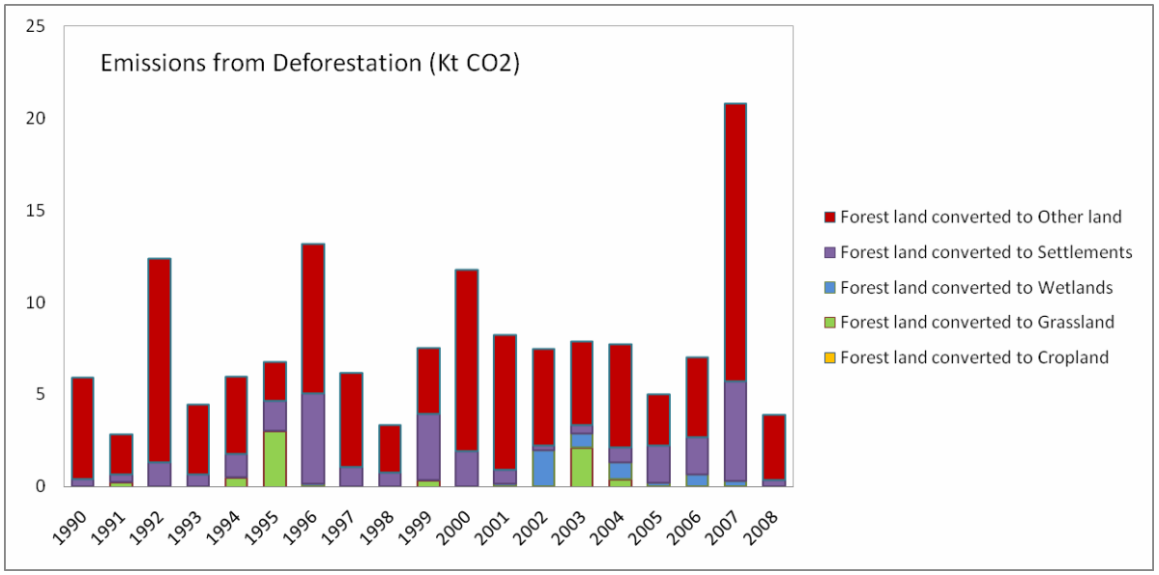


Figure 2.5 CO_2 emissions (in kt) from deforestation for the period 1990 – 2008

3. Energy (CRF sector 1)

3.1 Overview of sector

In this chapter, estimations for greenhouse gas emissions from the energy sector are presented and the methodological approach followed per source category is described.

According to the IPCC Guidelines, this sector includes two general source categories: fuel combustion activities and fugitive emissions from fuels.

In the present report and for presentation purposes, fuel combustion activities are further divided in two main categories, on the basis of the characteristics of the methodology applied for the calculation of emissions:

- Stationary combustion[2], including energy industries, manufacturing industries and construction and the other sectors (agriculture, residential and commercial / institutional sectors).
- Transport, including internal civil aviation, road transport, railways and internal navigation.

3.1.1 Emissions trends

The energy sector relies on fossil fuel combustion for meeting the bulk of energy requirements in Greece. As shown in ***Figure 3.1***, gross inland consumption in 2009 amounted to approximately 1229 PJ. The consumption of solid fuels and oil products accounts for 84% of total consumption, while the contribution of biomass and of the rest renewable energy sources (mostly hydropower, solar and wind energy) are 2.1% and 3.1% respectively. Finally, the share of natural gas in gross inland consumption is 9.5% while the rest 1.3% of gross inland consumption is covered by electricity (net imports – exports). In 2009, gross inland consumption increased by approximately 38% compared to 1990, presenting a 1.8% average annual rate of increase. It should be mentioned that up to 1996 supply of natural gas was exclusively minor quantities from domestic primary production. In essence, the introduction of natural gas in the Greek energy system started in 1997 and since then its consumption has been continuously increasing. Furthermore, till 2007 a decrease in gross inland consumptin is observed.

[2] Emissions from off-road machinery should be reported under Stationary combustion according to the IPCC Guidelines

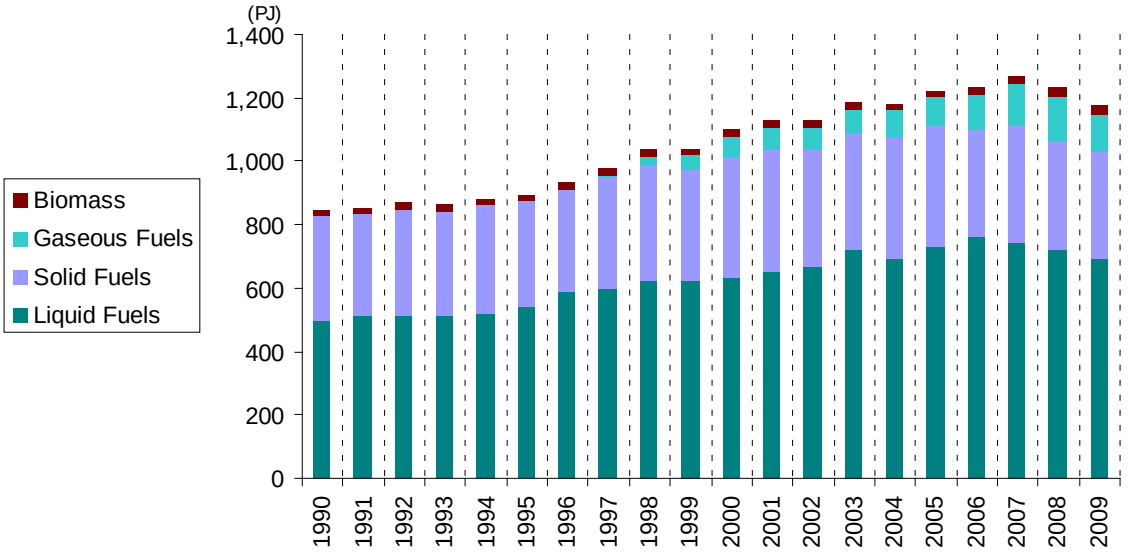


Figure 3.1 Gross inland consumption (in PJ) by energy type for the period 1990 - 2009

GHG emissions from *Energy* in 2009 increased by 29.9% compared to 1990 (***Figure 3.2***), while the average annual rate of increase for the period 1990 – 2009 was 1.4%. The highest increase on an annual basis (compared to the previous year) was recorded in 1997 (emissions increased by 5.9%), due to the significant increase in electricity demand as a result of particular weather conditions (very high summer temperatures).

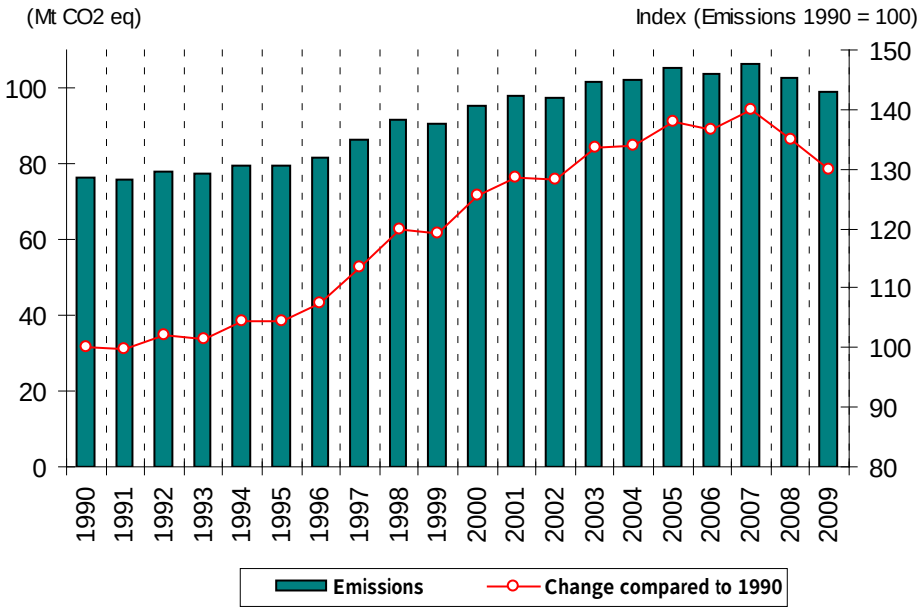


Figure 3.2 Total GHG emissions from Energy (in Mt CO2 eq) for the period 1990 – 2009

The evolution of GHG emissions from *Energy* can be distinguished into five periods that are related to economic development and the penetration of natural gas. At first (1990 – 1995) GHG emissions increased with an average annual rate of 0.9% while Gross Domestic Product (GDP)

increased with an annual rate of 1.7%. Then and up to 2000, GHG emissions increased with an annual rate of 3.8% which is higher that the rate of increased of GDP for the same period (3.4%). The average annual rate of emissions increase for the period 2000 – was 1.9% while GDP increased with higher rate (approximately 4%). For the period 2005-2008, a stabilization of the emission levels is observed, although the GDP increased with an annual rate of 3.3%. Finally, after 2008 a reduction of emission is observed by 3.7%, higher than the respective decrease of GDP (2.3%) due to economic recession.

Energy is mainly responsible for carbon dioxide emissions, while it contributes also to methane and nitrous oxide emissions. Emissions from energy per greenhouse gas are presented in ***Table 3.1***.

The majority of GHG emissions (54.6%) in 2009 derived from energy industries, while the contribution of transport, manufacturing industries and construction and other sectors is estimated at 25.6%, 7.4% and 10.9% respectively. The rest 1.5% of total GHG emissions from *Energy* derived from fugitive emissions from fuels.

Within the fuel combustion activities, the sector with the greatest increase of emissions since 1990 is transport, showing an average rate of increase of 3%, followed by Other sectors (i.e. residential, tertiary and agriculture sectors) with a 1.6% average annual rate of increase. Emissions from energy industries increased with an average annual rate of 1.4%, while emissions from manufacturing industries and construction emissions had a mean annual rate of decrease of 1%. Finally, fugitive emissions from fuels increased with an average annual rate of 1.4% for the period 1990 – 2009.

Table 3.1 GHG emissions from Energy by source category and gas for the period 1990 – 2009

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO2 emissions (in Mt)																				
A. Fuel Combustion																				
1. Energy Industries	42.99	41.85	44.13	44.03	46.01	44.77	43.95	47.47	50.08	50.26	54.63	55.15	54.58	55.82	57.14	57.97	55.79	59.25	57.62	54.62
2. Industry	9.57	9.47	8.83	8.53	8.45	9.22	9.77	9.97	10.03	8.98	9.72	9.89	9.44	9.13	8.49	10.17	10.38	10.10	9.26	7.41
3. Transport	14.49	15.22	15.62	15.83	16.14	16.50	16.98	17.75	19.51	19.93	19.06	19.87	20.09	21.24	21.62	21.71	22.57	23.37	22.38	25.32
4. Other Sectors	8.13	8.42	8.06	7.92	7.98	8.05	9.95	10.22	10.57	10.39	11.00	11.84	12.39	14.28	13.49	14.13	14.03	12.66	12.38	10.61
B. Fugitive Emissions from Fuels																				
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO
2. Oil and Natural Gas	0.07	0.07	0.06	0.05	0.05	0.04	0.04	0.04	0.03	0.00	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CH4 emissions (in kt)																				
A. Fuel Combustion																				
1. Energy Industries	0.60	0.61	0.62	0.63	0.64	0.65	0.65	0.67	0.70	0.71	0.79	0.78	0.78	0.80	0.80	0.83	0.84	0.90	0.89	0.79
2. Industry	0.43	0.43	0.43	0.42	0.40	0.42	0.44	0.45	0.44	0.42	0.48	0.47	0.48	0.41	0.42	0.49	0.46	0.45	0.49	0.42
3. Transport	4.52	4.55	4.49	4.55	4.53	4.56	4.58	4.64	4.79	4.89	5.00	5.12	5.06	5.02	5.05	4.81	4.72	4.51	4.22	3.95
4. Other Sectors	4.00	4.01	4.81	4.39	3.98	3.90	4.01	3.78	3.68	4.23	4.79	4.37	3.45	3.52	3.97	3.46	3.87	3.79	3.66	3.64
B. Fugitive Emissions from Fuels																				
1. Solid Fuels	52.16	52.96	55.33	55.09	56.96	57.95	60.08	59.14	61.19	62.36	64.21	66.68	70.82	68.64	70.39	69.74	64.84	66.80	67.80	68.80
2. Oil and Natural Gas	4.36	4.23	3.74	3.01	2.82	2.64	5.15	5.44	6.14	5.12	6.54	6.60	6.57	6.87	6.99	6.90	7.42	7.62	7.93	8.19
N2O emissions																				
A. Fuel Combustion (in kt)																				
1. Energy Industries	0.50	0.48	0.51	0.51	0.53	0.51	0.50	0.54	0.57	0.56	0.60	0.61	0.60	0.61	0.63	0.63	0.59	0.62	0.60	0.59
2. Industry	0.14	0.15	0.15	0.15	0.15	0.16	0.16	0.17	0.18	0.16	0.17	0.17	0.16	0.15	0.14	0.15	0.15	0.15	0.15	0.13
3. Transport	0.54	0.57	0.64	0.74	0.85	0.93	0.98	1.07	1.19	1.31	0.88	0.91	0.91	0.93	0.96	0.93	0.98	0.98	0.95	0.86
4. Other Sectors	1.23	1.27	1.21	1.17	1.17	1.10	1.13	1.12	1.12	1.13	1.15	1.16	1.24	1.35	1.18	1.19	1.24	1.12	1.08	0.78
B. Fugitive Emissions from Fuels (in t)																				
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	0.64	0.64	0.53	0.43	0.41	0.35	0.40	0.36	0.24	0.01	0.22	0.15	0.15	0.11	0.11	0.09	0.08	0.06	0.05	0.07

NA: Not Applicable, NO: Not Occurring

3.1.2 Methodology

The calculation of GHG emissions from fuel combustion activities is based on the IPCC Guidelines, the IPCC Good Practice Guidance and the CORINAIR methodology, while fugitive emissions from fuels are estimated according to the methodologies suggested by the IPCC Guidelines and the IPCC Good Practice Guidance.

The methodology applied for the calculation of emissions by source category for 2009 is briefly presented in ***Table 3.2***.

Table 3.2 Methodology for the estimation of emissions from energy

CRF	IPCC categories	CO_2		CH_4		N_2O	
1A	**Fuel combustion**	Method	Emission factor	Method	Emission factor	Method	Emission factor
1A1	**Energy industries**						
1A1a	Public electricity and heat production	T2	CS, PS	T2	D	T2	D
1A1b	Petroleum refining	T2	CS, PS	T2	D	T2	D
1A1c	Solid fuel manufacturing and other energy industries	T2	PS	T2	D	T2	D
1A2	**Manufacturing industries and Construction**	T2	CS, PS	T2	D	T2	D
1A3	**Transport**						
1A3a	Aviation	T2	D	T2	D	T2	D
1A3b	Road transport	T1	D	M, T1	D, M	M, T1	D, M
1A3c	Railways	T1	D	CR	CR	CR	CR
1A3d	Navigation	T1	D	T1, CR	D, CR	T1, CR	D, CR
1A3e	Pipeline transport	CR	D	CR	CR	CR	CR
1A4	**Other sectors**						
1A4a	Commercial / Institutional	T2	CS, D	T2	D	T2	D
1A4b	Residential	T2	CS, D	T2	D	T2	D
1A4c	Agriculture / Forestry / Fisheries	T2	D	T2	D	T2	D
1B	**Fugitive emissions from fuels**						
1B1	Solid fuels	IE, NO	NA	T1	D	NA	NA
1B2	Oil and Natural gas	T1	D	T1	D	T1	D
	International transport						
	Aviation	T2a	D	T2a	T2a	T2a	T2a
	Marine	T1	D	CR	CR	CR	CR

CR=Corinair. CS= Country specific emission factor. PS= Plant Specific. T2a = IPCC Tier 2a. T1= IPCC Tier 1. D = IPCC Default. M= Copert IV model

The energy data used for the calculation of emissions derived from the national energy balance compiled by the Ministry of Development and the reports of installations under the EU ETS. The Ministry of Transport and the Hellenic Statistical Authority are the main sources of information regarding road transport, while data on civil aviation come from the Civil Aviation Organization.

Key categories

The key categories identified in the energy sector are presented in ***Table 3.3*** (see Paragraph 1.5 for a complete presentation of the results of the key categories analysis and Annex I for the presentation of the relevant calculations). These sources are responsible for about 79% of total national GHG emissions in 2009 (without *LULUCF*).

Table 3.3 Key categories from Energy

IPCC source categories	Gas	Criteria
Energy Industries: Gaseous fuels	CO_2	L, T
Energy Industries: Solid fuels	CO_2	L
Energy Industries: Liquid fuels	CO_2	L
Manufacturing Industries & Construction: Liquid fuels	CO_2	L, T
Manufacturing Industries & Construction: Gaseous fuels	CO_2	L, T
Manufacturing Industries & Construction: Solid fuels	CO_2	T
Oher Sectors: Liquid fuels	CH_4	L, T
Oher Sectors: Gaseous fuels	CO_2	L, T
Oher Sectors: Liquid fuels	N_2O	T
Coal Mining (surface)	CO_2	L
Road Transportation	CO_2	L, T
Navigation	CO_2	L, T
Civil Aviation	CO_2	L, T

Uncertainty

The results of the uncertainty analysis undertaken for the Greek GHG emissions inventory are presented in Paragraph 1.7, while the detailed calculations are presented in Annex IV. In general, the uncertainty of emissions estimates for the energy sector is relatively small (***Table 1.9***). In ***Table IV.1 and IV.2*** the uncertainty of activity data and emission factors is illustrated.

3.1.3 Completeness

Table 3.4 gives an overview of the IPCC source categories included in this chapter and presents the status of emissions estimates from all sub-sources in the energy sector.

Table 3.4 Energy – Completeness of emissions inventory

ENERGY	Greenhouse gases						Other gases			
	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NOx	CO	NMVOC	SO_2
Energy industries										
Public electricity and heat production	☒	☒	☒				☒	☒	☒	☒
Petroleum refining	☒	☒	☒				☒	☒	☒	☒
Manufacturing of solid fuels and other energy industries	☒	☒	☒				☒	☒	☒	
Manufacturing industries and Construction										
Iron and steel	☒	☒	☒				☒	☒	☒	☒
Non ferrous metals	☒	☒	☒				☒	☒	☒	☒
Chemicals	☒	☒	☒				☒	☒	☒	☒
Paper. pulp and print	☒	☒	☒				☒	☒	☒	☒
Food processing. Beverages and Tobacco	☒	☒	☒				☒	☒	☒	☒
Other industries	☒	☒	☒				☒	☒	☒	☒
Transport										
Aviation	☒	☒	☒				☒	☒	☒	☒
Road transport	☒	☒	☒				☒	☒	☒	☒
Railways	☒	☒	☒				☒	☒	☒	☒
Navigation	☒	☒	☒				☒	☒	☒	☒
Pipeline transport	☒	☒	☒				☒	☒	☒	☒
Other sectors										
Commercial / Institutional	☒	☒	☒				☒	☒	☒	☒
Residential	☒	☒	☒				☒	☒	☒	☒
Agriculture / Forestry / Fisheries	☒	☒	☒				☒	☒	☒	☒
Fugitive emissions from fuels										
Solid fuels	IE/NO	☒	NA/NO				NA	NA	NA	
Oil	☒	☒	☒				☒	☒	☒	☒
Natural gas	☒	☒	☒						NE	NE
International transport [1)]										
Aviation	☒	☒	☒				☒	☒	☒	☒
Marine	☒	☒	☒				☒	☒	☒	☒

[1)] Emissions from international transport are not included in national totals

IE: Include Elsewhere

NE: Not Estimated

NA: Not Applicable

3.2 Fuel Combustion (CRF Source Category 1.A)

3.2.1 Comparison of the sectoral approach with the reference approach

According to the IPCC Guidelines, carbon dioxide emissions from the energy sector should be calculated using both the reference and the sectoral approach (see Sections 3.2 – 3.3). The reference approach (see **Annex III** for an analytical presentation of the methodology) is based on detailed data on primary energy consumption, which lead to the calculation of apparent consumption and to the consequent calculation of CO_2 emissions, while the sectoral approach is based on a detailed disaggregation of energy consumption by sector, fuel and technology for the calculation of CO_2 emissions.

The application of the reference approach can be considered as a quality control procedure, as the deviation of estimations should not be significant (deviations in the order of ±2%) or else explanations should be provided.

The estimation of carbon dioxide emissions according to the two methodologies is presented in ***Table 3.5***.

Table 3.5 ***CO_2 emissions (in kt) according to the reference and the sectoral approach for the period 1990 – 2009***

Year	Reference approach	Sectoral approach	Deviation %
1990	75850	75171	0.90
1991	76515	74958	2.08
1992	78214	76640	2.05
1993	78278	76303	2.59
1994	80604	78579	2.58
1995	81009	78541	3.14
1996	81989	80653	1.66
1997	86031	85406	0.73
1998	90365	90181	0.20
1999	89497	89562	-0.07
2000	94285	94407	-0.13
2001	97359	96757	0.62
2002	97451	96501	0.98
2003	100027	100482	-0.45
2004	100534	100745	-0.21
2005	103119	103983	-0.83
2006	99600	102771	-3.09
2007	101934	105377	-3.27
2008	100783	101636	-0.84
2009	98264	97963	0.31

As shown in the table above, the estimated deviation (which ranges from –3.3% to 3.11%) is within the threshold defined by the IPCC Guidelines, with the exception of the deviation estimated for the years 1993-1995 and 2006-2007. The existing differences result mainly from:

1. ***Statistical differences in fuel consumption***. The sectoral approach uses the actual consumption of the different fuels, while the reference approach uses their apparent consumption. Theoretically, both consumption estimates should be equal, but there is usually a difference between them (statistical differences) due to the collection of information from different sources. The reference approach does not provide for the calculation of these differences. The deviation in the calculation of the consumption of liquid fuels (***Table 3.6***) is mainly attributed to the statistical differences.
2. ***Losses from transformation, transport and distribution***. During the refining of crude oil and the transmission/distribution of natural gas losses may occur, due to possible leaks in the refining systems, the transmission/distribution pipelines etc. These losses are not taken into account in the reference approach.
3. ***Emission factors***. In the reference approach, CO_2 emissions from liquid fuel consumption are mainly estimated assuming "combustion" of crude oil. On the contrary, the sectoral approach calculates emissions using the actual consumption per liquid fuel and appropriate emission factors. Additionally, the emission factor as well as the calorific value of solid fuels (lignite) is differentiated by sector, resulting in deviations in the calculated energy consumption (Table 3.6).
4. ***Reallocation to the industrial processes sector.*** Emissions like the ones from solid fuel consumption in the ferroalloys industries have been reallocated to the industrial processes sector. However, the respective quantities of fuels that are allocated to the IP sector are accounted by the reference approach.

Finally, the 2010 September ERT recommendations about the reference approach were taken into account and the following recalculations were carried out:

- ✓ Reallocation of gas work gas to the secondary solid fuels
- ✓ Fuels that are reported in Industrial Processes sector were properly reported in CRF table 1.A(d)
- ✓ Fuels for international aviation were properly reported in CRF tables 1.A(b) and 1.C.

Table 3.6 ***Deviations during the calculation of energy consumption (apparent and actual) for the period 1990 – 2009 (%)***

Year	Liquid fuels	Solid fuels	Gaseous fuels
1990	-0.61	-1.53	0.00
1991	1.59	-1.28	-0.63
1992	2.89	0.95	-0.84
1993	1.16	0.86	-0.88
1994	3.03	0.96	-0.09
1995	-0.82	3.59	0.00
1996	-1.01	0.85	0.00
1997	-2.22	0.63	0.83
1998	-2.88	0.62	0.13
1999	-2.59	0.38	0.07
2000	-2.73	-1.17	0.78
2001	-1.85	-0.40	1.42
2002	-1.19	-0.19	-0.21
2003	-5.17	-1.36	-0.25
2004	-2.66	-1.76	-0.28
2005	-3.53	-1.01	-0.05
2006	-2.85	-1.09	0.10
2007	-2.48	-0.05	-0.81
2008	-1.59	-0.50	-2.41
2009	-0.82	0.59	1.24

3.2.2 International bunker fuels

GHG emissions from international aviation and marine bunkers are calculated with the same methodologies as described for internal aviation and navigation. The allocation of fuel consumption between domestic and international transportation is based on the data of the national energy balance, as declared by oil trading companies. Finally, the allocation of LTOs between domestic and international aviation is based on data provided by the Civil Aviation Organisation (***Table 3.7***).

GHG emissions from international bunkers (***Table 3.8a,b***) increased by about 4% since 1990. The 2009 decrease in both international aviation and marine bunkers is associated with the economic crisis.

An update of activity data was taken into account for years 2005, 2006, 2007 and 2008, and the updated emissions data are now properly inserted into the relevant ***Table 3.8.b***. Additionally, as for marine bunkers emissions, methane emissions were recalculated with the use of the same emission factor. Finally, methane and nitrous oxide emissions from lubricants were also included

Table 3.7 Allocation of LTOs to domestic and international aviation for the period 1990-2009

Year	Domestic	International
1990	121070	123606
1991	105306	118074
1992	115898	143206
1993	127499	149398
1994	127565	160974
1995	135252	157113
1996	145115	153990
1997	164879	167612
1998	167701	175713
1999	200527	196097
2000	222962	204347
2001	199529	196663
2002	171441	188841
2003	195948	199825
2004	212216	207635
2005	200672	202491
2006	211854	217565
2007	222848	232351
2008	214364	226550
2009	240214	217570

Table 3.8(a) GHG emissions in the transportation sector per category. for the period 1990 – 1999

Memo items 1) – International bunkers Emissions (kt CO_2 eq)										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
International aviation	2474	2134	2227	2370	2812	2637	2526	2444	2565	2880
International marine	8097	7432	8537	9954	10561	11353	9988	10013	11155	9923

1) Emissions from international transport are not included in national emissions

Table 3.8(b) GHG emissions in the transportation sector per category. for the period 2000 – 2009

Memo items 1) – International bunkers Emissions (kt CO_2 eq)										
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
International aviation	2527	2349	2349	3056	3142	2409	2890	2953	3071	2641
International marine	11457	11125	9978	10215	10308	9157	9884	10097	9852	8365

1) Emissions from international transport are not included in national emissions

3.2.3 Feedstocks and non-energy use of fuels

Non-energy fuel use concerns the consumption of fuels as raw materials (e.g. in chemical industry, metal production) for the production of other products, or the use of fuels for non-energy purposes (e.g. bitumen). Part of the carbon content of fuels is stored in final products and is not oxidized into carbon dioxide for a certain time period. The fraction of the carbon contained in final products and the time period for which carbon is stored in them, depend on the type of fuel used and of the products produced.

The oxidation of the carbon stored in final products occurs either during the use of the product (e.g. solvents) or during their decomposition (e.g. through combustion). It should be noted that emissions during production processes (e.g. ammonia production) should be reported under the sector of industrial processes (as it was implemented in this submission for the first time), while emissions from burning of products should be reported under the waste sector or energy sector (as long as energy exploitation takes place).

Non-energy use of fuels in Greece refers to the consumption of:

- naphtha, natural gas, and lignite (for the period 1990 – 1991) in chemical industry,
- petroleum coke in the production of non-ferrous metals,
- lubricants in transport (including off-road transportation),
- bitumen in construction and
- other petroleum products in the industrial and residential sectors

The calculation of carbon dioxide emissions from non-energy use of fuels is based on the relevant consumption by fuel type (***Table 3.9***) and the fraction of the carbon stored by fuel type (***Table 3.10***), according to the following equation:

$$E = \sum_f FC_f \cdot CC_f \cdot (1 - CS_f)$$

where, E represents carbon emissions, f is the index of fuel type, FC_f is non-energy consumption of fuel f, CC_f is the carbon content of fuel f and CS_f is the fraction of carbon stored from the non-energy use of fuel f.

Data on the non-energy consumption of fuels derive from the national energy balance. However, plant specific data derived from verified ETS reports and information provided by specific greek industries resulted to the improvement of reallocation of non-energy use fuels from the energy to the industrial processes sector:

- The non-energy use of natural gas for ammonia production has been reallocated in industrial processes sector, by using data from ETS reports and plant specific information. Non-energy use of lignite is accounted in Energy sector and refers only to ammonia production (in one installation for 1990 and 1991) and as a result the fraction of carbon stored is equal to 0. The operation of this installation ended at 1998 while it did not produce ammonia for the period 1992 – 1998.

- No data regarding non-energy use in the iron and steel industry are reported in the national energy balance and, as a result, CO_2 emissions from the use of fuels as reduction agents, are only reported under the industrial processes sector.
- Solid fuels consumption in the ferroalloys production industry is included (in the national energy balance) in the solid fuels consumption of the non-ferrous metals sector. However, by using data from ETS reports and plant specific information, emissions from solid fuels for ferroalloys production are reallocated to the industrial processes sector, as from 2010 submission.
- The non-energy use of petroleum coke (see Table 3.9) refers exclusively to the primary aluminium production. Given that the relevant emissions are reported under the industrial processes sector, petroleum coke consumption is not taken into account in the energy sector.

On the basis of the above-mentioned clarifications, the possibility to double-count or underestimate CO_2 emissions from the non-energy use of fuels is minor.

Table 3.9 Non-energy fuel use (in PJ) for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Naphtha	2.66	3.15	2.34	2.34	1.49	3.20	3.92	2.21	0.63	1.04	2.12	1.71	0.90	2.66	4.55	3.69	6.03	3.28	1.33	3.12
Lubricants	5.31	3.46	3.50	3.42	3.46	2.97	2.69	3.22	2.09	2.57	2.25	3.18	2.17	2.57	2.81	3.22	1.52	1.07	1.48	1.43
Bitumen	8.20	8.96	9.44	10.01	10.17	12.02	12.18	12.34	13.87	14.23	16.32	16.64	17.32	14.79	16.64	11.09	14.55	12.18	18.85	14.95
Natural gas	4.05	3.87	3.68	2.37	NO	NO	NO	1.51	6.37	6.26	5.01	2.45	2.99	5.17	5.50	5.36	5.67	5.74	7.94	8.16
Lignite	3.24	3.15	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other petroleum products[3]	2.49	0.52	1.33	0.68	1.29	1.04	0.92	0.92	1.25	0.40	2.93	3.74	4.74	7.52	5.83	6.83	5.51	4.62	4.42	5.51
Paraffin waxes	2.66	3.15	2.34	2.34	1.49	3.20	3.92	2.21	0.63	1.04	2.12	1.71	0.90	2.66	4.55	3.69	6.03	3.28	1.33	3.12
Other oil products	5.31	3.46	3.50	3.42	3.46	2.97	2.69	3.22	2.09	2.57	2.25	3.18	2.17	2.57	2.81	3.22	1.52	1.07	1.48	1.43

Table 3.10 Carbon stored (%) by fuel

	Naphtha	Lubricants	Bitumen	Natural gas	Lignite	Petroleum coke	Paraffin waxes	Other oil products
Carbon stored	75%	50%	100%	0%	0%	NA	50%	50%

NA: Not Applicable

Carbon dioxide emissions from non-energy fuel use, as well as the amount of carbon stored in the final products are presented in ***Table 3.11***. Carbon dioxide emissions in 2009 increased by 72% compared to 1990 levels.

[3] Petroleum coke, paraffin waxes and other oil products

Table 3.11 ***CO_2 emissions (in kt) from non-energy use and total amount of carbon stored (in kt) for the period 1990 - 2009***

Year	Carbon stored (kt)	CO_2 emissions (kt)
1990	347.31	334.57
1991	328.91	203.65
1992	331.77	219.75
1993	314.63	193.22
1994	273.07	201.12
1995	328.46	205.95
1996	338.46	204.42
1997	321.24	192.22
1998	368.52	307.38
1999	407.26	188.88
2000	485.17	228.88
2001	464.58	284.82
2002	471.60	279.72
2003	510.80	432.78
2004	566.32	415.23
2005	439.45	432.86
2006	524.34	363.28
2007	423.77	260.17
2008	511.67	424.39
2009	466.26	576.71

3.2.4 Stationary combustion (CRF Source Category 1.A except 1.A.3)

3.2.4.1 Source category description

As it was already mentioned, stationary combustion includes energy industries, manufacturing industries and construction and the other sectors (agriculture, residential and commercial/ institutional sectors).

The consumption of fossil fuels in these sectors accounts for 69% - 75% of total fossil fuel consumption in Greece for the period 1990 – 2009 (***Figure 3.3***).

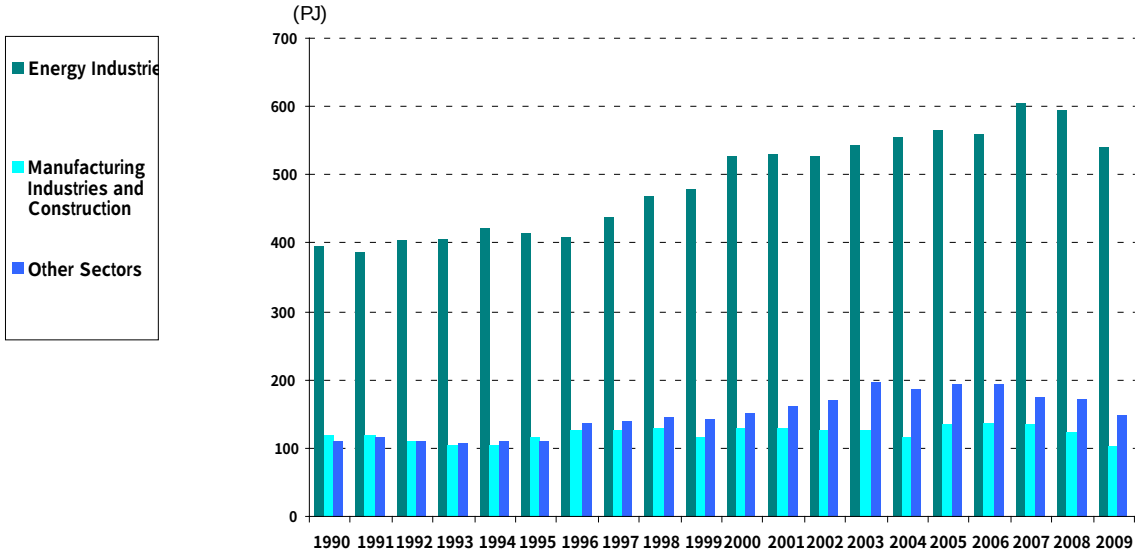


Figure 3.3 ***Consumption of fossil fuels (in PJ) in stationary combustion for the period 1990 – 2009***

The consumption of fossil fuels in 2009 increased by approximately 27% compared to 1990, with an average annual rate of increase of 1.4% for the period 1990 – 2009. In 2008 and 2009 the consumption of fossil fuels had a decreasing trend with annul rates of -2.7% and -10.9%, respectively.

- Fuel consumption in energy industries accounts for 64% (average value for the period 1990 – 2009) of fuel consumption in stationary combustion. The average annual rate of increase for the period 1990 – 2008 is estimated at 1.8%, resulting in an increase of 37% in 2009 compared to 1990 levels. It is noted, however, that this increase took place mostly after 1996, due to the significant increase of electricity consumption attributed to the improvement of living standards and weather conditions. In 2008 and 2009 the fuel consumption in energy industries had a decreasing trend with annul rates of -2% and -9%, respectively.

- The consumption of fossil fuels in industry presented significant variations on an annual basis that are related to the trend of the industrial production in Greece. Overall, fuel consumption in 2009 decreased by 13.5% compared to 1990 levels.
- Fossil fuels consumption in Other sectors increased by 34% from 1990 to 2009.

GHG emissions from stationary combustion follow the trend of fossil fuels consumption, presenting however a lower annual rate of increase. Therefore, GHG emissions in 2009 (73.2 Mt CO_2 eq) increased by 19.3% compared to 1990 (61.4 Mt CO_2 eq), with an average annual rate of increase estimated at 1% for the period 1990 – 2009 (***Figure 3.4***). The last 2 years, a decreasing trend of emissions is observed with annual rates of -3.4% and -8.4% for years 2008 and 2009, respectively. This decreasing trend is attributed to the penetration of natural gas and RES technologies to the energy mix, but also, especially for the year 2009, to the economic recession that the country is facing.

It is noted that emissions from stationary combustion account for around 60% of total national emissions (without *LULUCF*) for the period 1990 – 2009, while **nine key categories** are included in this sector (**CO_2 emissions from solid, liquid and gaseous fuels combustion of Energy industries and Manufacturing industries, CO_2 emissions from liquid and gaseous fuels combustion from Other sectors, and N_2O emissions from liquid fuels combustion from Other sectors**).

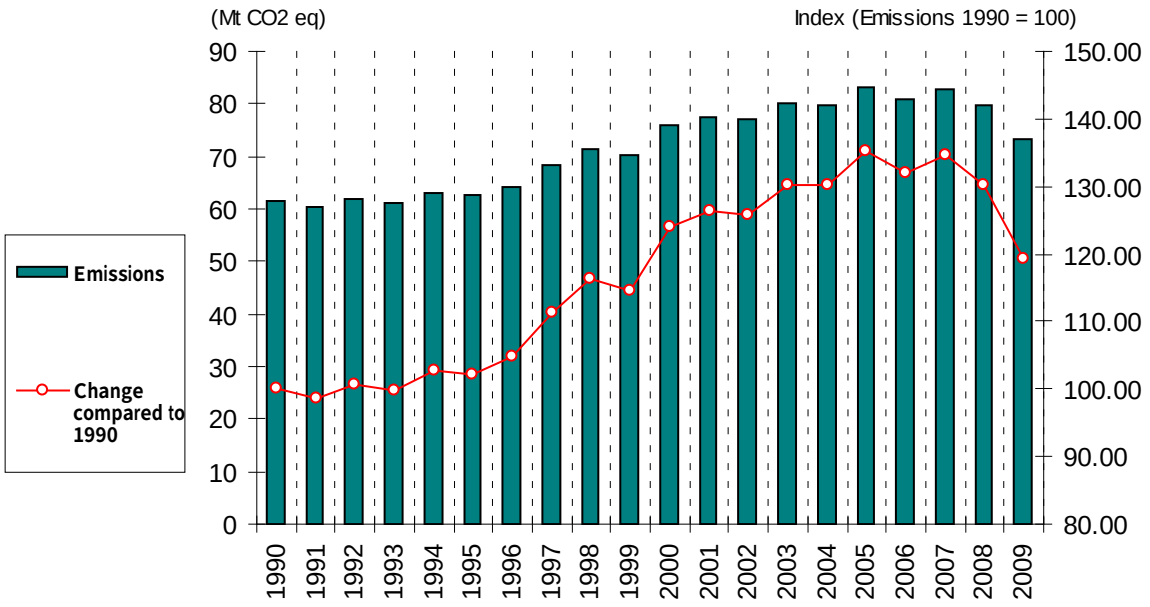


Figure 3.4 ***GHG emissions (in Mt CO_2 eq) from stationary combustion for the period 1990 – 2009***

Emissions from stationary combustion per gas and source category are presented in ***Table 3.12***.

Carbon dioxide represents the major GHG from stationary combustion with a share in total emissions from stationary combustion being 99.2% in 2009. Overall, CO_2 emissions in 2009 increased by 19.7% compared to 1990 levels with an average annual rate of increase estimated at 1%. N_2O emissions in 2009 account for 0.6% of emissions from stationary combustion, decreasing with an average annual rate of 1% during the period 1990 – 2009. CH_4 emissions account for the rest 0.2% of total emissions of the sector and decreased by 3.5% from 1990 to 2009. The annual rate of decrease of CO2 emissions in 2009 were 8.4%, mainly due to economic recession.

Table 3.12 GHG emissions per gas and source category from stationary combustion for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GHG emissions per gas																				
CO_2 (in Mt)	60.68	59.74	61.02	60.48	62.44	62.04	63.67	67.66	70.67	69.63	75.35	76.89	76.41	79.24	79.12	82.27	80.20	82.01	79.26	72.64
CH_4 (in kt)	5.03	5.05	5.86	5.43	5.02	4.97	5.10	4.91	4.82	5.36	6.05	5.62	4.70	4.74	5.18	4.78	5.17	5.14	5.04	4.85
N_2O (in kt)	1.87	1.90	1.87	1.83	1.85	1.77	1.79	1.84	1.87	1.86	1.93	1.94	2.00	2.11	1.95	1.97	1.99	1.89	1.83	1.50
GHG emissions per source category (in Mt CO_2 eq)																				
Energy industries	43.16	42.01	44.30	44.20	46.18	44.94	44.12	47.65	50.27	50.45	54.83	55.36	54.78	56.03	57.36	58.19	55.99	59.46	57.82	54.82
Industry	9.62	9.52	8.88	8.58	8.51	9.27	9.83	10.04	10.09	9.04	9.78	9.96	9.50	9.19	8.54	10.23	10.44	10.16	9.31	7.46
Other sectors	8.59	8.90	8.54	8.37	8.42	8.47	10.39	10.64	10.99	10.83	11.46	12.30	12.84	14.78	13.94	14.57	14.49	13.08	12.80	10.93
TOTAL (Mt CO_2 eq)	61.37	60.43	61.72	61.16	63.12	62.69	64.33	68.33	71.35	70.32	76.07	77.61	77.13	80.00	79.84	82.98	80.92	82.71	79.93	73.21

Energy industries constitute the major contributor (75% in 2009) in the overall GHG emissions from stationary combustion, followed by manufacturing industry and construction from 1990 to 1995 and by other sectors since 1996. Emissions from other sectors increase with a mean annual rate of 1.6% for the period 1990 – 2009. However, they have a decreasing trend the last years, which is attributed to the increasing share of natural gas in other sectors fuel mix and the economic recession (for 2009).

3.2.4.2 Methodological issues

The calculation of GHG emissions from stationary combustion was based on the Revised 1996 IPCC Guidelines and the IPCC Good Practice Guidance. CH_4 and N_2O emission factors are differentiated by technology and fuel, while CO_2 emission factors are differentiated only by fuel. The determination of emission factors was based on data derived from verified ETS reports and IPCC guidelines, as described in this paragraph.

CO_2 emissions from stationary combustion are estimated on the basis of fuel consumption and fuel characteristics, according to the following equation:

$$E_{CO_2} = \sum_f FC_f \cdot NCV_f \cdot CC_f \cdot OX_f \cdot 44/12$$

where, E_{CO2} is CO_2 emissions, *f* is an index referring to the fuel consumed, FC_f is the consumption of fuel-*f*, CC_f is the carbon content of fuel-*f*, NCV_f is the net calorific value of fuel-*f* and OX_f is the oxidation factor of fuel-*f*.

The national energy balance and the verified ETS reports are the main sources of information regarding fuel consumption by sector and activity (see Annex II). The basic characteristics of fuels used in the Greek energy system and the estimated CO_2 emission factors are presented in ***Table 3.13***.

Concerning the data presented in the Table 3.13, the following should be mentioned

- The IPCC Guidelines constitute the main source of information regarding carbon content, fraction of carbon oxidised and therefore the calculated EF by fuel type (IPCC 1997, Tables 1-1 and 1-6). However, as indicated in Table 3.13 for the cases of lignite, LPG used in refineries, petcoke, steamcoal, lignite, domestic and imported natural gas plant and/or country specific data have been processed for the calculation of the respective EFs.
- Information on the net calorific value (NCV) per fuel is mainly provided by the national energy balance, compiled by the Ministry for Development (Energy Policy Division). This information is also submitted by the Ministry annually to both the IEA and the EUROSTAT. For the fuels refinary gas, petcoke, steam coal and lignite NCV values were obtained from plant specific data, as indicated in Table 3.13. Diesel's NCV was obtained from greek refineries' statistics.
- The carbon content of domestic natural gas derives from data of the company involved on the exploitation of domestic crude oil and natural gas fields. The carbon content of the domestic

natural gas is higher than the one of the imported natural gas and as a result the corresponding CO_2 emission factor is higher.

Table 3.13 Carbon dioxide emission factors (in t CO_2 / TJ), net calorific value (in TJ / kt) and other parameters by fuel type (2009)

Fuel type	Net calorific value (TJ/kt)	Carbon content. CC (tC/TJ)	Oxidation factor. OF (%)	EF (tCO_2/TJ)
Liquid fuels				
Refinery gas	49.20[4]	15.42	99.0	55.99
LPG	47.31	17.2	99.0	62.44[5] , 62.57[6]
Gasoline	44.80	18.9	99.0	68.61
Jet fuels	44.60	19.5	99.0	70.79
Kerosene	44.75	19.6	99.0	71.15
Diesel oil	43.00	20.2	99.0	73.33
Heavy fuel oil	40.19	21.1	99.0	76.59
Naphtha	45.01	20.0	99.0	72.60, 64.43[7]
Petroleum coke	32.25[8], 32.02[9]	27.5[8] , 25.83[9]	99.0	99.83[8], 93.75[9]
Other oil products	40.19	20.0	99.0	72.60
Solid fuels				
Steam coal	26.23[10]	26.33	98.0	94.63[10]
Lignite				
Electricity generation	5.141	34.17	98.0	122.79
Other sectors	7.435	27.6	98.0	99.18
Oven and gas coke	29.31	29.5	98.0	106.00
BKB / Patent fuel	14.20	25.8	98.0	92.71
Gaseous fuels				
Natural gas – Domestic		16.04 - 16.30[11]	99.5	57.07[12]
Natural gas – Imports		15.14[13] , 15.08[14]	99.5	55.24[13], 55.00[14]
Gas works gas		15.3	99.5	55.82

[4] Mean value. It depends on refineries' feedstock characteristics and processes applied. It is derived from PS data contained in the verified EU ETS emission reports of refineries.
[5] For use in sectors other than refineries.
[6] Only for petroleum refining category. It comprises emissions from LPG used as feedstock for hydrogen production. It is derived from PS data contained in the verified EU ETS emission reports of refineries.
[7] Only for petroleum refining category – naptha used as feedstock for hydrogen production.
[8] Mean value. Petcoke consumed in refineries. It is derived from PS data contained in the verified EU ETS emission reports of refineries.
[9] Mean value. Petcoke consumed in manufacturing industries (i.e. cement, lime and ceramics plants). It is derived from PS data contained in the verified EU ETS emission reports.
[10] Derived from PS data of verified EU ETS emission reports.
[11] Depends on the reservoir that the gas is extracted.
[12] The emission factor was calculated to comprise emissions from a)the combustion of domestic gas from two different reservoirs, b)the combustion of gas by the company that extracts the domestic natural gas which derived from the Public Gas Corporation distribution network (imported gas) and c)the processing of sour gas.
[13] Mean value based on chemical composition data of NG provided by DESFA (Hellenic Gas Transmission System Operator S.A.).
[14] Mean value for electricity production based on PS data derived from verified EU ETS emission reports.

- Calorific values for gas works gas (in use until 1997) and natural gas do not appear in the table above, because the relative consumption in the energy balance is given directly in energy units (TJ).
- Domestic natural gas is produced from two reservoirs:
  1. the South Kavala reservoir, which has a NCV of 11305 kcal/Nm^3 and a carbon content of 16.04 tC/TJ.
  2. the Prinos reservoir, which has a NCV of 12195 kcal/Nm^3 and a carbon content of 16.30 tC/TJ.
- The calorific value of lignite is differentiated annually, as it is related to the characteristics of mining fields, and therefore it is presented separately in ***Table 3.14***.

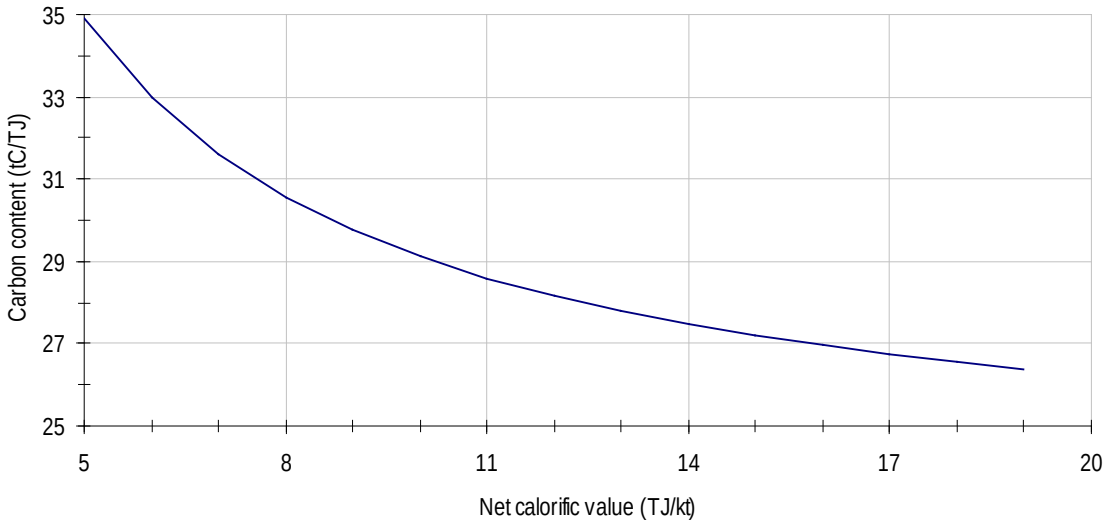
Table 3.14 Net calorific value of lignite by sector (in TJ / kt) for the period 1990 - 2009

Year	Electricity generation	Industry	Other sectors
1990	5.711	8.399	5.740
1991	5.447	8.323	5.481
1992	5.225	9.504	5.288
1993	5.355	11.074	5.443
1994	5.355	11.317	5.418
1995	5.179	11.300	5.451
1996	4.915	11.204	5.037
1997	5.384	11.300	5.485
1998	5.506	11.380	5.589
1999	5.366	11.110	5.421
2000	5.346	10.902	5.388
2001	5.296	10.006	5.296
2002	5.087	8.620	5.296
2003	5.043	10.886	5.002
2004	5.182	9.807	5.109
2005	5.240	10.471	5.200
2006	5.240	10.471	5.280
2007	5.297	10.235	5.297
2008	5.179	8.025	5.179
2009	5.141	7.435	5.275

- The carbon content in lignite used for electricity production is based on studies of the Public Power Corporation (PPC 1993). The value of 34.17 t C / TJ lies out of the range suggested by the IPCC Guidelines and the IPCC Good Practice Guidance. However, given that the net calorific value of the Greek lignite is one of lowest (see Papanicolaou et al., 2004 for an overview of the properties of the Greek lignites) a high value for the carbon content is expected. Moreover, according to international literature (Fott, 1999) the suggested value by

IPCC corresponds to a net calorific value of 13 TJ / kt that is not representative of national circumstances (see Table 3.14).

- The NCV and EF used for Electricity generation are mean values of lignite that is mined from various mining fields, located in 5 different locations in Greece (scattered both to north and south Greece). The lignite used in Industry originates from a single mining field. The quality of lignite from this mining field is superior than the others used for Electricity generation. For that reason both NCV and EF used in Industry are greater than the ones used for Electricity production.
- Based on chemical composition data of natural gas provided by DESFA (Hellenic Gas Transmission System Operator S.A.) a country specific CO2 EF of NG per year was calculated. Especially for the public electricity and heat sector and for the years 2005-2009, a CO2 EF of NG, based on plant specific data (ETS reports), was also calculated (plant specific EF).



Source: Fott. P.. (1999). Environmental Science & Policy. 2

Figure 3.5 The relationship between the net calorific value and the carbon content of lignite

For the estimation of CH_4 and N_2O emissions (as well as of other gases) from stationary combustion a Tier 2 methodology with IPCC defaults emission factors was applied. For the application of the tier 2 methodology, the disaggregation of energy consumption into different activities / technologies is required. CH_4 and N_2O emissions are estimated on the basis of the following equation:

$$E_g = \sum_{f,t} FC_{f,t} \cdot NCV_f \cdot EF_{g,f,t}$$

where, g is an index referring to a greenhouse gas, E_g is emissions of gas-g, f is an index referring to the fuel consumed, t is an index referring to an activity / technology, $FC_{f,t}$ is the consumption of fuel-f in activity-t, NCV_f is the net calorific value of fuel-f and $EF_{g,f,t}$ is the emission factor for gas-g in activity-t using fuel-f.

ETS data of years 2005-2009 were used for the disaggregation of energy consumption into different activities / technologies. Average emission factors per fuel and source category / activity were estimated by combining ETS data and IPCC default emission factors per technology / activity and fuel. Emissions were calculated by multiplying the fuel consumption obtained from national energy balance per activity by the average emission factors of the respective source activity and fuel, which has been estimated as above-mentioned.

Further analysis of fuel consumption by technology is presented hereafter.

3.2.4.3 Energy industries (CRF Source Category 1A1)

3.2.4.3.1 Source category description and methodological issues

Public electricity and heat production (CRF Source Category 1.A.1.a)

Electricity production in Greece increases continuously at average annual rate of 3.4% for the period 1990 - 2009. Gross electricity production in 2008 (63.7 TWh) was approximately 82% higher compared to 1990 levels (***Figure 3.6***).

Electricity generation relies mostly on the use of fossil fuels (approximately 85% of electricity production in 2009). Specifically, 55.7% of electricity is produced by solid fuels (mainly lignite), while the share of liquid fuels (diesel, heavy fuel oil and refinery gas) and natural gas is 12.5% and 18.0% respectively. The rest of electricity production derives from hydropower, wind energy and biogas.

The calculation of GHG emissions from this sector was performed as described in section 3.2.4.2. The allocation of energy consumption by technology was made on the basis of Public Power Corporation (PPC) verified ETS reports on the installed capacity and the characteristics of electricity production plants. Therefore:

- Electricity production from lignite is produced exclusively by steam turbines.
- Natural gas is used mainly in combined cycle units and secondarily in gas turbines.
- Heavy fuel oil is used in gas turbines and in internal combustion engines (only in the islands' electricity systems).
- Diesel is used in gas turbines and in internal combustion engines in the islands' electricity systems.

It is noted that emissions from industrial CHP plants are not included in electricity and heat production, but are allocated to the relative industrial sectors (as suggested by the IPCC Guidelines). Additionally, energy consumption for off-road transportation is not considered.

GHG emissions from electricity and heat production for the period 1990 – 2009 are presented in ***Table 3.15***.

GHG emissions from electricity generation in 2009 increased by 24.5% compared to 1990 levels at an average annual rate of 1.2% for the period 1990 – 2009. This increase is attributed to the high increase of electricity demand in Greece as well as to the structural characteristics of the Greek electricity generation system. It should be mentioned that the availability of hydroelectric plants has a significant effect to emissions trends. For instance, the significant increase of electricity demand in 1999 (by 3.3% compared to 1998) was not followed by a similar increase of emissions (1.3%) because of the penetration of natural gas and the high availability of hydroelectric plants. On the contrary, electricity generation from hydroelectric plants in 2000 decreased by 14% compared to 1999, while energy demand increased by 6.2% and as a result fossil fuels consumption and GHG emissions increased accordingly.

CO_2 emissions in 2009 accounted for 99.64% of total emissions from public electricity and heat production, while emissions from solid fuels consumption accounted for 81.5% of total emissions in 2009. However, due to the penetration of natural gas and RES technologies, total emissions per electricity produced by fossil fuels has a decreasing trend.

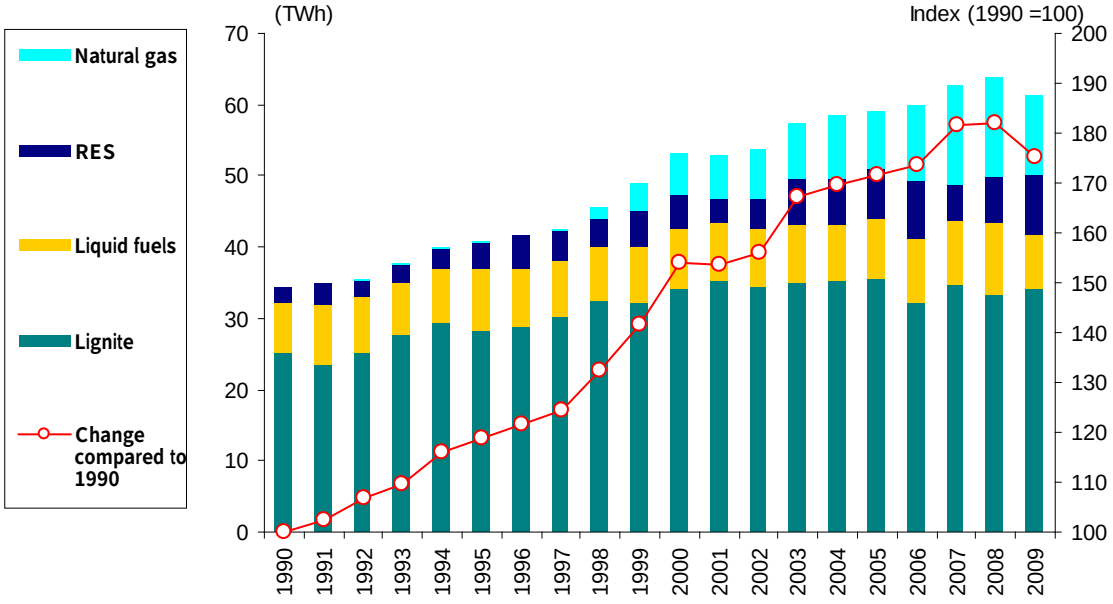


Figure 3.6 Electricity production (in TWh) by energy type for the period 1990 – 2009

Petroleum refining (CRF sector 1.A.1.b)

The inventory for the sector of petroleum refining includes emissions from the production of heat, steam and/or electricity in furnaces, gas turbines and internal combustion engines within the

refineries as well as emissions from thermal cracking of heavy hydrocarbons. Additionally, emissions from fluid catalytic cracking/CO boiler, flaring and production of chemicals, such as hydrogen, are also included.

GHG emissions from refineries (***Table 3.16***) are calculated on the basis of fuel consumption (liquid and gaseous fuels only) which is obtained from the national energy balance and plant specific data derived from verified ETS reports and the estimated emission factors described previously. It is noted that only CO_2 and N_2O emissions from catalytic cracking are included in this sub-source category, while CH_4 emissions are supposed to be included in Fugitive emissions from fuels.

The total increase of GHG emissions from refineries in 2009, compared to 1990 levels, is estimated at 72%, with an average annual rate of increase estimated at 3.2% for the period 1990 – 2009. This increasing trend is a result of the requirements for the production of sulphur-free fuels (sulphur content less than 10 ppm) set by the EU Directive 2003/17/EC.

Table 3.15 GHG emissions from public electricity and heat production per gas and fuel type and total emissions for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 emissions (in Mt)																				
Liquid fuels	5.37	5.80	5.71	5.85	5.73	6.19	6.10	5.91	5.74	5.95	6.37	5.92	5.82	6.38	5.70	6.27	6.42	6.57	6.95	5.33
Solid fuels	35.21	33.59	36.04	35.83	37.74	36.02	35.05	38.51	40.47	39.73	42.21	43.17	42.40	42.89	44.43	44.40	40.73	42.57	40.60	41.18
Gaseous fuels	NO	NO	NO	NO	NO	NO	NO	0.10	0.78	1.96	2.87	2.84	3.03	3.37	3.66	3.55	4.24	5.66	5.72	4.04
CH_4 emissions (in kt)																				
Liquid fuels	0.21	0.23	0.23	0.23	0.23	0.24	0.24	0.23	0.23	0.23	0.25	0.23	0.23	0.25	0.23	0.25	0.25	0.26	0.27	0.21
Solid fuels	0.29	0.28	0.30	0.29	0.31	0.30	0.29	0.32	0.33	0.33	0.35	0.35	0.35	0.35	0.36	0.36	0.33	0.35	0.33	0.34
Gaseous fuels	NO	NO	NO	NO	NO	NO	NO	0.00	0.01	0.04	0.05	0.05	0.06	0.06	0.07	0.06	0.08	0.10	0.10	0.07
N_2O emissions (in kt)																				
Liquid fuels	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04
Solid fuels	0.43	0.41	0.44	0.44	0.46	0.44	0.43	0.47	0.50	0.49	0.52	0.53	0.52	0.53	0.55	0.55	0.50	0.52	0.50	0.50
Gaseous fuels	NO	NO	NO	NO	NO	NO	NO	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
TOTAL (Mt CO_2 eq)	40.74	39.54	41.92	41.84	43.64	42.38	41.31	44.70	47.18	47.81	51.64	52.13	51.44	52.84	53.99	54.43	51.57	55.00	53.46	50.74

NO: Not Occurring. The use of natural gas for electricity generation started in 1997.

Table 3.16 GHG emissions from petroleum refineries for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 (kt)	2308	2350	2283	2262	2433	2459	2694	2827	2995	2619	3072	3117	3232	3090	3240	3654	4309	4355	4257	3979
CH_4 (kt)	0.10	0.10	0.10	0.10	0.11	0.11	0.12	0.12	0.12	0.11	0.13	0.14	0.14	0.14	0.14	0.15	0.18	0.18	0.17	0.16
N_2O (kt)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.03
TOTAL (kt CO_2 eq)	2317	2359	2292	2270	2442	2468	2704	2837	3005	2628	3084	3128	3244	3101	3252	3666	4323	4371	4271	3993

Other energy industries (CRF Source Category 1.A.1.c)

The inventory for the other energy industries includes GHG emissions from the combustion of natural gas during oil and gas extraction.

Data collected during the formulation of the NAP for the period 2005 – 2007 and verified ETS reports (for years 2005 - 2009) were used in this inventory. GHG emissions (***Table 3.17***) are calculated on the basis of the consumption of natural gas and the emission factors as described previously. To be stated that the CO2 EF of natural gas was estimated to comprise emissions from the processing of sour gas, based on data derived from verified ETS reports.

GHG emissions from the other energy industries in 2009 decreased by approximately 16% compared to 1990. The annual variation of emissions is related to the changes of the primary production of crude oil and natural gas.

Table 3.17 GHG emissions (in kt CO_2 eq) from other energy industries for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Emissions (in kt CO_2 eq)																				
CO_2	102.03	108.48	94.15	89.50	103.14	98.59	103.88	110.38	83.63	6.19	104.04	98.86	104.30	90.29	108.96	90.71	96.50	93.08	88.87	85.97
CH_4	0.04	0.04	0.03	0.03	0.04	0.04	0.04	0.04	0.03	0.00	0.04	0.04	0.04	0.03	0.04	0.03	0.03	0.03	0.03	0.03
N_2O	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.04	0.00	0.05	0.05	0.06	0.05	0.06	0.05	0.05	0.05	0.05	0.05
TOTAL	102.12	108.57	94.23	89.58	103.23	98.68	103.97	110.48	83.71	6.19	104.13	98.94	104.39	90.37	109.06	90.79	96.58	93.17	88.95	86.05

3.2.4.3.2 Recalculations

Through the comparison of Sectoral .vs. Reference approach, an error was located concerning the activity data used in caclulations in Public electricity and heat production (CRF Source Category 1.A.1.a) – gaseous fuels. The recalculations performed had an impact on total emissions (without LULUCF) of 0.36%.

3.2.4.4 Manufacturing industries and construction (CRF Source Category 1.A.2)

3.2.4.4.1 Source category description and methodological issues

Emissions from energy consumption for the production of steam and process heat are mainly reported under Manufacturing industry and construction.

Data collected (through questionnaires) during the formulation of the NAP for the period 2005 – 2007 and verified installation ETS reports of 2005 - 2009 provided significant information regarding the structure of energy demand in industry per activity / technology. Energy consumption in activities not included in the EU emissions trading scheme (e.g. grey iron foundries) is estimated on the basis of the official data (national energy balance).

The calculation of GHG emissions from this sector was performed as described in section 3.2.4.2. The assumptions made for the estimation of GHG emissions for the period 1990 – 2009 (***Table 3.18***) are the following:

- The energy consumption in the energy balance sector *Iron & Steel* is allocated to steel production (exclusively in electric arc furnaces) and grey iron foundries.

  Plant specific data on energy consumption for steel production cover the period 1990 – 2003 and 2005 - 2009. According to those data natural gas represents the main fuel consumed while the consumption of other fuels includes small quantities of heavy fuel oil, LPG and diesel oil. The specific consumption for steel production has decreased from 3.6 GJ / t steel in 1990 to 1.6 GJ / t steel in 2003. For 2004, it was assumed that unit consumption decreased further to 1.5 GJ / t steel while heavy fuel oil, LPG and diesel oil consumption remained constant at 2003 levels. For 2005 - 2009 activity data were available through the verified ETS reports. Emission factors as described previously were applied.

- Primary aluminium production and ferroalloys production are included, among others, in the energy balance sector of *Non ferrous metals*.

  The available plant specific energy consumption data (heavy fuel oil) refer only to primary aluminium production and cover the years 1990 and 1998 – 2003 and 2005 - 2009. On the basis of those data an average specific consumption is estimated (heavy fuel oil consumption per aluminium produced) which is used for the estimation of energy consumption for the period 1991 – 1997. The specific consumption for 2004 is kept constant at 2003 levels. For 2005 - 2009 plant specific energy consumption data were available through the verified ETS reports.

  The rest of the energy consumption in the sector (according to the energy balance data) refers exclusively to steam production in boilers.

  The emissions from the non-energy use of solid fuels for ferroalloys production were reallocated to the industrial processes sector (2.C.2) as from 2010 submission

- Energy consumption reported in the energy balance under *Chemicals*, *Paper, pulp and print* and *Food and Tobacco* refers exclusively to steam production in boilers.

- The rest of the industrial sectors are included in Other industries (1.A.2f in the CRF tables). With the exception of *Mining* and *Non metallic minerals*, energy consumption refers exclusively to steam production in boilers.

  Energy consumption in *Mining* refers to internal combustion engines and therefore CH_4 and N_2O emissions are estimated using the respective IPCC default emission factors.

  Energy consumption in Non metallic minerals is disaggregated into energy consumption for cement production (SNAP 030311), lime production (SNAP 030312), ceramics production (SNAP 030319) and glass production (SNAP 030105) according to verified ETS reports of years 2005 - 2009.

GHG emissions from manufacturing industries and construction are closely related to industrial activity trends. However, it should be noted that in cases of major industrial units, variations in emissions should be attributed to the realization of investments for the modernization of the installations and for capacity expansion.

Overall, GHG emissions from industry in 2009 decreased by 22.4% compared to 1990.

3.2.4.4.2 Recalculations

In this submission, minor recalculations were performed compared to the estimates presented in the previous submission:

1.A.2e Food Processing, Beverages and Tobacco

1. The activity data of solid fuels were updated for the year 2008, based on plant specific data, derived from verified ETS reports. Therefore, the emissions of CO2, CH4 and N2O from solid fuels combustion were recalculated for the year 2008. The impact on total emissions was minor (+8.7 kt CO2).

1.A.2f Other

2. Following the suggestions of the last ERT, GHG emissions resulted from the use of alternative fuels in cement plants (e.g. scrap tyres) were reallocated from solid fuels of 1A2f source category to other fuels of the same category. This reallocation has no impact on total emissions.

1.A.2d, e, & f

3. Following the suggestions of the last ERT and in accordance with the Revised 1996 IPCC Guidelines, gas work gas is considered a secondary solid fuel. Therefore, GHG emissions resulted from the use of gas works gas were reallocated from gaseous fuels to solid fuels of the same source category. This reallocation has no impact on total emissions.

Table 3.18 GHG emissions (in kt CO_2 eq) from manufacturing industries and construction for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Iron and Steel																				
CO_2	475.14	428.33	425.83	376.75	366.44	352.45	259.78	283.57	270.09	316.22	284.19	308.93	322.49	303.32	228.83	184.85	173.32	199.03	189.43	159.61
CH_4	1.19	1.06	1.06	0.94	0.92	0.89	0.66	0.70	0.57	0.60	0.49	0.51	0.53	0.52	0.29	0.13	0.13	0.15	0.13	0.11
N_2O	1.19	1.06	1.06	0.94	0.92	0.89	0.66	0.70	0.57	0.60	0.49	0.51	0.53	0.52	0.29	0.13	0.13	0.15	0.13	0.11
Non ferrous metals																				
CO_2	607.68	693.60	692.91	678.52	653.71	665.66	685.55	677.23	767.86	884.45	926.99	919.28	966.11	1002.69	968.57	808.74	823.89	817.47	740.55	533.77
CH_4	0.44	0.51	0.51	0.50	0.48	0.49	0.51	0.50	0.57	0.64	0.66	0.66	0.68	0.70	0.67	0.55	0.57	0.57	0.50	0.33
N_2O	2.14	2.45	2.45	2.40	2.32	2.36	2.47	2.45	2.81	3.34	3.56	3.51	3.70	3.89	3.76	3.38	3.22	3.17	3.05	2.81
Chemicals																				
CO2	1153.02	844.73	418.74	435.50	446.72	459.91	689.04	750.39	926.85	505.74	638.85	632.88	653.54	776.21	876.48	916.57	872.96	863.25	750.36	839.64
CH4	0.31	0.18	0.17	0.14	0.14	0.15	0.34	0.40	0.53	0.27	0.29	0.27	0.27	0.25	0.35	0.36	0.39	0.38	0.33	0.29
N2O	2.42	2.38	2.40	2.90	3.13	3.07	3.10	3.65	4.46	3.61	3.55	3.52	3.40	3.54	3.76	4.07	3.81	3.65	3.55	3.97
Paper. pulp and print																				
CO_2	301.47	288.51	281.40	265.90	250.81	211.00	289.37	340.30	305.80	314.58	373.79	344.10	354.17	364.50	252.27	229.31	268.83	255.59	239.91	197.38
CH_4	0.22	0.22	0.21	0.19	0.17	0.16	0.21	0.23	0.19	0.25	0.25	0.21	0.21	0.21	0.16	0.14	0.16	0.15	0.14	0.10
N_2O	0.44	0.42	0.40	0.38	0.37	0.32	1.02	1.24	1.47	2.23	1.94	1.91	1.84	1.85	1.18	1.10	1.38	1.28	1.30	1.25
Food processing – Beverages – Tobacco																				
CO_2	902.31	925.19	939.89	960.05	920.05	936.47	1005.83	973.47	1059.77	963.38	1086.77	992.76	1038.20	1090.53	875.18	790.12	846.88	704.82	651.74	587.96
CH_4	0.64	0.66	0.67	0.68	0.64	0.62	4.90	4.89	4.94	4.90	5.91	5.73	6.15	5.27	5.37	6.06	5.51	5.54	6.58	6.06
N_2O	1.41	1.39	1.41	1.44	1.40	1.37	10.71	11.19	11.60	12.13	14.34	13.99	14.71	13.21	13.18	14.97	13.79	13.19	15.32	14.66
Other industries																				
CO_2	6126.41	6287.00	6070.10	5810.45	5814.33	6590.29	6839.81	6949.05	6700.54	5994.82	6411.02	6696.86	6109.80	5596.25	5290.17	7241.17	7397.91	7262.30	6683.43	5093.57
CH_4	6.93	7.09	7.09	6.92	6.71	7.00	3.15	3.17	2.84	2.54	2.73	2.76	2.50	2.05	2.08	3.07	2.88	2.76	2.62	2.04
N_2O	36.03	37.98	37.87	37.81	38.36	41.70	32.95	33.65	33.85	28.11	29.12	29.89	26.40	23.56	22.29	22.10	23.72	26.03	23.16	17.36
TOTAL	9618.60	9522.06	8883.45	8581.79	8507.02	9274.23	9829.63	10036.32	10094.93	9038.02	9784.65	9957.96	9504.89	9188.77	8544.72	10226.77	10439.43	10159.40	9312.17	7460.98

3.2.4.5 Other sectors (CRF Source Category 1.A.4)

3.2.4.5.1 Source category description and methodological issues

Residential – Tertiary sector (CRF Source Category 1.A.4 a and b)

GHG emissions from the residential – tertiary sector result from energy consumption for heat in order to cover the needs for the space heating, water heating etc. Thermal needs in these sectors are covered mainly by liquid fossil fuels, while the contribution of biomass (fuel wood), especially in the residential sector, is also significant (mainly in rural areas). The penetration of natural gas to the fuel mixture has an increasing trend..

Activity data of biomass consumption were obtained from fuelwood statistics of the Ministry of Rural Development and Food.

Two basic technologies are considered: central heating boilers, and other stationary equipment (e.g. oil stoves, fireplaces etc.). For the allocation of fuel consumption by technology, it is assumed that the consumption of diesel, heavy fuel oil, gas works gas (until 1997) and natural gas concern central heating boilers and the consumption of the rest of the fuels concern the other stationary equipment.

GHG emissions (***Table 3.19*** for the residential sector and ***Table 3.20*** for the commercial/ institutional sector) are calculated on the basis of fuel consumption as it is presented in Annex II, the emission factors of CO_2 presented in Table 3.13 and default IPCC EF for CH_4 and N_2O as in the previous categories of stationary combustion (s. section 3.2.4.2).

GHG emissions from the residential and the commercial/institutional sector in 2009 increased substantially compared to 1990 levels (57% and 133% respectively), as a result of the great increase of liquid fuel consumption since 1996, according to the national energy balance. A decreasing trend of the last years is attributed to the penetration of natural gas to the fuel mixture and economic recession (for year 2009).

Agriculture (CRF Source Category 1.A.4c)

GHG emissions from agriculture result from combustion activities are related to heating needs (e.g. space heating in greenhouses) and to agricultural machinery. Fuel consumption is not allocated to forestry or fisheries since the available information does not allow for such a disaggregation.

Energy needs are covered by diesel and heavy fuel oil in boilers and by lignite and biomass in other stationary equipment. Agricultural machinery uses diesel oil and gasoline. The distribution of diesel consumption between thermal needs and machinery is kept constant during the whole period 1990 – 2009.

GHG emissions (***Table 3.21***) are estimated on the basis of fuel consumption as it is presented in Annex II, CO_2 emission factors presented in Table 3.13 and default IPCC EF for CH_4 and N_2O as in the previous categories of stationary combustion (s. section 3.2.4.2).

The majority of GHG emissions from agriculture are attributed to agricultural machinery (approximately 70% for the period 1990 – 2008). Overall, in 2009 emissions from agriculture decreased by approximately 33% compared to 1990 emissions.

3.2.4.5.2 Recalculations

In this submission, no recalculations were performed compared to the estimates presented in the previous submission, which have an effect on total emissions:

1.A.4a & b

1. Following the suggestions of the last ERT and in accordance with the Revised 1996 IPCC Guidelines, gas work gas is considered a secondary solid fuel. Therefore, GHG emissions resulted from the use of gas works gas were reallocated from gaseous fuels to solid fuels of the same source category. This reallocation has no impact on total emissions.

Table 3.19 GHG emissions (in kt CO_2 eq) from the residential sector for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 emissions																				
Solid fuels	86.64	120.63	116.15	115.40	114.66	106.09	115.24	126.97	102.11	62.68	69.86	65.70	23.46	14.17	23.45	11.35	5.53	6.87	23.68	14.73
Liquid fuels	4584.82	4560.85	4470.27	4437.91	4466.13	4697.02	6397.26	6686.39	7032.67	6917.13	7494.44	8075.67	8402.61	9978.31	9497.86	9683.35	9213.55	8177.13	7880.55	6797.43
Gaseous fuels									10.49	8.93	11.15	12.05	19.74	43.15	79.99	166.49	316.75	407.48	479.18	591.90
CH_4 emissions																				
Solid fuels	0.03	0.04	0.04	0.04	0.03	0.03	0.04	0.04	0.02	0.01	0.02	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00
Liquid fuels	3.76	3.75	3.66	3.65	3.69	3.89	5.35	5.60	5.92	5.84	6.35	6.85	7.15	8.50	8.08	8.24	7.84	6.96	6.70	5.78
Gaseous fuels									0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.06	0.12	0.16	0.18	0.23
Biomass	76.59	76.59	93.76	85.01	76.29	74.71	75.29	70.37	67.84	79.43	90.20	81.10	61.14	59.43	69.01	56.96	66.08	65.23	63.52	63.44
N_2O emissions																				
Solid fuels	0.44	0.61	0.59	0.59	0.58	0.54	0.58	0.64	0.50	0.31	0.35	0.32	0.12	0.07	0.12	0.06	0.03	0.03	0.11	0.07
Liquid fuels	10.95	10.92	10.66	10.61	10.74	11.34	15.67	16.40	17.37	17.13	18.65	20.12	21.03	25.02	23.78	24.27	23.09	20.48	19.72	17.02
Gaseous fuels									0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.09	0.18	0.23	0.27	0.33
Biomass	31.80	31.80	38.93	35.30	31.68	31.02	31.26	29.22	28.17	32.98	37.45	33.67	25.39	24.67	28.65	23.65	27.43	27.08	26.37	26.34

Table 3.20 GHG emissions (in kt CO_2 eq) from the commercial / institutional sector for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2	527.06	671.02	625.79	595.82	614.20	659.38	798.84	772.29	787.34	760.73	777.09	1010.52	1029.17	1129.86	1219.98	1534.58	1595.88	1497.92	1494.01	1229.50
CH_4	0.45	0.55	0.52	0.49	0.51	0.53	0.64	0.60	0.61	0.60	0.62	0.81	0.83	0.91	0.92	1.17	1.21	1.11	1.08	0.84
N_2O	1.48	1.74	1.61	1.53	1.58	1.63	1.94	1.73	1.73	1.72	1.78	2.35	2.42	2.61	2.60	3.32	3.39	3.07	2.96	2.22

NO: Not Occurring

Table 3.21 GHG emissions (in kt CO_2 eq) from agriculture for the period 1990 - 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2	2927.39	3068.66	2847.30	2769.57	2783.16	2589.00	2641.65	2632.32	2632.63	2641.80	2644.32	2680.19	2911.18	3119.16	2666.28	2734.12	2894.37	2568.32	2506.10	1976.15
CH_4	3.17	3.31	3.07	2.98	3.00	2.78	2.84	2.83	2.83	2.93	3.36	2.96	3.24	5.11	5.23	6.23	6.12	6.20	5.48	6.23
N_2O	337.65	349.96	323.96	316.06	318.40	295.55	299.92	299.50	299.50	299.58	299.77	303.54	334.92	366.70	310.66	316.51	331.68	295.20	286.79	197.05

3.2.4.6 Uncertainties and time-series consistency

In general, the uncertainty of emissions of the stationary combustion sector is relatively small. The uncertainty associated with activity data -i.e. fuel consumption- is less than 5%, since the AD are obtained from the national energy balance and are cross-checked with data from other sources (e.g. plant specific data from major industrial installations). On the other hand, the uncertainty associated with emission factors is also very low for the case of CO2, less than 5%, since plant and country specific EFs are mainly applied. For the case of CH4 and N2O EFs, the uncertainty is higher, about 100 and 300% respectively, since IPCC defaults emission factors per technology / activity are applied. The results of uncertainty analysis are presented in ***Table 1.9***. The detailed calculations of uncertainty are presented in Annex IV (***Tables IV.1 – IV.3***).

The time-series consistency of emissions is controlled by applying consistent methodologies and verified activity data inline with IPCC guidelines. In case of changes or refinements in methodologies and EFs based on plant-specific data, e.g. from the European Union emissions trading scheme (EU ETS) reports, time-series consistency is ensured by performing recalculations according to the IPCC good practice guidance.

3.2.4.7 Source-specific QA/QC and verification

The following source-specific QC procedures are applied to the stationary combustion sector. These procedures are based on the plant specific data that become available through the ETS reports. To be mentioned that ETS reports have been both verified by external verification bodies and reviewed by the competent authorities of Ministry of Environment, Energy and Climate Change (MEECC).

1. **Activity data comparison**: Cross-checking between energy consumption data derived from national energy balance and plant specific energy consumption data of major industrial plants derived from verified ETS reports is performed. The findings of the above quality check are communicated to the competent department of MEECC that is the compiler of national energy balance. By this way both the national energy balance and the energy consumption used in emission calculations is verified and improved.
2. **Emissions comparison**: Verified ETS reports were used for the computation of plant specific CO2 EFs and NCVs. For quality control purposes emissions calculated by applying PS EFs and NCVs are compared with the emissions calculated by using IPCC defaults EFs and NCVs derived from energy balance. By this way emission estimations were verified. The most appropriate EFs and NCVs per sector are selected and applied.

The application of the above-described procedures lead to recalculations that are summarised in the next chapter.

3.2.4.8 Recalculations

The recalculations of emissions that were performed in the present inventory, compared to the previous one, were discussed in details per category in the previous pararagraphs. Summarizing, the recalculations performed in stationary combustion sector were as follows:

- Reallocation of emissions to more appropriate sector: alternative fuels in cement plants (e.g. scrap tyres) were reallocated from solid fuels of 1A2f source category to other fuels of the same category. Moreover, GHG emissions resulted from the use of gas works gas were reallocated from gaseous fuels to solid fuels of the same source category. These reallocation has no impact on total emissions.
- Correction of errors and updated activity data.

The impact of recalculations on total emissions excuding LULUCF, between present and previous emissions estimates, was less than 0.5%.

3.2.4.9 Planned improvements

Based on the findings of internal inventory reviews described in section 1.6, EU internal audits and UNFCCC ERT reviews actions are being planned and executed that lead to the recalculations / improvements of the stationary combustion GHG emission inventory. The above-mentined recalculations resulted from findings that were identified during these reviews.

3.2.5 Transport (CRF Source Category 1.A.3)

3.2.5.1 Source category description

Internal aviation, road transportation, railways and internal navigation are included in the transport sector. Emissions from international marine and aviation bunkers are not included in national totals, but are calculated and reported separately as Memo items.

In total, GHG emissions from transport (***Table 3.22(a,b)***) in 2009 increased by approximately 61% compared to 1990 emissions (from 14.77 Mt CO_2 eq in 1990 to 23.75 Mt CO_2 eq in 2009). The average annual rate of emissions increase from transport for the period 1990 – 2009 was approximately 3%, however, in 2008, an approximately 5% decrease of total emissions was observed compared to 2007 emissions.

In 2009, the majority of GHG emissions derived from road transport, the contribution of which increased from 81% in 1990 to approximately 91% of total emissions of the sector, since the number of vehicles in the country has considerably increased between 1990 and 2009.

The share of internal navigation in the emissions of the transport sector fluctuated from 8-14% during the whole time period with almost 12% in 2009. Additionally, the contribution of internal aviation increased from 5% in 1990 to 6.2% in 2009, while the contribution of railways decreased from 1.6% in 1990 to less than 0.5% in 2009. The contribution of other transport (pipeline transportation) is negligible.

Finally, the aggregated contribution of transport in total National GHG emissions is 21%.

Table 3.22(a) GHG emissions in the transportation sector per category for the period 1990 – 1999

	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		Emissions (kt)									
Aviation	CO_2	717	621	679	745	771	818	877	997	1014	1212
	CH_4	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
	N_2O	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04
Road transport	CO_2	11742	12589	12890	13189	13372	13803	14465	14801	15550	15828
	CH_4	4.28	4.33	4.28	4.34	4.32	4.37	4.4	4.46	4.55	4.68
	N_2O	0.39	0.44	0.51	0.61	0.71	0.81	0.85	0.94	1.02	1.14
Railways	CO_2	203	158	152	155	168	139	145	136	149	129
	CH_4	0.11	0.09	0.08	0.09	0.09	0.08	0.08	0.08	0.08	0.07
	N_2O	0.08	0.06	0.06	0.06	0.06	0.05	0.06	0.05	0.06	0.05
Navigation	CO_2	1825	1851	1899	1738	1831	1744	1493	1812	2793	2761
	CH_4	0.11	0.12	0.12	0.12	0.11	0.1	0.08	0.09	0.13	0.12
	N_2O	0.05	0.05	0.05	0.04	0.05	0.04	0.04	0.05	0.07	0.07
Other	CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
kt CO_2eq	Total	14,750	15,490	15,914	16,152	16,499	16,889	17,381	18,175	19,976	20,439

Table 3.22(b) GHG emissions in the transportation sector per category for the period 2000 – 2009

	Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	Emissions (kt)										
Aviation	CO_2	1331	1227	1052	1185	1227	1213	1280	1347	1296	1452
	CH_4	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	N_2O	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.05
Road transport	CO_2	16020	16365	16942	17974	18083	18281	18866	19751	19037	21407
	CH_4	4.82	4.9	4.86	4.82	4.85	4.68	4.6	4.41	4.12	3.84
	N_2O	0.74	0.76	0.78	0.79	0.81	0.79	0.83	0.84	0.81	0.71
Railways	CO_2	129	129	129	129	129	127	131	118	115	96
	CH_4	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.05
	N_2O	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04
Navigation	CO_2	1580	2145	1937	1923	2153	2054	2262	2107	1885	2808
	CH_4	0.09	0.12	0.11	0.11	0.11	0.03	0.04	0.03	0.03	0.05
	N_2O	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.07
Other	CO_2	NO	2.06	5.43	3.62	2.21	3.81	4.91	7.44	14.32	0
	CH_4	NO	0	0	0	0	0	0	0	0	0
	N_2O	NO	0	0	0	0	0	0	0	0	0
kt CO_2eq	Total	19,437	20,258	20,478	21,634	22,025	22,097	22,977	23,763	22,760	25,673

Table 3.23(a) Energy consumption (in TJ) in the transportation sector per category. for the period 1990 – 1999

Energy consumption (in TJ)										
Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Aviation	10152	8792	9623	10554	10926	11583	12428	14120	14362	17173
Road transport	167182	179052	183365	187638	190257	196369	205851	210651	221208	225134
Railways	2757	2150	2064	2107	2280	1890	1977	1847	2037	1773
Navigation	24848	24913	25568	23445	24652	23482	20091	24333	37397	36918
Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	204939	214908	220620	223744	228115	233324	240346	250950	275003	280998
Energy consumption (in TJ)										
International aviation	34646	29875	31168	33175	39373	36921	35360	34201	35895	40309
International marine	106578	97909	112585	131104	138960	149526	131447	131752	146341	130423

Table 3.23(b) Energy consumption (in TJ) in the transportation sector per category. for the period 2000 – 2009

Energy consumption (in TJ)										
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Aviation	18846	17373	14901	16781	17394	17185	18143	19084	18358	20572
Road transport	227903	232929	241641	256195	257910	260893	270979	285270	274546	300900
Railways	1773	1773	1773	1773	1773	1758	1801	1630	1587	1329
Navigation	21363	28895	26155	26024	28980	27674	30610	28405	25371	37251
Other	NO	37	97	65	40	68	88	133	257	0
Total	269885	281007	284567	300838	306097	307579	321622	334522	319595	360052
Energy consumption (in TJ)										
International aviation	35360	32863	32863	42776	43972	33762	40497	41389	43039	37018
International marine	150495	145963	131216	134067	135395	119726	129215	132085	128662	109312

3.2.5.2 Methodological issues

Road transportation

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

Carbon dioxide emissions calculations from road transport are based on the consumption of gasoline, diesel, LPG and natural gas and the carbon content of the fuels consumed. For the estimation of emissions from road transportation, except CO_2, the newer version of COPERT, (COPERT 4 Computer programme to calculate emissions from road transport - Users Manual, D. Gkatzoflias, L. Ntziachristos and Z. Samaras (LAT/AUTH)., 2007, ETC-ACC European Topic Centre on Air and Climate Change), was applied.

COPERT 4 is an MS Windows software program aiming at the calculation of air pollutant emissions from road transport. The technical development of COPERT is financed by the European Environment Agency (EEA), in the framework of the activities of the European Topic Centre on Air and Climate Change. Since 2007, the European Commission's Joint Research Centre has been coordinating and financing the further scientific development of the model. In principle, COPERT has been developed for use from the National Experts to estimate emissions from road transport to be included in official annual national inventories. In this version of COPERT hybrid vehicle fuel consumption and emission factors were introduced as well as N_2O/NH_3 emission factors for PCs and LDVs and heavy duty vehicle emissions calculation methodology.

The major revisions made since previous version of the methodology are the following:

- New emission factors for diesel Euro IV PCs
- Revised emission factors for LDVs
- New emission factors for Euro V and VI PCs, LDVs and HDVs
- Emission factors for urban CNG buses
- Hybrid fuel consumption and emission factors
- New corrections for emission degradation due to mileage
- Revised CO_2, N_2O, NH_3 and CH_4 calculations
- Effect of biodiesel blends on emissions from diesel cars and HDVs
- Split of NOx emissions to NO and NO_2
- Developments on the cold start emission front
- Developments on evaporation losses

The methodology applied is also part of the EMEP/CORINAIR Emission Inventory Guidebook. The Guidebook, developed by the UNECE Task Force on Emissions Inventories and Projections, is intended to support reporting under the UNECE Convention on Long-Range Transboundary Air Pollution and the EU directive on national emission ceilings. The COPERT 4 methodology is fully consistent with the Road Transport chapter of the Guidebook. The use of a software tool to calculate road transport emissions allows for a transparent and standardized, hence consistent and comparable data collecting and emissions reporting procedure, in accordance with the requirements of international conventions and protocols and EU legislation.

Basic data requirements for the application of the model include: (a) energy consumption by fuel type, (b) fuel characteristics, (c) the number of vehicles per vehicle category, engine size or weight and emission control technology, (d) other parameters such as: the mileage per vehicle class and per road class, the average speed per vehicle type and per road (urban, rural and highway) and (e) climatic conditions. The energy consumption as well as the associated emissions are calculated based on those data and a number of equations described in Ntziachristos and Samaras (2000).

It should be noted here that COPERT IV, is a simulation model for road transport sector and not an optimization one. The solution algorithm is based on the minimisation of differences between energy consumption as reported in the national energy balance account and the estimated (by the model) energy consumption. This is achieved by adjusting appropriately the mileage driven by each vehicle category.

As had already been discussed in the last year's NIR, the traffic characteristics applied for each vehicle type and category needed to be further investigated. This is what was done for 2007 and 2008 traffic data in last year's calculations. In this year's submission a reconstruction of the whole time-series input data was completed and used for the calculations. The different vehicle categories population along with the total annual kilometres driven by each category as well as fuel consumption data are presented in ***Figures 3.7-3.10***.

It is obvious that an updated vehicles fleet population and composition along with different traffic characteristics and the use of COPERT IV has lead, in last year's calculations, to an important differentiation of emissions values. Moreover, it was already mentioned in the previous years NIR, that, for consistency and comparison reasons, a planned improvement was the reconstruction of the whole time-series input data and the recalculation of all emissions (except CO2) with COPERT IV. This is what was done in this year submission. The whole time-series was recalculated with COPERT IV and taking into account the new updated data on fleet population and composition as well as new traffic characteristics. All the updated data used, namely fleet composition and mileage as well as other traffic characteristics, were based on up to date statistics and measurements in the framework of surveys and routine checks and controls of the Ministry of Infrastructure, Transport and Networks and the Ministry of Environment Energy and Climate Change.

In the last years, the vehicle fleet has increased by 265% compared to 1990 levels, while an increase of the share of medium and larger size passenger vehicles is observed (from 27% in 1990, to 36% in 2008).

Road transport is a key category of CO_2 emissions. CO_2 emissions in 2009 increased by approximately 80% compared to 1990 emissions, CH_4 emissions decreased slightly (about 10%), while N_2O emissions increased by 82% (***Table 3.24(a,b)***). During this period, energy consumption augmented by 80%.

The significant increase of GHG emissions is attributed to the increase of passenger cars. This trend is expected to decelerate in the near future as a consequence of the economic crisis, although the percentage of car ownership in Greece is lower than the EU average. It should be noted that, despite the increase of the population of circulating vehicles, as there is a remarkable increase of less polluting vehicles, CO, NOx and NMVOC emissions decrease. Finally, after the considerable reduction of SO_2 emissions attributed to the improvement of the fuels characteristics (i.e. the reduction of their sulphur content), due to the increase in fuel consumption an increase of SO_2 emissions was found too.

Emissions from lubricants combustion in road transportation were estimated using an adjustment coefficient applied to the total lubricants consumption as it was proposed by a previous in country review. CO2 emissions from energy combustion of lubricants from road transportation in 1990 are several times higher than the possible calculations based on fleet data and distance travelled. During the in-country review of initial report (Report FCCC/IRR/2007/GRC / 28Dec2007), the ERT identified this issue as a potential overestimation in the base year and decided to calculate and apply an adjustment for the whole time-series. The ERT concluded that the most appropriate methodology for the adjustment in accordance with the Technical Guidance for Adjustments (attached to decision 20/CMP.1) would be the use of an appropriate driver (lubricant consumption/fuel consumption) from a cluster of countries which estimate CO2 emissions from the combustion of lubricants. The lubricant consumption per fuel consumption ratio in 1990, based on Greece's activity data allocation, is 0.0236 (3.938,62 TJ/166.745,16 TJ), which is nine times higher than the average of other countries that report CO2 emissions from combustion of lubricants. The ERT and the Greek inventory team compiled a proxy bottom-up calculation for the amount of lubricants combusted in road transportation. This resulted in CO2 emission estimates an order of magnitude lower than reported by Greece, comparable with estimates from other Parties. The adjusted estimate for CO2 emissions from energy combustion of lubricants from road transportation in the base year amounts to 29.811 Gg CO2 compared to the 142.972 Gg CO2 originally reported by Greece in the 2006 inventory submission.

CO_2 emissions were based on fuel consumption and, hence, they are reported separately. On the contrary, all the other pollutants emissions are calculated with COPERT and are based on the distance travelled and not on the statistical fuel consumption, as emission factors are determined experimentally with measurements of the gas mass exhausted per kilometre at the end-of-pipe. Therefore, the lubricants emissions for all other gases, except CO_2, are incorporated in the total emissions amount for each gas and are not reported separately

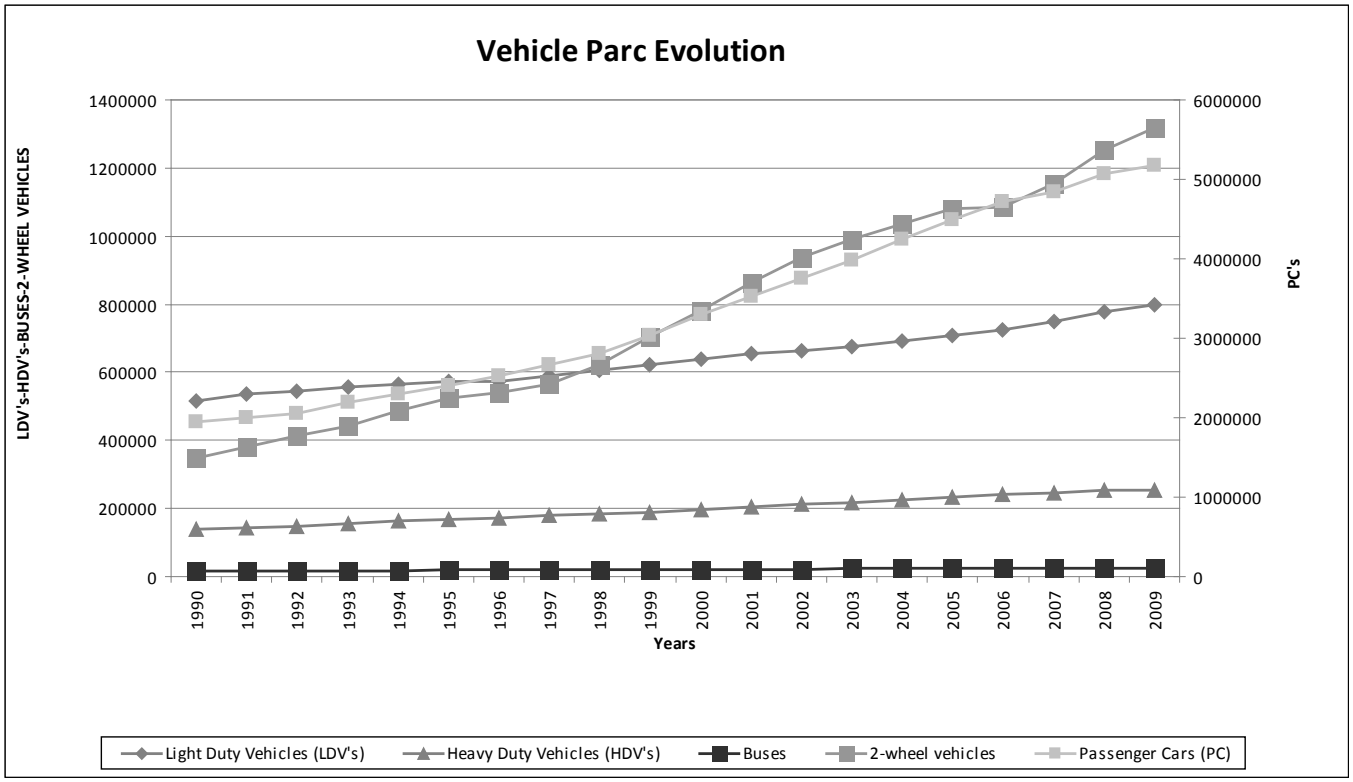


Figure 3.7 Vehicles population evolution for all vehicles categories during the whole time period 1990 – 2009

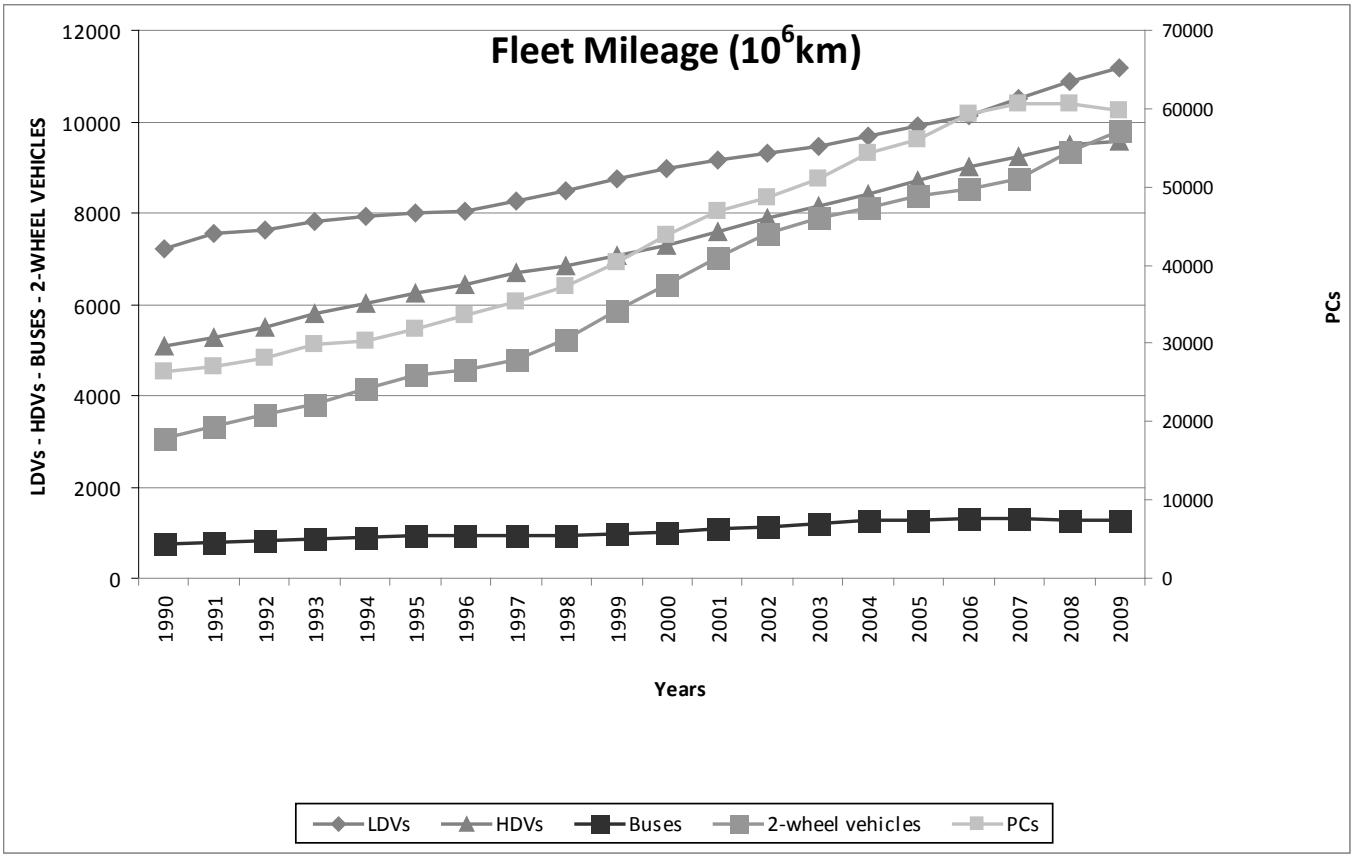


Figure 3.8 *Annual mileage driven by all vehicles categories during the whole time period 1990 – 2009*

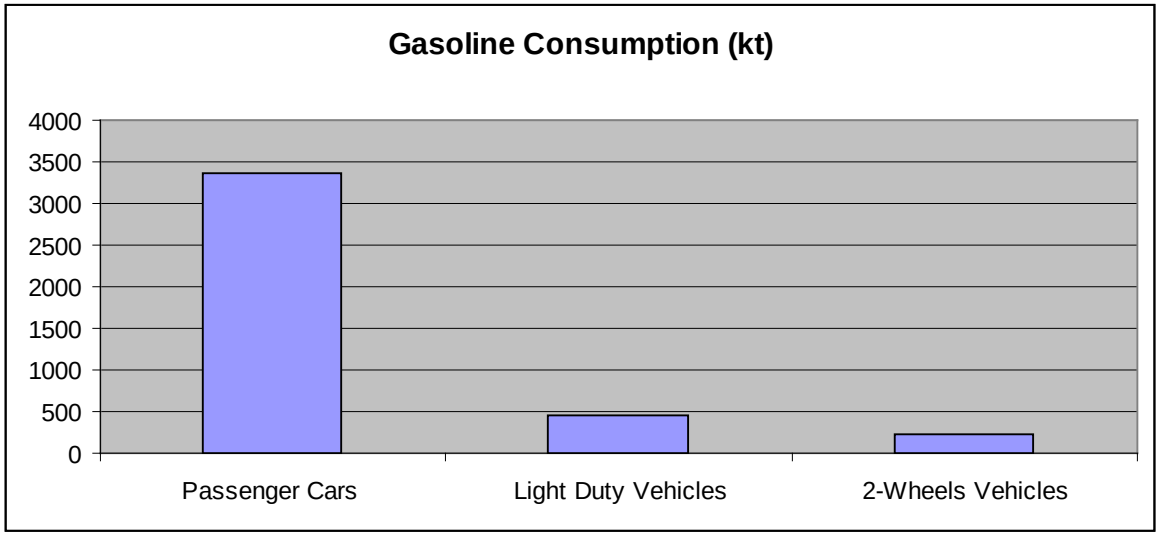


Figure 3.9 *Gasoline consumption (kt) by all vehicles categories for 2009*

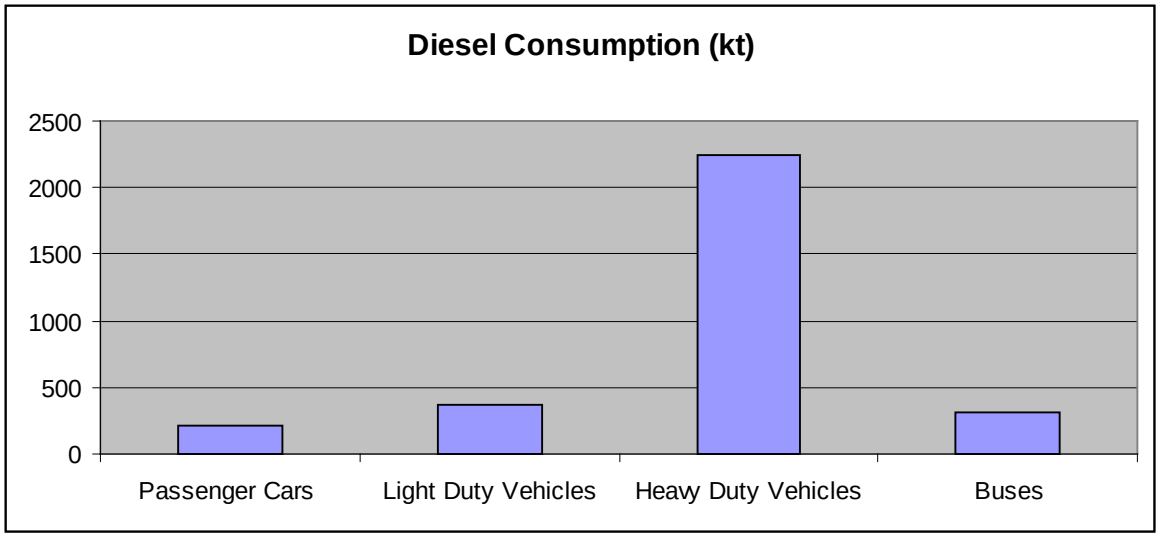


Figure 3.10 Diesel consumption (kt) by all vehicles categories for 2009

Table 3.24(a) GHG emissions (in kt CO_2 eq) and energy consumption (in TJ) from road transportation for the period 1990 – 1999

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
					Emissions (in kt CO2 eq)					
CO_2 (kt)	11742	12589	12890	13189	13372	13803	14465	14801	15550	15828
CH_4 (kt)	4.28	4.33	4.28	4.34	4.32	4.37	4.40	4.46	4.55	4.68
N_2O (kt)	0.39	0.44	0.51	0.61	0.71	0.81	0.85	0.94	1.02	1.14
TOTAL	11953	12816	13138	13469	13683	14146	14821	15186	15961	16280
					Energy consumption (in TJ)					
Gasoline	106,310	109,715	113,434	116,211	118,496	122,035	129,472	133,728	139,149	141,792
Diesel	59,015	67,118	67,465	68,808	69,371	71,928	74,138	75,048	80,204	81,807
LPG	1,419.30	1,750.47	1,987.02	2,128.95	1,892.40	1,892.40	1,703.16	1,324.68	1,277.37	946.20
Natural Gas										
Other liquids	436.84	467.86	479.13	490.30	497.14	513.11	537.88	550.43	578.01	588.27
TOTAL	167,182	179,052	183,365	187,638	190,257	196,369	205,851	210,651	221,208	225,134

Table 3.24(b) GHG emissions (in kt CO_2 eq) and energy consumption (in TJ) from road transportation for the period 2000 – 2009

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
					Emissions (in kt CO2 eq)					
CO_2 (kt)	16020	16365	16942	17974	18083	18281	18866	19751	19037	21407
CH_4 (kt)	4,82	4,90	4,86	4,82	4,85	4,68	4,60	4,41	4,12	3,84
N_2O (kt)	0,74	0,76	0,78	0,79	0,81	0,79	0,83	0,84	0,81	0,71
TOTAL	16350	16704	17285	18320	18436	18625	19220	20105	19374	21708
					Energy consumption (in TJ)					
Gasoline	144.704	149.453	156.486	163.520	167.100	170.920	172.813	180.593	177.208	177.692
Diesel	81,894	82,11	83,41	90,993	89,173	88,272	94,459	99,187	95,793	120.959
LPG	709.65	756.96	709.65	567.72	520.41	520.41	520.41	567.72	567.73	804.27
Natural Gas			404.00	446.00	444.00	489.80	516.42	600.30	534.60	660.00
Other liquids	595.51	608.64	630.35	668.27	672.77	690.97	712.36	734.46	716.71	784.52
TOTAL	227,903	232,929	241,641	256,195	257,910	260,893	269,021	281,682	274.820	300.900

Internal navigation

Carbon dioxide emissions from internal navigation are calculated according to the IPCC Tier 1 default methodology, which is based on the relative consumption of energy per fuel and default emission factors. The other GHG emissions are calculated according to the default methodology of CORINAIR, which is based on the relative consumption of energy per fuel and default emission factors (SNAP 0804 – EEA 2001). Update activity data were taken into account for methane emissions for the period 1990-2004. Methane and nitrous oxide emissions from lubricants were also included.

The application of a higher Tier methodology requires detailed data for the composition of the fleet and the routes performed, which are not available at present.

Internal navigation (CO_2 emissions) is a key category. GHG emissions from navigation in 2009 were considerably higher (54%) than the emissions in 1990, on the basis of fuel consumption data from this sector (***Table 3.25***).

Table 3.25 GHG emissions (in kt CO_2 eq) and energy consumption (in TJ) from internal navigation for the period 1990 – 2009

	Emissions (in kt CO_2)			ktCO2eq	Energy consumption (in TJ)			
	CO_2	CH_4	N_2O	Total	Diesel	Fuel Oil	Lubricants	Total
1990	1,825	0.11	0.05	1,843	14,559	9,525	764	24,848
1991	1,851	0.12	0.05	1,869	15,469	9,284	161	24,913
1992	1,899	0.12	0.05	1,918	15,079	10,248	241	25,568
1993	1,738	0.12	0.04	1,755	15,166	8,078	201	23,445
1994	1,831	0.11	0.05	1,849	14,082	10,289	281	24,652
1995	1,744	0.10	0.04	1,761	12,349	10,771	362	23,482
1996	1,493	0.08	0.04	1,508	9,923	9,847	322	20,091
1997	1,812	0.09	0.05	1,830	10,226	13,665	442	24,333
1998	2,793	0.09	0.07	2,821	15,252	21,622	522	37,397
1999	2,761	0.12	0.07	2,788	12,522	23,752	643	36,918
2000	1,580	0.09	0.04	1,595	11,396	9,485	482	21,363
2001	2,145	0.12	0.05	2,166	14,949	13,464	482	28,895
2002	1,937	0.11	0.05	1,956	14,299	11,374	482	26,155
2003	1,923	0.11	0.05	1,942	13,042	12,298	683	26,024
2004	2,153	0.11	0.05	2,175	13,346	15,071	563	28,980
2005	2,054	0.03	0.05	2,071	14,090	13,102	482	27,674
2006	2,262	0.04	0.06	2,279	15,378	14,428	804	30,610
2007	2,107	0.03	0.05	2,130	13,746	14,067	592	28,405
2008	1,885	0.03	0.05	1,901	13,274	11,735	362	25,371
2009	2,808	0.05	0.07	2,831	11,770	25,320	161	37,251

Internal aviation

GHG emissions from domestic aviation are calculated according to the Tier 2a methodology suggested by the IPCC Guidelines, which is based on the combination of energy consumption data and air traffic data (Landing and Take off cycles, LTOs). The emission factors used and the distribution of consumption in LTOs and cruise are the suggested CORINAIR values (SNAP 080501 & 080503 – EEA 2001) for average fleet.

The data on energy consumption derive from the national energy balance, while data on LTOs are provided by the Civil Aviation Organisation. However, some inconsistencies were identified, as according to the Civil Aviation Organisation the number of LTOs increased by 71% from 1990 to 2004 while energy consumption (as recorded in the national energy balance) for the same time period decreased by 15.6%. For this reason adjustments have been made to the energy consumption data of the whole time period, as suggested in a previous in-country review (***Table 3.26(a,b)***).

More specifically, during the in-country review of the initial report of Greece (Report FCCC/IRR/2007/GRC / 28Dec2007), the ERT informed Greece of the potential problem of an overestimation in the base year for CO2, CH4 and N2O emissions from civil aviation. After the in-country review, Greece provided additional information on domestic LTOs and number of passengers travelling on domestic flights. The number of passengers, travelling on domestic flights, increased by 40 per cent over the period 1990-2004. The ERT identified that there is a potential overestimation of CO2, CH4 and N2O emissions from civil aviation in the base year and decided to calculate and apply an adjustment.

To determine whether fuel consumption and consequently emissions of CO2, CH4 and N2O were overestimated in 1990 or underestimated in 2004, the ERT estimated fuel consumption for 2004 based on number of LTOs, and the average share (10.20 per cent) of LTO emissions in relation to total emissions from domestic flights (as provided in the Revised 1996 IPCC Guidelines). This approach depends mainly on the length of the domestic flight, which depends on the size of the country. As almost all domestic flights from Athens are in the range of 100-500 km, and flights from Greece to the Greek islands are relatively short, the share of LTOs in total flight fuel consumption would be expected to be closer to the upper part of the range or even higher than the range indicated in the Revised 1996 IPCC Guidelines. For example, the share of LTOs in total fuel consumption for domestic flights reported by Italy (with larger distances between major domestic hubs) was 25.4 per cent in 1990 and 25.0 per cent in 2004. Applying the upper part of the IPCC range (20 per cent) to reported fuel consumption in 2004 for Greece resulted in 383 kg of fuel per LTO. The ERT considered that this would be the expected amount of fuel consumption for Greece for fleets operating domestic routes. Furthermore the ERT compared Greece's ratio, fuel consumption/domestic flight (0.085 TJ/flight), in 2004 with data from a cluster of comparable countries and concluded that Greece's data were closely aligned with the cluster of countries selected (United Kingdom 0.08 TJ/flight, Italy 0.12 TJ/flight, Norway 0.05 TJ/flight). The ERT agreed that fuel consumption in 2004 as reported in the NIR is a solid starting point for extrapolation back to 1990. The adjusted estimate for CO2, CH4 and N2O emissions from civil

aviation in the base year amounts to 593.691 Gg CO2 eq., compared to the 1,469.238 Gg CO2 eq. reported by Greece in the 2006 GHG inventory submission. Since the discrepancies between the number of LTOs and the corresponding fuel consumption still persist, the above adjustment continues to be applied.

Update acitivity data were taken into account for years 2007 and 2008. GHG emissions from internal aviation increased by 102% since 1990 with an average annual increase rate of approximately 5% (***Table 3.26(a,b)***).

Railways

GHG emissions from railways are calculated according to the default methodology proposed in CORINAIR, which is based on the relative consumption of energy per fuel and the typical emission factors (SNAP 0802 – EEA 2001).

GHG emissions from railways (***Table 3.27(a,b)***) decreased by 53% from 1990 to 2009.

Table 3.26(a) GHG emissions (in kt CO_2 eq). energy consumption (in TJ) and air movement (in thousands LTOs) for the period 1990 – 1999

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Emissions (in kt CO2)									
CO_2	717	621	679	745	771	818	877	997	1.014	1.212
CH_4	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
N_2O	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04
TOTAL (in kt CO2eq)	725	628	687	753	780	827	887	1.008	1.025	1.226
Energy Consumption (TJ)	10.152	8.792	9.623	10.554	10.926	11.583	12.428	14.120	14.362	17.173
LTOs (1000s)	118.55	102.66	112.37	123.24	127.58	135.26	145.12	164.88	167.70	200.53

Table 3.26(b) GHG emissions (in kt CO_2 eq). energy consumption (in TJ) and air movement (in thousands LTOs) for the period 2000 – 2009

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	Emissions (in kt CO2)									
CO_2	1.331	1.227	1.052	1.185	1.227	1.213	1.280	1.348	1.296	1.452
CH_4	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
N_2O	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.05
TOTAL (in kt CO2eq)	1.345	1.240	1.064	1.198	1.241	1.226	1.294	1.363	1.292	1.468
Energy Consumption (TJ)	18.846	17.373	14.901	16.781	17.394	17.185	18.143	19.084	18.358	20.572
LTOs (1000s)	220.07	202.87	174.00	195.95	203.11	200.67	211.85	222.85	214.36	240.21

Table 3.27(a) GHG emissions from railways for the period 1990 – 1999

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 (kt)	202.69	158.21	151.85	155.03	167.74	139.14	145.50	135.97	149.33	128.55
CH_4 (kt)	0.11	0.09	0.08	0.09	0.09	0.08	0.08	0.08	0.08	0.07
N_2O (kt)	0.08	0.06	0.06	0.06	0.06	0.05	0.06	0.05	0.06	0.05
Total (in kt CO_2 eq)	229.29	178.89	171.70	175.29	189.69	157.30	164.50	153.70	169.17	145.44

Table 3.27(b) GHG emissions from railways for the period 2000 – 2009

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 (kt)	128.55	128.55	128.55	128.55	128.55	127.45	130.60	118.00	114.85	95.95
CH_4 (kt)	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.05
N_2O (kt)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04
Total (in kt CO_2 eq)	145.44	145.44	145.44	145.44	145.44	144.34	147.91	133.64	130.05	108.62

3.2.5.3 Uncertainties and time-series consistency

Road Transport

Several input data in applying the methodology can obviously be only estimates. Such data include total annual mileage, share of mileage to different driving modes (urban, rural, highway), mean travelling speeds, etc. There is a certain degree of uncertainty in estimating these data. A firm checkpoint in estimating the accuracy of calculations is that the total calculated fuel consumption per fuel type should equal the consumption statistics for the level of activity considered. If however the calculated value does not match the true one, the "soft" input variables should be modified. "Soft" in this case denotes those variables associated with large uncertainty as for example the distribution of mileage in driving conditions (urban, rural, highway) and the respective average travelling speeds are those variables for which most attention should be given in most of the cases. Additionally, consumption statistics in some cases should not be considered as very accurate as they cannot reflect fuel smuggling and other illegal uses.

In principle systematic errors may be distinguished into two categories:

- Errors concerning emission factors and measurements (e.g. driving cycles applied)
- Errors concerning assessment of vehicle park and usage (e.g. errors in total kilometres travelled and in the average trip length as well as erroneous estimates of the vehicle park sub-categories.

Aviation

In this sector an important uncertainty parameter is the assessment of aircraft types. In our case the lack of relevant data does not allow the application of a higher Tier methodology and, hence, the emission factors used only partially reflect the aircraft fleet.

Navigation

In the navigation sector uncertainty is mostly connected to the general lack of data concerning the type of the engines of the ships as well as their use (fuel consumption for vessel categories) and ship movement information.

3.2.5.4 Source-specific QA/QC and verification

Road traffic

1. Cross-checking vehicles fleet comparing to the previous year data
2. Cross-checking fuel consumption data from the energy balance with the respective data calculated from COPERT IV.

3. Association of emissions trends with the input parameters trends.

Aviation

1. Cross-checking consumption data and number of flights
2. Cross-checking data trends and emissions trends

Railways/Navigation

1. Cross-checking data trends and emissions trends

3.2.5.5 Recalculations

Road transportation: CH4, N2O, CO, NOX, NMVOCs and SO2

A recalculation of the whole timeseries was carried out with more accurate and up-to-date input data and with the same methodological approach (COPERT IV). The whole emissions database is now coherent and credible in terms of input data used and calculation method applied.

Navigation

Minor changes in CH4 emissions (1990-2004) as well as in CH4 and N2O emissions from lubricants (1990-2008) were made due to an update of activity data used.

Aviation

Minor emissions changes were made due to an update of activity data used for years 2007 and 2008.

Railways

Minor emissions changes were made due to an update of activity data used for years 2007 and 2008.

International Bunkers

Minor emissions changes were made in international aviation, due to an update of activity data used for years 2005-2008.

As for marine bunkers, minor changes in CH4 emissions as well as in CH4 and N2O emissions from lubricants (1990-2008) were made due to an update of activity data used.

3.2.5.6 Planned improvements

Future actions for the improvement of the estimation of GHG emissions from transport include the following:

Road Transport

- The reconstruction of the whole timeseries fleet population and composition database is already being accomplished based on the most up to date and accurate data existed. However, the effort still continues for further improvement in the future.
- As was already mentioned in last year's NIR, the problem with emissions calculation cross-check using statistical data for energy consumption due to fuel smuggling and other illegal uses, was expected to be reconsidered in the following years, as from 2007 legal measures have been applied. As a matter of fact, in this year's statistical diesel consumption a relatively sharp increase is observed as a result of the new measures taken. As a result, the values of the calculated and statistically determined diesel consumption have now converged and are in much better accordance. Still new measures are planned to be taken from October 2011 to further limit fuel smuggling and illegal uses. In 2014 calculation data a better convergence between statictical and calculated diesel consumption is expected.

Aviation

- In the aviation sector, effort is being made to collect data on aircraft fleet composition but we have still major difficulties to be able to apply a more detailed methodology in the next NIR.
- The approaches for the allocation between internal and external transportation are investigated in collaboration with the Civil Aviation Organisation (CAO). After a survey by CAO, it was found that the only possible way to collect detailed data was through fuel companies. These data are subject to confidentiality issues. However, they will become available through the inclusion of the aviation sector in the EU ETS. It is expected that from 2012 new data will be available in this matter.

Navigation

- In the navigation sector, there is a very limited possibility to use detailed fleet data in order to calculate emissions. The application of the analytic methodology requires detailed data for the composition of the fleet and the routes performed, which are not available at present.

3.3 Fugitive emissions from fuels (CRF Source Category 1.B)

3.3.1 Coal mining and handling (CRF Source Category 1.B.1a)

3.3.1.1 Source category description

The geological process of coal formation also produces methane (CH_4), some of which remains trapped in the coal seam until it is mined. Generally, deeper underground coal seams contain more in-situ methane than shallower, surface seams.

Coal mining in Greece concerns exclusively the extraction of lignite. All lignite mines in Greece are surface mines and methane is emitted directly into the atmosphere, as the rock strata overlying the coal are removed during the process.

Fugitive emissions from coal mining and handling (CH_4 emissions) are a key category. CH_4 emissions (***Table 3.28***) from the mining of lignite in 2009 account for 1.36% of total GHG emissions from *Energy* and 1.12% of total national emissions (without *LULUCF*). Moreover, lignite mining is the third more important source of CH_4 emissions (following enteric fermentation and solid waste disposal on land) and is responsible for 15.7% of total methane emissions in 2009 (without LULUCF). A 25% increase for the period 1990 – 2009 is observed.

Table 3.28 ***CH_4 emissions from lignite mining (in Mt) and primary production of lignite (in kt) for the period 1990 – 2009***

Year	Production (Mt)	CH_4 emissions (kt)
1990	51.90	52.16
1991	52.70	52.96
1992	55.05	55.33
1993	54.82	55.09
1994	56.67	56.96
1995	57.66	57.95
1996	59.78	60.08
1997	58.84	59.14
1998	60.88	61.19
1999	62.05	62.36
2000	63.89	64.21
2001	66.34	66.68
2002	70.47	70.82
2003	68.30	68.64
2004	70.04	70.39
2005	69.40	69.74
2006	64.52	64.84
2007	66.46	66.80
2008	65.72	66.05
2009	64.89	65.22

3.3.1.2 Methodological issues

CH_4 emissions from lignite mining are calculated on the basis of lignite production and the use of typical emission factor (Tier 1 methodology), as information with regard to the availability of measurements that would allow the calculation of national factors do not exist. More specifically:

- The national energy balance is the basic source for the activity data (production of lignite, see Table 3.28) used for the calculation of emissions.
- The typical emission factor (1.5 m^3 / t of lignite) suggested by IPCC Good Practice Guidance (IPCC 2000), which also covers emissions from post-mining activities, is used. The density of methane has been considered equal to 0.67 kg / m^3.

3.3.1.3 Recalculations

No recalculation of emissions was performed.

3.3.2 SO2 scrubbing (CRF Source Category 1.B.1c)

3.3.2.1 Source category description

When SO_2 scrubbing technology is used in conjunction with combustion of coal, the process, which removes sulphur dioxide from the flue gas, also releases CO_2 from the chemical reactions during the process. Typically, calcium carbonate reacts with sulphur oxides in flue gas to produce calcium sulphate and carbon dioxide. The emissions of this category have been reallocated to the Industrial Processes sector (2.A.3), since 2010 submission.

3.3.3 Oil and natural gas (CRF Source Category 1.B.2)

3.3.3.1 Source category description

Activities related to primary production (extraction), processing, storage and transmission/ distribution of crude oil, petroleum products and natural gas are included in this sector. GHG released in the atmosphere during these operations is the direct result of leaks, disruptions and maintenance procedures. Moreover, the sector includes also emissions resulting from venting and flaring of gases that cannot be controlled by other means.

- The Greek market of oil and petroleum products comprises four refineries, approximately 50 companies active in the marketing of petroleum products and a large number of retailers and gas stations. The refining capacity of the four refineries exceed 19 Mt of crude oil.
- The basic infrastructure of the system for transport, storage and distribution of natural gas in Greece includes (a) the main pipeline with a length of 512 km, and branch pipelines to several cities with a length of about 754 km, (b) the terminal of the liquefied natural gas which includes two storage tanks with a total capacity of 130,000 m^3 and (c) the medium and low pressure distribution network of natural gas. The expected length of the low pressure network, to cover the needs of four major Greek cities (Athens, Thessalonica, Larissa and Volos) is 6,500 km.

GHG emissions (***Table 3.29***) from oil and natural gas in 2009 accounted for 0.18% of total GHG emissions from *Energy* and for 0.15% of total national emissions (without *LULUCF*). Overall, emissions in 2009 increased by 11% compared to 1990 levels.

The parameters affecting GHG emissions trends from oil and natural gas are the gradual penetration of natural gas in the Greek energy system and the domestic production of crude oil and natural gas.

- The introduction of natural gas in the Greek energy system started in 1996 and at the moment its development is in progress. Therefore an increasing trend in the future is expected.
- The domestic production of crude oil and natural gas (***Table 3.30a*** and ***Table 3.30b*** respectively) present a continuous decreasing trend and as a result emissions from venting and flaring are decreasing.

3.3.3.2 Methodological issues

GHG emissions from oil and natural gas are estimated according to the Tier 1 methodology described in the IPCC Good Practice Guidance (IPCC 2000). This methodology, based on a detailed description of the sub-systems comprising oil and natural gas industry, is different from the default methodology described in IPCC Guidelines (IPCC 1997) where emissions are correlated only to energy data.

Table 3.29 GHG emissions (in kt CO2 eq) from oil and natural gas for the period 1990 – 2009

Year	Oil	Natural gas	Venting and flaring	LPG transport	Total
1990	42.12	9.59	110.29	0.00	162.01
1991	40.94	9.19	109.70	0.01	159.84
1992	35.83	8.71	92.37	0.01	136.92
1993	29.44	5.70	75.45	0.01	110.58
1994	30.64	0.86	72.99	0.01	104.50
1995	28.52	0.66	65.15	0.01	94.34
1996	33.14	34.44	84.31	0.01	151.90
1997	31.55	42.71	79.29	0.01	153.56
1998	26.29	61.84	67.98	0.01	156.12
1999	13.28	66.23	29.41	0.01	108.93
2000	25.73	71.20	64.67	0.01	161.62
2001	22.26	77.29	56.08	0.01	155.64
2002	21.75	77.00	57.01	0.01	155.76
2003	20.31	86.35	49.17	0.01	155.85
2004	19.74	89.43	49.16	0.01	158.34
2005	18.83	90.25	45.29	0.01	154.37
2006	18.88	98.16	47.82	0.01	164.86
2007	18.17	102.71	46.16	0.01	167.05
2008	16.46	110.27	45.16	0.01	171.90
2009	16.7837	114.42	48.30	0.01	179.52

In relation to the estimation of emissions from oil systems, the following should be noted:

- The national balance of energy is the main source of information regarding the activity data, (see Table 3.30a) used for the calculation of emissions.
- Emissions are estimated for the following activities:
  - Primary production of crude oil (CO_2 and CH_4),
  - Crude oil transport by tankers (CO_2 and CH_4),
  - Refining and storage of oil products (CH_4, NOx, CO, NMVOC and SO_2),
  - Distribution of oil products (NMVOC) and

- LPG transport (CO_2 and N_2O).

- Emissions from crude oil transport are reported under Venting, while emissions from LPG transport are reported under Other (1.B.2d - Other).
- The CH_4 emission factor used for refining and storage derives from IPCC Guidelines (Table 1.58 – Western Europe, IPCC 1997). The CO_2 and CH_4 emission factors used in the rest sub-sources derive from IPCC Good Practice Guidance (Table 2.16, IPCC 2000). In all cases the emission factors are estimated as the average values of the proposed range.

Table 3.30a Key activity data for the estimation of GHG emissions from oil systems for the period 1990 - 2009

Year	Primary production		Imports	LPG
	Crude oil (kt)	Natural gas liquids (kt)	Crude oil (kt)	supply (kt)
1990	773	57	14539	277
1991	789	47	12362	304
1992	653	34	13967	330
1993	537	25	11777	357
1994	500	31	12914	369
1995	435	22	15329	412
1996	483	31	17529	443
1997	436	29	17957	462
1998	293	22	18569	498
1999	15	1	15944	462
2000	256	23	19371	454
2001	171	20	18906	472
2002	165	24	19116	431
2003	120	17	19782	410
2004	118	15	20297	407
2005	100	11	18699	520
2006	94	12	19836	520
2007	74	7	20330	568
2008	59	3	19286	568
2009	80	7	17780	804

In relation to the estimation of emissions from natural gas systems, the following should be noted:

- Activity data for the estimation of emissions (Table 3.30b) derive from the national energy balance and the Public Gas Corporation (length of transmission pipeline).
- Emissions are estimated for the following activities
  - Production and processing of natural gas (CO_2 and CH_4) and
  - Transmission and distribution of natural gas (CH_4).
- Emissions from transmission and distribution of natural gas for the period 1990 – 1995 (domestic natural gas only) are estimated according the Tier 1 methodology described in the

IPCC Guidelines, as the available information does not allow for the application of the Tier 1 methodology described in the IPCC Good Practice Guidance. However, the use of natural gas in that period is negligible (self-consumption in the energy sector and feedstock for ammonia production) and restricted at the area of production.

- The emission factors used for the estimation CO_2 and CH_4 emissions for the period 1996 – 2009 derive from the IPCC Good Practice Guidance (Table 2.16, IPCC 2000).

Table 3.30b ***Key activity data for the estimation of GHG emissions from natural gas systems for the period 1990 - 2009***

Year	Primary production		Distribution	Transmission
	Natural gas (10^6 m^3)	Sour gas (%)	Pipeline (km)	Pipeline (km)
1990	123	29%		
1991	116	37%		
1992	109	33%		
1993	81	33%		
1994	38	79%		
1995	36	69%		
1996	38	68%	519	511
1997	37	51%	1000	558
1998	33	61%	1337	837
1999	2	50%	1720	837
2000	36	47%	1870	862
2001	35	46%	1940	960
2002	37	73%	2014	960
2003	27	7%	2751	960
2004	25	20%	2899	960
2005	16	25%	3048	960
2006	23	17%	3196	1072
2007	21	14%	3332	1127
2008	14	21%	3534	1224
2009[15]	11	36%	3600	1266

In relation to emissions from venting and flaring (CO_2, CH_4 and N_2O), it should be mentioned that in most cases more that one variable is used as activity data (see ***Table 3.31*** for a detailed presentation of emissions from venting and flaring) and as a result significant inter-annual changes are observed in both emissions and implied emission factors.

[15] Provisional data

3.3.3.3 Recalculations

Recalculations were performed for the categories 1.B.2.b.3 and 1.B.2.c.1.2 for the years 2006-2008 and 1.B.2.b.4 for the years 2004-2008. The reason of the recalculations was the availability of updated activity data as concerns the activated NG distribution and transmission network. The impact of recalculation on total emissions was minor.

Table 3.31 GHG emissions (in t) from venting and flaring for the period 1990 – 2009

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Venting																				
Oil – Production																				
CO_2	11.99	12.02	9.85	8.04	7.64	6.55	7.40	6.70	4.55	0.23	4.05	2.80	2.79	2.02	1.95	1.61	1.55	1.18	0.89	1.27
CH_4	1348.88	1352.09	1108.20	904.79	859.52	736.80	832.63	753.86	512.16	25.94	455.84	314.73	314.09	227.42	219.84	181.48	174.10	132.54	99.97	142.52
Oil – Transport																				
CO_2	39.19	33.32	37.64	31.74	34.81	41.31	47.24	48.40	50.05	42.97	52.21	50.96	51.52	53.32	54.70	50.40	53.46	54.79	51.98	47.92
CH_4	425.93	362.15	409.17	345.02	378.33	449.07	513.53	526.06	543.99	467.09	567.49	553.87	560.02	579.53	594.62	547.80	581.11	595.58	565.00	520.88
N.G. – Production																				
CO_2	2556.00	3053.00	2556.00	1917.00	2130.00	1775.00	1850.34	1353.74	1427.11	78.11	1214.33	1144.16	1925.16	150.16	363.16	292.16	293.11	222.58	223.40	294.76
CH_4																				
N.G. – Transmission & Distribution																				
CO_2							8.18	8.93	13.39	13.39	13.79	15.36	15.36	15.36	15.36	15.36	17.15	18.02	19.58	20.26
CH_4							1608.19	2019.20	2930.86	3152.60	3376.35	3666.70	3650.11	4103.37	4249.79	4291.64	4666.11	4883.35	5245.24	5443.72
Flaring																				
Oil – Production																				
CO_2	66945	67104	54999	44904	42658	36567	41323	37414	25418	1287	22623	15620	15588	11287	10910	9007	8641	6578	4961	7073
CH_4	134.89	135.21	110.82	90.48	85.95	73.68	83.26	75.39	51.22	2.59	45.58	31.47	31.41	22.74	21.98	18.15	17.41	13.25	10.00	14.25
N_2O	0.64	0.64	0.53	0.43	0.41	0.35	0.39	0.36	0.24	0.01	0.22	0.15	0.15	0.11	0.10	0.09	0.08	0.06	0.05	0.07
N.G. – Production																				
CO_2	221.40	208.80	196.20	145.80	68.40	64.80	68.40	66.60	59.40	3.60	64.80	63.00	66.60	48.60	45.00	28.80	41.40	37.80	25.20	19.80
CH_4	1.35	1.28	1.20	0.89	0.42	0.40	0.42	0.41	0.36	0.02	0.40	0.39	0.41	0.30	0.28	0.18	0.25	0.23	0.15	0.12
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N.G. – Processing																				
CO_2	165.60	197.80	165.60	124.20	138.00	115.00	119.60	87.40	92.00	4.60	78.20	73.60	124.20	9.20	23.00	18.40	18.40	13.80	13.80	18.40
CH_4	1.04	1.25	1.04	0.78	0.87	0.73	0.75	0.55	0.58	0.03	0.49	0.46	0.78	0.06	0.15	0.12	0.12	0.09	0.09	0.12
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

3.3.4 Uncertainties and time-series consistency

In general, the uncertainty of emissions of the fugitive emissions from fuels sector is relatively high. The uncertainty associated with activity data is small, less than 5%, since the AD are obtained from the national energy balance and plant specific data. On the other hand, the uncertainty associated with emission factors is rather high (300%), since both the methodologies applied are of low tier (Tier 1) and the EFs are the default ones. The results of uncertainty analysis are presented in ***Table 1.9***. The detailed calculations of uncertainty are presented in Annex IV (***Tables IV.1 – IV.3***).

The time-series consistency of emissions is controlled by applying consistent methodologies inline with IPCC guidelines.

4. Industrial processes (CRF sector 2)

4.1 Overview of sector

This chapter includes information on GHG emissions from *Industrial processes* and description of the methodologies applied per source for the calculation of emissions.

According to the IPCC Guidelines, the following source categories are found in this sector:

- Mineral products
- Chemical industry
- Metal production
- Other production
- Production of halocarbons and SF_6
- Consumption of halocarbons and SF_6

The remainder of this chapter is organized as follows. Paragraph 4.1 continues with the presentation of emissions trends from *Industrial processes*, a brief description of the methodology applied for the calculation of GHG emissions and the assessment of the completeness of the GHG inventory for the industrial processes sector. Then the following paragraphs (4.2 – 4.14) present detailed information on the methodologies applied (including references on the activity data and the emission factors used) for the calculation of GHG emissions per source of emissions.

4.1.1 Emissions trends

In 2009, GHG emissions from *Industrial processes* account for 7.67% of total emissions (including LULUCF) and have decreased by 25.60% compared to base year emissions and by 9.88% compared to the emissions of 1990 (***Figure 4.1***), while the average annual rate of decrease is estimated at -0.26% for the period 1990 – 2009.

Emissions from *Industrial processes* are characterized by intense fluctuations during the period 1990 – 2009 reaching a minimum value of 9.17 Mt CO_2 eq in 2009 and a maximum value of 14.57 Mt CO_2 eq in 1999. The minimum value for 2009 is closely related to the effects of the economical recession whereas the maximum value is attributed to changes in industrial production and especially in HCFC-22 production. In the Chart of ***Figure 4.1*** a second higher value of emissions can be observed for 2005, also being related to HCFC-22 production, since in the next year the respective plant cease its operation and about 2,157 kt are removed from the inventory. It is also important to note that emissions in 2009 are for the first time since 1995 far below the base year, depicting the low production levels that industrial processes are suffering in the recent years.

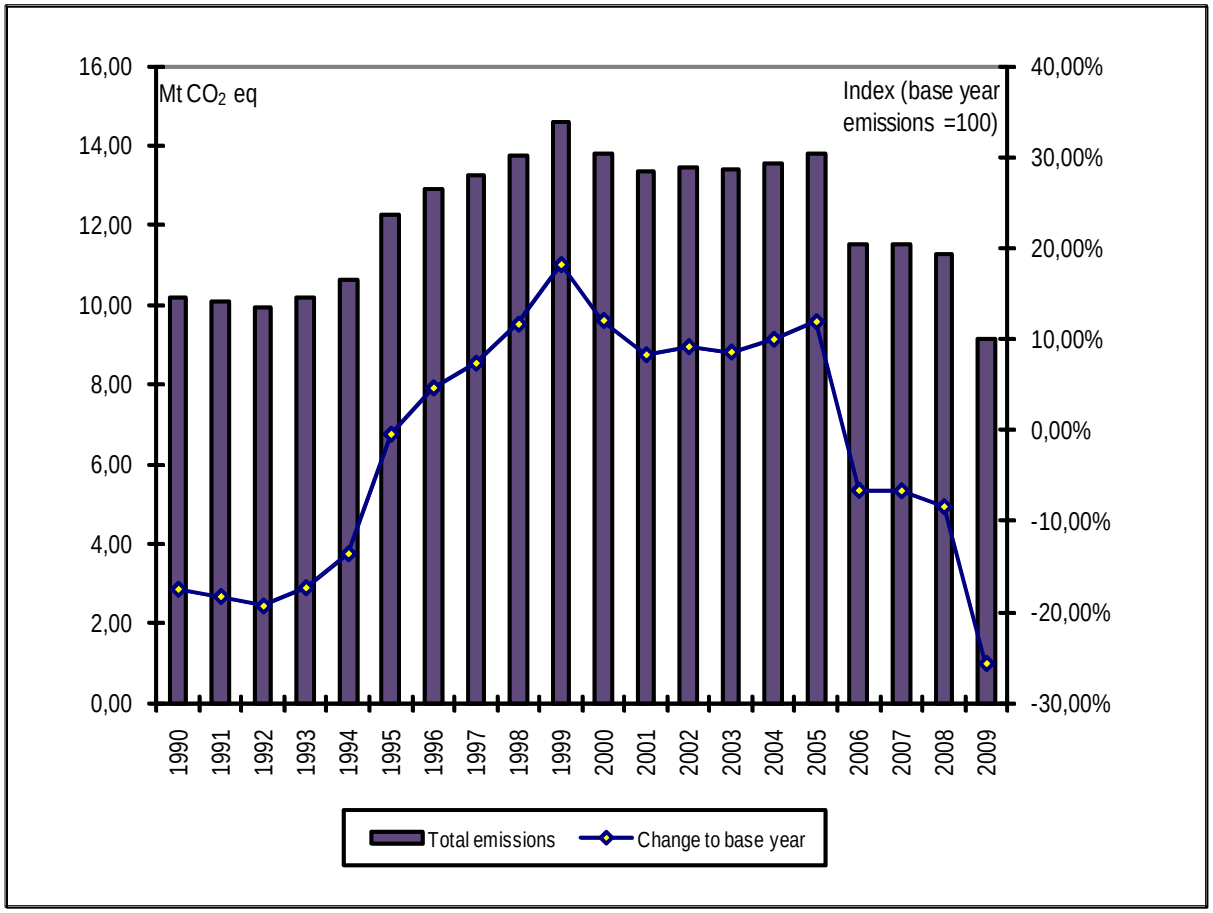


Figure 4.1 ***Total GHG emissions (in Mt CO_2 eq) from Industrial Processes for the period 1990 - 2009***

The sector of industrial processes is responsible for emissions of carbon dioxide, nitrous oxide, methane and F-gases. Emissions per gas from industrial processes are presented in ***Table 4.1***.

Carbon dioxide represents the major GHG from industrial processes, with a contribution ranging from 57.19% to 78.62%. Overall, CO_2 emissions in 2009 decreased by 25.43% from 1990, with an average annual rate of increase estimated at -1.01%. CO_2 emissions derive mainly from mineral products and metal production.

The contribution of F-gases to total emissions from industrial processes is also significant, increasing from 11.81% in 1990 to 37.64% in 1999 (peak). The contribution continues to be important until 2006 where an abrupt decrease is observed (from 29.26% in 2005 to 18.84% in 2006). This abrupt decrease is totally due to the cease of HCFC-22 production in 2006 (the contribution of emissions from HCFC-22 to total F-gases emissions was 53.44% in 2005). In the recent years (2006-2009) the trend is again increasing, following the substitution of CFCs according to the protocol of Montreal.

Nitrous oxide emissions (from chemical industry) present a declining trend during the period 1990 – 2009, with an average annual rate of change of -5.26%. The reduction of N_2O emissions in 2008 compared to 1990 levels is -61.92%, and is attributed to the reduction in the nitric acid production.

The contribution of CH_4 emissions (from chemical and metal industry) to total emissions from the sector is generally negligible, and since 2001 no emissions are reported due to the cease of ethylene and 1,2 dichloro-ethane production and emissions are only due to metal production. The average rate of decrease is 1.03% for the period 1990-2009.

Table 4.1 GHG emissions (in kt CO_2 eq) per gas from industrial processes for the period 1990 – 2009

Year	CO_2	CH_4	N_2O	HFC	PFC	SF_6	TOTAL
1990	7,863.03	0.73	1,109.04	935.06	263.38	3.07	10,174.31
1991	7,786.59	0.76	914.40	1,106.82	264,27	3.16	10,075.99
1992	7,820.78	0.71	956.20	908.39	258.36	3.26	9,947.71
1993	7,518.78	0.76	908.04	1,606.64	156.56	3.35	10,194.14
1994	7,527.41	0.75	882.84	2,143.91	96.05	3.45	10,654.41
1995	8,041.33	0.80	878.50	3,262.03	85.78	3.59	12,272.03
1996	8,045.38	0.80	1,003.21	3,772.29	73.61	3.68	12,898.98
1997	8,142.42	0.84	881.10	4,036.07	169.64	3.73	13,233.79
1998	8,291.90	0.82	725.06	4,531.22	208.53	3.78	13,761.30
1999	8,330.87	0.53	752.96	5,343.13	135.49	3.87	14,556.86
2000	8,609.72	0.47	771.07	4,274.52	151.70	3.99	13,811.46
2001	8,623.37	0.27	648.08	3,978.19	93.42	4.06	13,347.38
2002	8,527.24	0.39	623.93	4,210.49	90.66	4.25	13,456.96
2003	8,686.34	0.36	575.90	4,036.66	80.01	4.25	13,383.52
2004	8,709.95	0.41	547.53	4,221.57	73.22	4.47	13,557.15
2005	9,211.36	0.48	545.80	3,957.12	73.05	6.45	13,794.26
2006	8,966.52	0.51	442.70	2,032.02	62.43	8.37	11,512.54
2007	8,897.65	0.54	439.53	2,098.19	60.19	9.92	11,506.03
2008	8,302.08	0.52	422.30	2,482.95	76.08	7.53	11,291.46
2009	6,190.64	0.42	367,42	2,568.96	36.13	5.02	9,168.59

Throughout the inventory years, the main sources of emissions from *Industrial processes* are mineral products and production of halocarbons and SF_6 (***Figure 4.2***). Emissions show an upward trend until 1999. After 1999 this trend declines, mainly because of the gradual decrease of HCFC-22 production. A second higher value is observed in 2005, mainly as a result of the f-gases consumption contribution in combination with the cease of HCFC-22 production in the next year (2006). In the most recent years of the time series an ongoing decrease appears, resulting in an abrupt decline in 2009 mainly due to the important reduced production levels of mineral products.

As a result the contribution of GHG emissions from mineral sources and HFC production to the total sector emissions decreases from 75.81% in 1990 to 57.95% in 2009. The contribution of halocarbons consumption to total emissions from the sector has increased considerably in the recent years (28.07% in 2008 against 0.03% in 1995) due to the replacement of Ozone Depleting Substances (ODS), from halocarbons. The average annual rate of increase is 54.22% for the period 1995 – 2009. Finally, the contribution of emissions from the chemical production decreases from 13.27% in 1990 to 6.05% in 2009, whereas metal industry in general is more stable (11.90% in 1990 versus 7.90% in 2007).

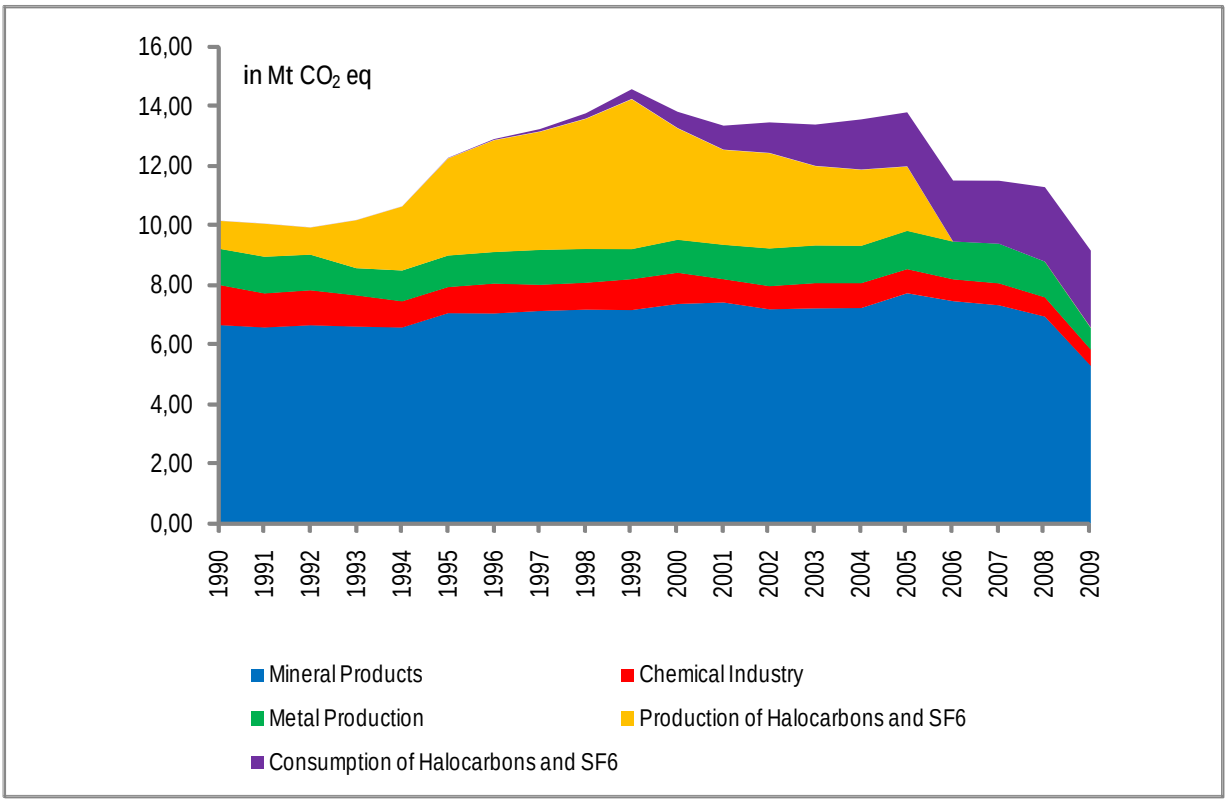


Figure 4.2 GHG emissions (in Mt CO_2 eq) from Industrial processes. per main source category for the period 1990 – 2009

4.1.2 Methodology

The calculation of GHG emissions from Industrial processes is based on the methodologies described in Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, the 2000 IPCC Good Practice Guidance, the 2006 IPCC Guidelines and the EMEP/CORINAIR Emission Inventory Guidebook 2007. Also, depending on data availability, country specific methodologies are implemented, mostly in cases of time series recalculation due to access of updated data, but also in cases where the lack of data does not allow the use of the above mentioned methodologies.

- CO_2 emissions from the majority of mineral and metal industries, as well as PFC emissions from primary aluminium production are estimated on the basis of country-specific emission

factors. These emission factors derive of plant specific activity and emission data in the context of the EU ETS, as well as from other information received by the plants and by the Hellenic Statistical Authority. All the information received is archived in the Input File, according to the Greek QA/QC system. For the Consumption of Halocarbons and SF_6 subcategory, emission factors have been estimated by the National Association of Refrigerating and Cooling Technicians. After the recommendations of the ERT Centralised Review in September 2010, Greece has re-evaluated and resubmitted emissions estimations using revised product lifetime factors in MAC and transport refrigeration subcategories. Default emission factors from the IPCC Guidelines and the IPCC Good Practice Guidance are used for the estimation of GHG emissions from the rest source categories of the sector.

- Activity data for the calculation of emissions from industrial processes are provided by the Hellenic Statistical Authority (El.Stat.). More specifically, in the recent years the data used in the inventory are substantially improved by the raise of confidentiality issues, after close cooperation with the ElStat, which has been achieved through various meetings between the inventory team and the Production Statistics Section of the service. Additionally, plant specific information has been collected through questionnaires for the formulation of the NAP and verified reports under the EU ETS (years 2005-2008). It should be noted that in some cases (cement production, glass production, primary aluminium production, ferroalloys production and HCFC-22 production) further information and data have been requested and provided by the plants. Such data are considered confidential in some cases and, therefore, are neither presented in the current report nor in the CRF tables.
- For the *Consumption of Halocarbons and SF_6*, data have been provided by market surveys, the National Statistics Authority (Division of Trade and Services Sector Statistics and Division of Secondary Sector Division), the National Organization of Medicines, the Public Power Corporation, the Hellenic Aerosol Association and other relevant private companies. As proved by source specific quality control checks, data show intense variations throughout the years. In order to use the more realistic values, several meetings have taken place between the inventory team, members of the ElStat, experts on the consumption of f-gases in the Refrigeration and A/C Equipment and experts on the implementation of the F-gases regulations in Greece. As regards to the foam blowing and aerosols subcategories data have been collected by the respective industries/importers.
- Finally, in some cases data have been recalculated to ensure consistency of the time series and to improve accuracy and completeness of the sectors. This has been mostly performed in the previous years in order to estimate emissions from the first time and also due to the availability of updated data.
- The methodology applied for the calculation of emissions per source category is briefly presented in ***Table 4.2***, while a detailed description is given in the corresponding sections (Sections 4.2 – 4.14).

Table 4.2 Methodology for the estimation of emissions from industrial processes

	CO_2		CH_4		N_2O		F-gases	
	Method	Emission factor	Method	Emission factor	Method	Emission factor	Method	Emission factor
Mineral products	CS, T1	CS, PS, D, OTH						
Chemical industry	T1a	PS	T1	D	D	D		
Metal production	CR, CS, T1	CR,CS, PS	CR	CR			T3	PS
Production of F-gases							T1	D
Consumption F-gases							T2, CS	D, CS

T1. T2. T2a. T3. T3b: IPCC methodology Tier 1. 2. 2a. 3 and 3b respectively

D: IPCC default methodology and emission factor

CS: Country specific emission factor and methodology

PS: Plant specific emission factor and methodology

Key categories

The key categories for 2009 (either with or without LULUCF) included in *Industrial processes* are presented in ***Table 4.3*** (see Paragraph 1.5 for a complete presentation of the results of the key categories analysis and Annex I for the presentation of the relevant calculations). It should be noted that the number of key categories in the IP sector has been substantially increased as a result of the breaking-up of larger categories in the key categories analysis, following the recommendations of the 2010 Expert Review Team.

Table 4.3 Key categories from industrial processes in the year 2008

Source category	Gas	Level assessment	Trend assessment
Cement production	CO_2	☒	☒
Lime production	CO_2		☒
Limestone and dolomite use	CO_2		☒
Nitric acid production	N_2O		☒
Ferroalloys production	CO_2		☒
Aluminium production	PFC		☒
HFC-23 from HCFC-22 production	HFC		☒
Consumption of halocarbons and SF_6 (ODS Substitutes)	HFC	☒	☒

Uncertainty

The results of the uncertainty analysis are presented in Paragraph 1.7, while the detail calculations are presented in Annex VII. Moreover in each of the sources described below the uncertainty will be discussed in the respective paragraph.

4.1.3 Completeness

Table 4.4 gives an overview of the IPCC source categories included in this chapter and presents the status of emissions estimates from all sub-sources in the industrial processes sector.

The completeness issue has generally been improved in the current inventory. The main improvements include the following subcategories:

- CO_2 emissions from magnesia production are included in the *Limestone and Dolomite Use* category since September 2010 (re-submission of files during the ERT Centralized Review).
- PFCs emissions from *Fire Extinguishers* and HFCs/PFCs emissions from *Solvents* as considered as Not Occurring since September 2010 (re-submission of files during the ERT Centralized Review).

The main reasons for the non estimation of GHG emissions refer to the lack of emission factors in the IPCC Guidelines (e.g. CO_2 emissions from *organic chemicals production* and *asphalt roofing-road paving with asphalt*). *Potential Emissions from the Consumption of Halocarbons and* Sf_6 are not estimated up to the present due to lack of data.

Table 4.4 Industrial processes – Completeness

	CO_2	CH_4	N_2O	HFC	PFC	SF_6
A. Metallic minerals						
1. Cement production	☒					
2. Lime production	☒					
3. Limestone and dolomite use	☒					
4. Soda ash production and use	NO/IE					
5. Asphalt roofing	NE					
6. Road paving with asphalt	NE					
7. Other						
Glass production	☒					
B. Chemical industry						
1. Ammonia production	☒	NA				
2. Nitric acid production			☒			
3. Adipic acid production			NO			
4. Carbide Production	NO	NO				
5. Other						
Sulphuric acid production	NO	NO	NO			
Organic chemicals production	NA / NE	☒ / NA	NA			
C. Metal production						
1. Iron and steel production	☒	☒				
2. Ferroalloys production	☒	NA				
3. Aluminium production	☒	NA			☒	
4. SF_6 used in aluminium and magnesium foundries						NA/NO
D. Other production						
1. Pulp and paper						
2. Food and drink	NA					
E. Production of halocarbons and SF_6						
1. Production of HCFC-22				☒		
2. Fugitive				NO	NO	NO
F. Consumption of halocarbons and SF_6						
1. Refrigerating and air conditioning equipment				☒	NA	NA
2. Foam blowing				☒	NO	NO
3. Fire extinguishers				☒	NA,NO	NO
4. Aerosols/metered dose inhalers				☒	NO	NO
5. Solvents				NA, NO	NA, NO	NA, NO
6. Semiconductor manufacture				NO	NO	NO
7. Electrical equipment				NO	NO	☒

NE: Not Estimated

IE: Included Elsewhere

NO: Not Occurring

NA: Not Applicable

4.2 Cement Production (CRF Source Category 2.A.1)

4.2.1 Description

Emissions of CO_2 occur during the production of clinker, which is an intermediate component in the cement manufacturing process. CO_2 emissions are attributed to the calcination of limestone (mainly $CaCO_3$), to produce lime (CaO) and carbon dioxide as a by-product.

Cement production (CO_2 emissions) is a key category by level and trend assessment. CO_2 emissions from cement production in 2009 (***Table 4.5***) accounted for 49.97% of total GHG emissions from industrial processes and for 3.83% of total national emissions including LULUCF (3.74% of total national emissions excluding LULUCF). The average annual rate of increase of CO_2 emissions from cement production during the period 1990 – 2009 was -0.87% (emissions decreased by 18.78% from 1990 to 2009).

Table 4.5 ***CO_2 emissions from cement production (in kt) and clinker production (in kt) for the period 1990 - 2009***

Year	Clinker production (kt)	CO_2 emissions (kt)
1990	10,645.13	5,640.90
1991	10,561.79	5,595.93
1992	10,831.27	5,738.26
1993	10,851.82	5,751.85
1994	10,930.92	5,792.37
1995	11,743.73	6,223.13
1996	11,773.83	6,240.61
1997	11,831.56	6,273.35
1998	11,789.07	6,249.41
1999	11,761.21	6,232.89
2000	12,071.73	6,399.72
2001	12,130.78	6,428.26
2002	11,666.18	6,180.91
2003	11,754.73	6,234.62
2004	11,754.73	6,230.48
2005	12,442.36	6,648.74
2006	12,244.24	6,460.86
2007	12,035.08	6,272.31
2008	11,361.40	6,053.53
2009	8,649.32	4,581.72

4.2.2 Methodological Issues

During the inventory preparation the calculation of CO_2 emissions from cement production is very important, as this is a key category by both trend and level assessment.

For the years 2005-2009 detailed data have been accessed via the verified EU ETS reports of the plants. These data refer to the quantities of carbonate raw material ($CaCO_3$, $MgCO_3$) used for the production of clinker. The general equation used for each of the eight operating cement plants is described in the following equation:

$$CO_2 Emissions = \sum_i \left(EF_i \cdot M_i \cdot F_i \right) - M_d \cdot C_d \cdot \left(1 - F_d \right) \cdot EF_d$$

where, EF_i is the emission factor for the particular carbonate i, M_i is the weight or mass of carbonate i consumed in the kiln, F_i is the fraction calcination achieved for carbonate i, M_d is the weight or mass of CKD not recycled in the kiln, F_d is the fraction calcination achieved for the CKD not recycled to the kiln, EF_d is the emission factor for the non-calcined carbonate in CKD not recycled to the kiln.

According to the collected data, in 2009 the average content of the raw materials in $CaCO_3$ and $MgCO_3$ has been estimated at 75.68% and 2.63%, whereas the emission factor used is 44% and 52.2%, respectively, deriving from the stoichiometry of the reaction. Also, the raw material used throughout 2009 was 13,178.98 kt.

As regards to the emissions from the non-calcined CKD not recycled to the kiln, these have already been included in the emissions from carbonates reported by the plants, therefore an assumption of F_d=1 has been used to avoid double counting.

In the recent years (2008 – 2009) the plants report also emissions from non-carbonate carbon (organic carbon). The percentage of organic carbon to the raw material has been low (average content of 0.19%) and the respective emissions constitute the 0.74% of total emissions from cement production.

Emissions prior to 2005 in the past were calculated using the Tier 2 methodology, based on clinker production. Following the change of the methodology to Tier 3, and acc to the IPCC GPG, the overlap method has been used in order to ensure the consistency of the time-series. This has been explained in detail in the NIR 2009, p. 125.

It should be noted that for the emissions estimated using the Tier 2 methodology (that is previous to the 2008 submission), the parameters of CaO and MgO content were determined using plant specific information collected during the formulation of NAP (See also NIR 2007, 2008 etc.).

For reasons of consistency between both the previous years and the other countries, the activity data of the more recent years (2005-2009) are still expressed in kt of clinker produced. The value of clinker is provided by the plants.

4.2.3 Uncertainties and time-series consistency

The uncertainty of the current category's estimations is quite low (2% for EF and AD), since the emissions are plant-specific and the reports of the emissions are being verified by accredited verifiers (all the cement plants of Greece are members of the EU ETS).

As regards to the time series, data are generally well in line in terms of methodology. This has been achieved by making use of the overlap method in 2009 in order to ensure the consistency of the time series (up to that year, emissions have been calculated using the Tier 2 and the country specific carbonates methodology described above). The recalculation methodology applied is in line with the IPCC GPG and has been approved by the ERT in the 2009 and in the 2010 centralised review. It should be noted that emissions since 2008 include emissions from non carbonate carbon used in the process, which was not the case for the other years. This might create a slight inconsistency in the time-series. Since up to now data are available only for two years and provided that emissions from cement production are a key category, the inventory team will recalculate the whole time-series in a future submission, in order to be able to use the collected data of more years to improve the representativeness of the emissions.

It is quite clear from the Chart in ***Figure 4.3*** that country's cement production is experiencing intense reduction in 2009, which is attributed to the economical recession that has been very important in the Construction Sector of Greece.

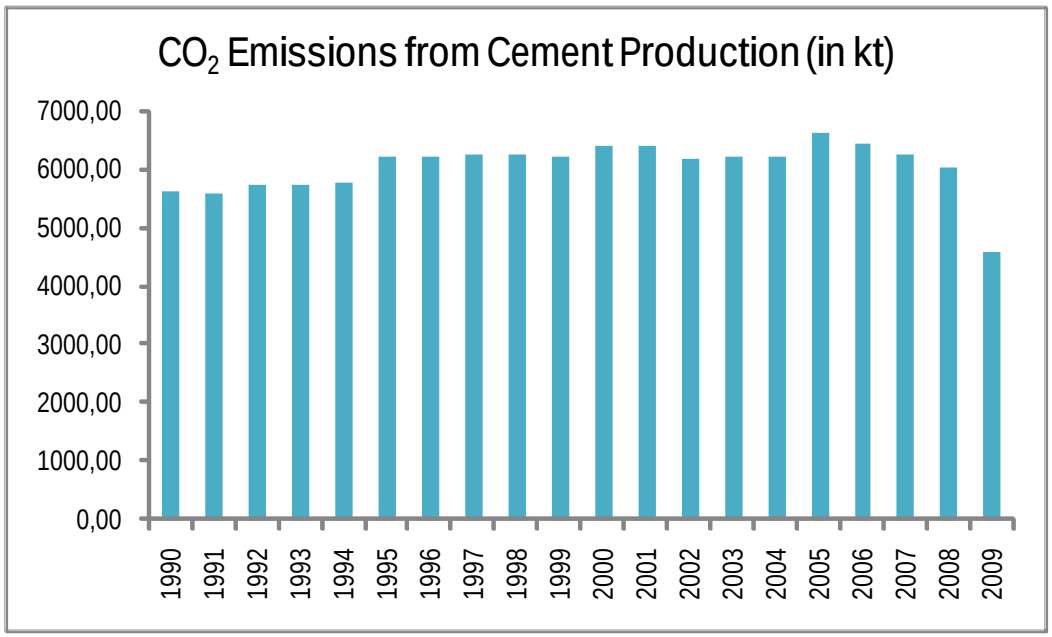


Figure 4.3 CO_2 emissions (in kt) from Cement Production for the period 1990 – 2009

Table 4.6 ***Country specific CO_2 emission factor (in t / t) for clinker (cement) production for the period 1990 - 2009***

Year	Emission factor ($t CO_2$ / t clinker)
1990	0.5299
1991	0.5298
1992	0.5298
1993	0.5300
1994	0.5299
1995	0.5299
1996	0.5300
1997	0.5302
1998	0.5301
1999	0.5300
2000	0.5301
2001	0.5299
2002	0.5298
2003	0.5304
2004	0.5300
2005	0.5344
2006	0.5277
2007	0.5212
2008	0.5328
2009	0.5297

During the years 1990-2005, emissions show some low level fluctuations (***Figure 4.3***). In general, annual variations of clinker production and, as a result, of CO_2 emissions are rather low, since a decrease in the domestic demand is counterbalanced by increased exports. However, there has been an abrupt shift in the production level between 1994 and 1995, amounting to 1 million tonnes of clinker produced. The shift was due to an increase of production in one particular plant, as result of a change in ownership which led to increased use of already existing production capacity. Also in the years 2005-2008 a general decrease of emissions is observed, a decrease that becomes very abrupt in 2009 probably due to the decreased infrastructure activity of the country in the recent years. The same situation has also been observed in other categories of the Industrial Processes Sector.

The IEF of 2009 is very close to the mean IEF of the previous years (0.5297 versus a mean of 0.5328), probably because the carbonates percentage of the raw materials is close to the values of previous years (***Table 4.6***). The average CaO and MgO content of clinker for the years 2005-2009, as provided by the plants, is presented in ***Table 4.7***.

Table 4.7 ***CaO and MgO content of clinker (2005-2008)***

Year	CaO content of clinker (%)	MgO content of clinker (%)
2005	64.68	2.93
2006	64.65	3.03
2007	64.47	3.26
2008	64.73	3.25
2009	65.00	2.79

4.2.4 Source-specific QA/QC and verification

In order to perform quality assurance activities, the total clinker produced reported by the plants is also checked with the value provided by the ElStat. In general the two sources agree, especially in the recent years where the produced clinker is additionally requested by the plants as a part of Greece QA procedures.

Because of the great decrease in emissions in 2009, the Inventory Team has also collected additional information for the sector by the ElStat. Indeed, the Production Index in Construction shows important decrease in 2009, with an average change of -19.9% with reference to 2008. According to provisional data made available by the same source, this will also be the case in 2010.

4.2.5 Recalculations

No recalculation has been performed in the 2010 submission. This is in line with the results of the 2010 Centralized Review.

4.2.6 Planned improvements

Gaps in activity data time series will be filled in as soon as new data become available. It should be noted that emissions from non carbonate carbon sources have been included only for the two last inventory years (namely 2008 and 2009), and a recalculation in order to improve the time-series consistency is likely to be performed in the years to come, after the collection of additional data.

4.3 Lime production (CRF Source Category 2.A.2)

4.3.1 Description

Lime production leads to carbon dioxide emissions because of the calcination of limestone ($CaCO_3$) or dolomite ($CaCO_3.MgCO_3$) to produce lime or dolomitic lime. Lime production in Greece is mainly based on limestone.

Lime production (CO_2 emissions) is a trend assessment key category. CO_2 emissions from lime production in 2009 (***Table 4.8***) account for 3.15% of total GHG emissions from Industrial processes and for 0.24% of total national emissions (including LULUCF) and are characterized by fluctuations, mainly because of the difference between plant-specific data and ElStat data. The

average annual rate of decrease of CO_2 emissions from lime production, for the period 1990 – 2009, is estimated at -1.61%.

Table 4.8 ***CO_2 emissions (in kt) from lime production and production of lime (in kt) for the period 1990 - 2009***

Year	CO_2 emissions (kt)	IEF	Lime production(kt)
1990	431.97	0.880	491.03
1991	412.89	0.880	476.17
1992	405.82	0.880	461.31
1993	392.63	0.886	443.21
1994	379.67	0.886	428.38
1995	392.00	0.884	443.49
1996	400.63	0.883	453.85
1997	409.96	0.875	468.46
1998	449.35	0.877	512.29
1999	481.76	0.889	541.63
2000	444.12	0.892	498.09
2001	426.38	0.892	477.76
2002	441.63	0.891	495.47
2003	388.41	0.891	435.71
2004	388.40	0.890	436.16
2005	372.30	0.874	425.98
2006	408.85	0.830	492.48
2007	468.98	0.844	555.97
2008	341.76	0.758	451.11
2009	288.78	0.758	380.77

4.3.2 Methodology

For years 2005 – 2009, the calculation of carbon dioxide emissions from lime production is based on the collection of plant-specific data on the type (s) and quantity(ies) of carbonate(s) consumed to produce lime, as well as the respective emission factor(s) of the carbonates consumed. The emissions are estimated according to the following equation, making use of plant-specific data provided by the verified reports of the plants under the EU ETS:

$$CO_2 Emissions = \sum_i \left(EF_i \cdot M_i \cdot F_i \right) - M_d \cdot C_d \cdot \left(1 - F_d \right) \cdot EF_d$$

where, EF_i is the emission factor for the carbonate i, M_i is the weight or mass of carbonate i consumed, F_i is the fraction calcination achieved for carbonate i, M_d is weight or mass of LKD, C_d

is the weight fraction of original carbonate in the LKD fraction, F_d is the fraction calcinations achieved for LKD and EF_d is the emission factor for the non-calcined carbonate.

The principal carbonates detected in the Greek lime industry were $CaCO_3$ and $MgCO_3$. The activity data resulted in 653.28 kt of $CaCO_3$ eq for the production of lime. The emission factor for $CaCO_3$ is 0.44 and for $MgCO_3$ 0.522.

As regards to the emissions from the non-calcined carbonate remaining in LKD, they have already been included in the emissions from carbonates reported by the plants, therefore an assumption of F_d=1 has been used to avoid double counting.

The lime production of Greece refers to high-calcium and hydraulic lime. Both values are provided by the ElStat for the years 1993-2008, whereas for the years 1990-1993 the missing data have been calculated using the trend extrapolation method as described in the IPCC GPG. In specific, lime production in the national statistics is reported as non hydrated lime, hydrated lime and hydraulic lime. The hydrated lime production data are converted to non hydrated lime using the correction for the proportion of hydrated lime as described in the IPCC GPG, using a water content of 28%. The average proportion of hydrated lime is 30%.

Especially for years 2008 and 2009 hydraulic lime data are provided directly by the sole plant producing it in Greece. The difference of the IEF that has been observed in 2008 continues in 2009 and therefore, the national production quantities have been reported (see also NIR 2010).

4.3.3 Uncertainties and time-series consistency

The uncertainty of the estimate is medium, although data derive of plant-specific, detailed reports of the plants in the context of the EU ETS. A value of 6% has been used for the emission factor accounting mainly for the uncertainty of lime composition (although data are available for the recent years, for the previous this was not the case). As regards to AD, a value of 5% has been used, provided the fact that the uncertainty of plant-specific weighting materials is at the level of 1-3%, while minor errors may derive from assuming 100% carbonate source from limestone. The non marketed lime has been taken into account: All the lime plants that report to the El Stat report also under the EU ETS, according to information received by the first. As regards to intermediate production of lime in the metal industry, it is only the aluminium industry that produces CaO by limestone and these emissions are reported under the Limestone and Dolomite Use category. Among the steel industries there is no lime production activity reported. It should be noted that these reports are also verified by external auditors, according to the basis of the Hellenic ETS system. Finally, as regards the sugar industry of Greece data indicate that indeed 3 out of 5 plants produce lime, but the CO_2 produced by the cracking of the carbonates is fully binded during the production process.

As regards to the time series consistency, the emissions have been recalculated in 2009 to improve the consistency between the different methods used. This has been performed by making use of the overlap method, as suggested in the IPCC Guidelines. The information over this recalculation can be found in the 2009 NIR. It should be noted that in the 2009 centralised reviews the ERT

concluded that "the recalculation methodologies used are in line with the IPCC good practice guidance".

In general emissions show some fluctuations throughout the years. This is due to the production levels, as well as to the IEF, that is calculated based on the reporting of the plants (the inclusion of minor carbonates changes the IEF from year to year). Especially for 2008 and 2009, important decreases depict the economical recession of the infrastructure sector.

4.3.4 Source specific QA/QC and verification

The source specific quality control is being performed by implementing the Tier 2 methodology using the ElStat production data.

The use of these data has resulted in a quite different IEF for years 2008-2009 than the one used in the previous years. Comparing to the default factors the above mentioned factor is in an accepted range however is more close to the factor used for dolomite lime than for the high calcium one. This issue has already been observed during the QC checks and any update will be provided in the next NIR.

4.3.5 Recalculations

A recalculation has been performed for emissions reported in 2006, due to an error in the working files. The difference between the previous and the current estimates and the impact on total emissions is -0.15% and 0.00% respectively.

4.3.6 Planned improvements

The main issue refers to the difference of the implied emission factor of 2008 and 2009 with reference to the previous years. Since this category is a key one, the inventory team has decided to collect more data in order to ensure the reported production level of the respective years. In case that any gaps in activity data time series shall be observed, it will be filled in as soon as new data become available.

4.4 Limestone and dolomite use (CRF Source Category 2.A.3)

4.4.1 Description

Limestone ($CaCO_3$) and dolomite ($CaCO_3.MgCO_3$) are basic raw materials having commercial applications in a number of industries including metallurgy (e.g., iron and steel), glass manufacture, agriculture, construction and environmental pollution control. In industrial applications involving the heating of limestone or dolomite at high temperatures, CO_2 is generated.

CO_2 emissions from limestone and dolomite use are a trend key category, according to the results of the analysis carried out in the present inventory. Emissions in 2009 (***Table 4.9***) accounted for 4.70% of total GHG emissions from *Industrial processes* and for 0.35% of total national emissions (without *LULUCF*).

Table 4.9 Limestone use (in kt) and CO_2 emissions (in kt) for the period 1990 – 2009

Year	Limestone & magnesite consumption (kt)	CO_2 emissions (kt)
1990	1,249.40	582.80
1991	1,215.96	563.20
1992	1,108.94	510.54
1993	1,006.80	466.33
1994	872.18	406.25
1995	938.32	439.93
1996	864.36	402.99
1997	948.03	442.40
1998	1,013.40	471.31
1999	949.46	439.59
2000	1,111.23	512.37
2001	1,195.47	549.56
2002	1,200.82	553.92
2003	1,287.63	588.84
2004	1,325.62	605.06
2005	1,516.05	698.61
2006	1,259.44	590.15
2007	1,237.94	577.19
2008	1,178.90	545.21
2009	948.24	431.03

4.4.2 Methodology

The present inventory includes emission estimates from limestone use in metal production (iron & steel and primary aluminium), SO_2 scrubbing, magnesia and ceramics production.

CO_2 emissions are estimated according to the following general equation:

$$CO_2 Emissions = \sum_i \left(M_i \cdot EF_i \cdot F_i \right)$$

where, CO_2 emissions refer to the emissions from iron & steel, primary aluminium and ceramics, M_i is mass of carbonate i consumed, , EF_i is the emission factor for carbonate i, and F_i is the fraction of calcination achieved for the particular carbonate.

In relation to the estimation of CO_2 emissions from limestone and dolomite use, the following are noted:

- **Steel production**: Data are generally plant specific, deriving from the EU ETS verified reporting of the plants (for the years 2005-2009) and the reporting performed for the NAP formulation in the previous years. For 2008, the total $CaCO_3$ equivalent amounts to 12.96 kt.
- **Primary aluminium production**: Data on primary aluminium production are plant specific and confidential (there is only one plant in Greece). The emission factor used is 0.44, whereas the single carbonate estimated is $CaCO_3$. Plant specific data on limestone consumption cover the years 1990 and 1998 – 2009. The specific limestone consumption has been used for filling in missing data. In 2009 the limestone consumption amounts to 116.72 kt of $CaCO_3$ eq.
- **Ceramics production**: Carbonates consumption data (in the context of the ETS reports) have been used to estimate emissions in the years 2005-2009. Activity data refer to $CaCO_3$ and $MgCO_3$ consumption (emission factors 0.44 and 0.522 respectively). The total $CaCO_3$ equivalent amounts to 210.06 kt, showing an important decrease (more than 50%) with reference to 2008. It is also interesting that eleven ceramics plant have declared zero emissions in 2009, as a result of the decreased market activity. Limestone consumption data are available also for the period 2000-2004 (questionnaires of the plants under the NAP formulation). Missing data for the period 1990 – 1999 were filled in on the basis of the ceramics production trend reported by the ElStat for the same period.
- **SO_2 scrubbing**: The operation of flue gas desulphurization systems in Greece started in 2000. The estimation of emissions is based on data collected during the formulation of the NAP for the period 2005 – 2007. For years 2005-2009 data from verified installation ETS reports were used. The emission factor used (0.44 t CO2 / t limestone) derives from the stoichiometry of the reaction. Emissions have increased considerably in 2009 as a result of the inclusion of new operation plants in the system.
- **Magnesia production:** Emissions are estimated using information for the single plant operating in Greece for the years 1999-2009 and the produced quantities of magnesia that have been provided by the Hellenic Statistical Authority for the years 1990-1998. The calculation of emissions for the whole time-series was performed according to the available data per year, as described in the following:
  - Years 2005-2009: for that period the following data were provided by the single plant operating in Greece:

    -the quantities and the chemical analysis of the magnesite used in the kilns

    -the production of magnesia (both types as a total)

    -detailed calculations of CO_2 emissions

    The emissions reported for that period were the ones provided by the plant, which have been verified by external verification bodies and reviewed by the competent authorities of Ministry of Environment, Energy and Climate Change (MEECC), in the context of EU Directive 2009/29/EC.

    Based on the $CaCO_3$ and $MgCO_3$ contents of the magnesite provided for the years 2005-2008, the implied emission factor (tn of CO_2/tn of magnesite) has been estimated in September 2010, which ranges between 0.4933-0.4975, depending on the $CaCO_3$ content

of magnesite (average calcium carbonate content at 2.59% versus to 92.34% average magnesium carbonate content). The IEF is very close to the one estimated in 2009, therefore the reporting is considered complete.

In the same time, using the quantity of magnesia produced, the emission factor of tn of CO_2/tn of magnesia produced has been estimated. This EF oscillates between 1.05-1.17, while the average is 1.10 t CO_2/t magnesia, and is considered a country specific one, as it has been estimated using information of the chemical analysis of the ore. This EF was used for the calculation of years prior to 1999, as it is described further below.

- Years 1999-2004: for that period the quantities of magnesite used in the kilns and the production of magnesia (both types as a total) has been provided by the single plant operating in Greece. Emissions have been estimated using the quantity of magnesite produced and the average carbonate contents of the years 2005-2008 in order to ensure the consistency between the time-series.
- Years 1990-1998: As regards to the years previous to 1999, the produced quantities of magnesia have been provided by the Hellenic Statistical Authority, since there were more than one plant operating in Greece in the period 1990-1999. Emissions have been calculated using the average EF of 1.10 t CO_2/t magnesia that has been estimated from the years 2005-2008, in order to ensure time-series consistency. In order to report activity data in the form of magnesite consumption (instead of magnesia), as it is required by the CRF reporting and since emissions from magnesia production are only a part of the emissions from Limestone and Dolomite Use, for the years 1990-1998, the IEF of 0.4951 t CO2/t magnesite (mean value of the detailed estimations of 2005-2008), has been used backwards.

It should be noted that, provided that data on the fraction calcination achieved are not available, it has been assumed that the fraction calcination is equal to 1.

4.4.3 Uncertainties and time-series consistency

In general the uncertainty associated with the emission factor for this source category is relatively low, as the emission factor is the stoichiometric ratio reflecting the amount of CO_2 released upon calcination of the carbonate. In practice, there are uncertainties due, in part, to variations in the chemical composition of the limestone and other carbonates and therefore the value of 5% is being used to account for the EF uncertainty.

Assuming that carbonate consumption is allocated to the appropriate consuming sectors/industries, the uncertainty concerning the activity data is associated with the weighing or proportioning of the carbonates and with the overall chemical analysis pertaining to carbonate content and identity. Therefore the uncertainty value associated with the activity data is estimated at 10%. This uncertainty value also accounts for the assumption of 100% calcination.

The time-series consistency is ensured by the fact that the applied methodology is consistent with the IPCC Guidelines and remains the same throughout the time-series. A slight difference of the emission factor used in the most recent years (2005-2009) is attributed to the fact that the IEF for

magnesia production (0.495 t CO_2/t magnesite) is also taken into account, leading to a value higher than 0.44.

In order to transform the carbon of the pet coke to carbonates equivalent, the carbon content of pet coke must be known. However, this is not reported by the plants, in a way that the activity data correspond to all the other emissions.

4.4.4 Source specific QA/QC and verification

The verification of the activity data by alternative sources is generally hard to be performed, given the complexity and the divergence of the manufacturing plants. In addition, although the activity data used are plant specific, the uncertainty of the estimation of emissions from limestone and dolomite use is increased by the fact that in some cases there is no production data available by the ElStat (i.e. ceramics production) in a way that it is really difficult to estimate emissions in different tiers. It should be noted however that all the reports made available in the ETS context have been additionally checked by external accredited verifiers, as defined by the Greek ETS system, and also that whenever available data are being cross-checked with information from different sources (i.e. in the case of magnesia production, as described above).

Especially for the magnesia production data have been available by different sources that include the National Statistics, a PhD thesis that includes production data of previous years and available information from the Greek Mining Enterprise Association. The different sources generally agree, mainly due to the low number of the respective industries.

4.4.5 Recalculations

No recalculations have been performed since the 2010 re-submission of files during the September 2010 Centralised Review of the inventory.

4.4.6 Planned improvements

The current submission can be considered satisfactory. In addition, the resubmitted data and the methodologies used were approved and accepted by the ERT in the 2010 Centralised Review. In case that any gaps in activity data time series shall be observed, it will be filled in as soon as new data become available.

4.5 Glass production (CRF Source Category 2.A.7.1)

4.5.1 Description

Glass production leads to carbon dioxide emissions due to the thermal decomposition of carbonate compounds included in raw materials.

CO_2 emissions from glass production are not a key source. CO_2 emissions from glass production in 2009 have decreased by 33.99% compared to 1990 levels (***Table 4.10***), represent 0.15% of GHG emissions from *Industrial processes* and 0.01% of total GHG emissions (including LULUCF).

Table 4.10 Glass production (in kt) and CO2 emissions (in kt) for the period 1990 - 2009

Year	Glass Production (kt)	CO_2 emissions (kt)
1990	134.94	20.20
1991	124.57	18.65
1992	97.26	14.56
1993	99.71	14.92
1994	108.55	16.25
1995	117.32	17.56
1996	126.10	18.88
1997	134.87	20.19
1998	143.65	21.50
1999	152.42	22.82
2000	161.20	24.13
2001	169.91	25.43
2002	170.75	25.56
2003	147.27	22.04
2004	138.16	20.68
2005	129.54	18.16
2006	103.09	14.50
2007	115.91	17.38
2008	114.44	17.15
2009	93.66	13.33

4.5.2 Methodology

In the recent years, the estimation of carbon dioxide emissions from glass production is based on accounting for the carbonate input to the glass melting furnace, by using the following equation:

$$CO_2 Emissions = \sum_i \left(M_i \cdot EF_i \cdot F_i \right)$$

where, M_i is mass of carbonate i consumed, , EF_i is the emission factor for carbonate i, and F_i is the fraction of calcination achieved for the particular carbonate. The reported carbonates are Na_2CO_3, Ca_2CO_3 and K_2CO_3 with emission factors 0.415, 0.44 and 0.522 respectively. The implied emission factor for 2009 is 0.14 t/t.

- Since February 2006 there is only one plant operating in Greece, whereas since 2005 this plant used to have two factories. Production data have been given for both factories for years 2005-

2006 and for the only plant left for the years 2007-2009. Also for the years 2005-2009 the reports in the EU ETS context have been extensively used.

- Activity data (glass production) for the period 1990 – 1992 are provided by the ElStat, while activity data for the period 2001 – 2004 were collected (through questionnaires developed according to the guidelines described in the Commission Decision 2004/156/EC) in the framework of the formulation of the NAP for the period 2005 – 2007, according to the EU Directive 2003/87/EC.
- Activity data for the period 1993 – 1999 were estimated by means of a linear interpolation due to the lack of sufficient official data for that period.

4.5.3 Uncertainty and time-series consistency

The estimated uncertainty concerning the glass production category is relatively low. The emission factor is stoichiometric, corresponding to a 3% uncertainty value, while the uncertainty estimate for the AD mainly lays on the uncertainty of the plant-level weighting of the materials and is considered to be 5%.

As regards to the time-series consistency, data have been recalculated in 2009 using the overlap method. Information on the performed recalculations is given in the 2009 NIR submission. It should be noted that the methodology used is in line with the IPCC GPG.

- As it can be observed in the ***Figure 4.4***, emissions of the period 2002-2006 show a continuous decrease. This slope is justified by the fact that one of the two glass industries that were operating in Greece at that period was about to close and has reduced significantly the annual glass production. Moreover, the other glass industry had invested in plants of neighbour countries, making easier the import of glass to Greece.
- Emissions in 2008 decreased by 1.27% with regards to 2007. This increase is not well in line with the slight increase observed in the production level (by 0.30%). According to the activity data this difference is due to the fact that the carbonate contents of soda and of dolomite are lower than the ones reported in 2007.
- Emissions in 2009 have decreased by 22,28% with reference to 2008, with a similar decrease in the production levels as a result of the economical recession of the Greek Industrial Processes Sector.

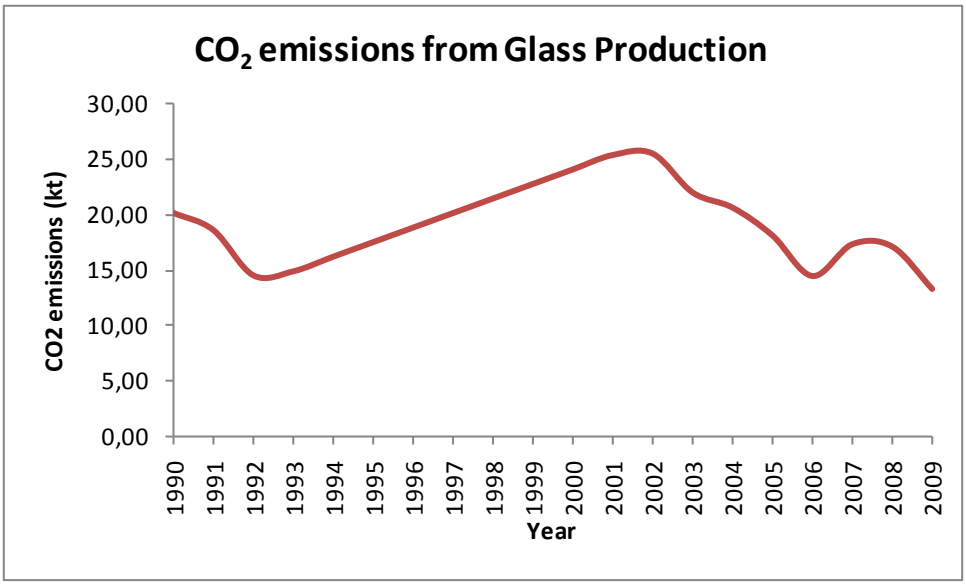


Figure 4.4 CO_2 emissions (in kt) from Glass Production for the period 1990 – 2009

4.5.4 Source specific QA/QC and verification

The category-specific QA/QC procedures regard the estimation of emissions with different tiers, since all the data refer to only one plant operating in Greece. The default emission factor as described in the CORINAIR Guidelines (SNAP 03314-03317) is 0.15 kg CO_2/kg glass produced for the case of container glass, leading to emissions that are very closed to the ones described by the plant. In any case the divergence is explained by the plant, and is attributed to the range of the cullet ratio and the desired quality of the production.

4.5.5 Recalculations

No recalculations have been performed in the 2011 submission. This is in line with the conclusions made by the ERTs in the 2009 and 2010 centralised review.

4.5.6 Planned improvements

The current submission can be considered satisfactory for the time being. In case that any gaps in activity data time series shall be observed, it will be filled in as soon as new data become available.

4.6 Ammonia production (CRF Source Category 2.B.1)

4.6.1 Description

Carbon dioxide is emitted as an intermediate product during the production of anhydrous ammonia. Catalytic steam reforming of the fuel used as feedstock (carbon source) takes place during the production process, leading to the release of CO_2 emissions.

Up to 1999 there were two ammonia plants in Greece. The first one has been operating since 1990, with an interruption between the years 1994-1997. It should be mentioned that imported Natural Gas was introduced to the Greek energy system by the Public Gas Company (DEPA) in 1996 and that till 1996 the NG consumption in Greece corresponds to small amounts of domestic NG explored by the company Kavala Oil. As a result, the plant has been using natural gas, provided by the Public Gas Company SA (DEPA) since 1998 while in the years 1990-1993 natural gas has been provided to the plant by the Kavala Oil Corporation.

The other plant has been operating since 1990 and up to 1999 with intervals. According to information already provided in NIR 2010, it used lignite as feedstock until 1991, and liquid fuels until its closure. In absence of gas consumption data, only CO_2 emissions from the first plant have been estimated CO_2 emissions in IP refer to emissions from natural gas (years 1990-1993 and 1998-2007), whereas emissions from the other fuels used (years 1990-1999) are included in the energy sector.

CO_2 emissions from ammonia production are not a key category by trend assessment, although it used to be in the past. As it has been explained in previous submissions, this was probably because emissions of 1990 were estimated in the energy sector, and therefore, they were misleadingly accounted for non-existing in the base year. The use of updated data from the Kavala Oil Corporation led to the correction of values and changed the results of the trend analysis regarding the specific Sector. CO_2 emissions have decreased by 21.92% since 1990 and by 18.56% since 2008 and represent 2.05% of total GHG emissions from *Industrial processes*.

4.6.2 Methodology

The methodology used for the estimation of CO2 emissions is based on the following equation (Tier 1a, IPCC 1996):

$$E = TRF \cdot CCF \cdot COF \cdot 44/12$$

where E stands for CO_2 emissions, TRF is the total fuel requirement (GJ of natural gas), CCF is the carbon content factor, COF is the carbon oxidation factor and 44/12 is the stoichiometric ratio of carbon dioxide to carbon. The country specific carbon content of fuel (natural gas) is estimated as described:

- The CC of domestic NG is 16.20 tC/TJ (it is the mean value of CC of NG from the different reservoirs that NG was extracted). This value has been used for years 1990-1993.
- The CC of imported NG is calculated basing on the chemical composition data of natural gas provided by DESFA (Hellenic Gas Transmission System Operator S.A.), as described in 3.2.4.4.2 of the present NIR. The CC of imported NG per year is presented in ***Table 4.11***:

Table 4.11 Carbon Content of imported NG for years 1997-2009

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CC (tC/TJ)	15.03	15.03	15.03	15.03	15.10	15.10	15.11	15.11	15.10	15.10	15.10	15.12	15.14

The carbon oxidation factor is assumed to be 100%.

Activity data concerning fuel consumption for the years 1998-2009 have been provided by the plant using natural gas and by DEPA. National ammonia production for the whole time-series has been provided by the El Stat and for the years 1998-2009 by the one plant still operating in Greece. All the activity data and the estimated emissions are presented in ***Table 4.12***.

Table 4.12 ***Ammonia production, natural gas consumption and CO_2 emissions for the period 1990 - 2009***

Year	Aluminium Production (kt)	NG consumption (TJ)	CO_2 emissions (kt)
1990	313.03	4,046	240.28
1991	255.61	3,866	229.59
1992	167.94	3,667	218.32
1993	69.78	2,370	140.72
1994	NO	NA	NO
1995	96.98	NA	IE
1996	133.91	NA	IE
1997	122.16	NA	IE
1998	244.76	3,221	177.48
1999	233.32	5,152	283.96
2000	147.48	5,006	275.90
2001	68.70	2,452	135.77
2002	94.14	2,816	155.94
2003	150.18	4,918	272.40
2004	159.92	5,224	289.46
2005	143.90	4,756	263.30
2006	160.90	5,285	292.59
2007	165.77	5,402	299.16
2008	125.91	4,156	230.37
2009	102.86	3,379	187.61

4.6.3 Uncertainty and time-series consistency

Although the data are plant-specific, a level of uncertainty originates from the fact that the gaseous inputs are generally more uncertain that the liquid or solids inputs. Therefore the EF uncertainty value used has been evaluated at 6%, based on a country-specific estimation. As regards to the activity data, in general the accounted uncertainty is considered quite lower (3%), on the basis that

data are plant-specific and have been quality checked by the input of different sources, as described in paragraph 4.6.4.

The emissions over the time-series are characterised by intense fluctuations. This is due to the fact that the operation of both plants was quite unstable, while part of the emissions is still accounted in the energy sector. Emissions show a minimum in 2001 (135.77 kt CO_2) and a maximum in 2007 (299.16 kt CO_2). The IEF values also show significant variation throughout the time-series, since the emissions that resulted from the use of solid fuels are not included, and thus part of emissions from the reported ammonia production are included in the energy sector. It should be noted however that the emissions factors of kt CO_2/TJ of NG is quite stable throughout the inventory years, as already described above.

4.6.4 Source-specific QA/QC and verification

The source-specific QA/QC procedures include the comparison of emissions calculated with different tiers. The default EF reported in the IPCC 1996 Guidelines is 1.6 t CO2/t ammonia produced for Canada and 1.5 t CO2/t ammonia produced. Both values are lower to the estimated IEF, however according to other sources the country specific emission factor is in the range of reported emission factors. This can be clearly seen in ***Figure4.5***.

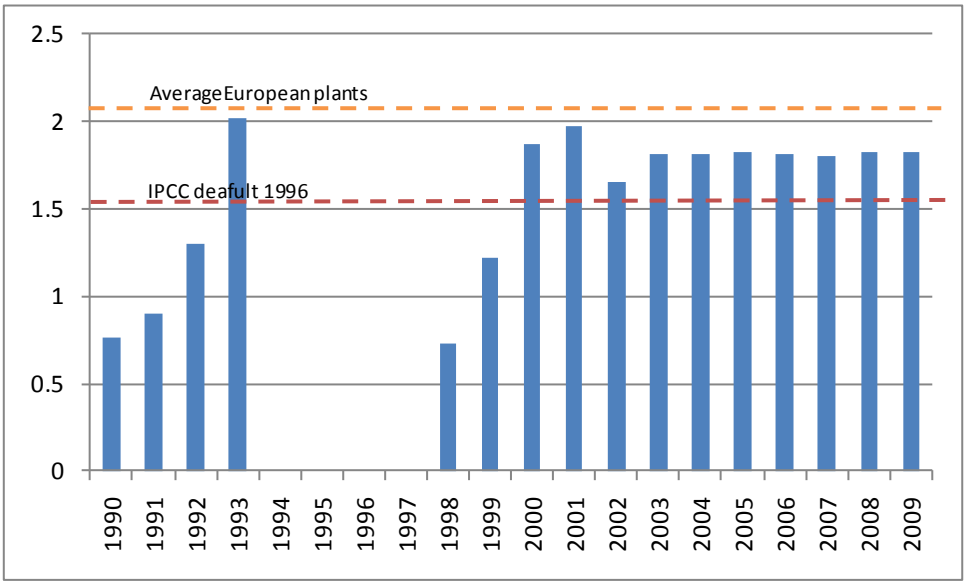


Figure 4.5 Fluctuation of the IEF in the inventory years

Additional QC checks include the gathering of data from different sources. This is being performed in two ways:

1. Ammonia production: the plant-specific production data are cross-checked with alternative sources. These sources include_ElStat(Prodcom department, confidential data) and the Ministry of Economy, Competitiveness and Shipping have been used, whenever available.
2. NG Consumption: The natural gas quantity used by the one plant operating in Greece is gathered by both the NG provider (DEPA) and by the sole plant producing ammonia in the recent years. In addition, for years 1990-1993 data have been received by Kavala Oil. In order to ensure time-series consistency and also consistency with the energy sector, DEPA and national statistics are being used, while the ammonia's producer information is gathered for additional QC use. In general there is a difference of 5% between the two values, which can be considered quite stable and is attributed to the general uncertainty of the gaseous fuels input.

4.6.5 Recalculations

The emissions that are described in the previous paragraphs have been estimated and submitted in September 2010. The estimations have been generally approved by the Expert Review Team in the Centralised Review; however there was a recommendation to re –check the values of 2008. This has been performed and the reported data of the energy sector have been corrected, while no recalculation has been performed in the IP sector.

4.6.6 Planned improvements

Up to now the methodology used is Tier 1a and the EF is country or plant specific. However, Greece would like to kindly indicate that the corresponding methodology is the higher available in the 1996 IPCC Guidelines.

In addition, and following the internal QC procedures, there is an implemented improvement plan in ammonia production sector that has as follows:

- An effort is being made to define the liquid fuel used as feedstock for ammonia production in the years 1992-1999, procedure that has been proved quite difficult up to now. In order to ensure the time-series consistency the Industrial Sector inventory team is working closely with the Energy sector team in order to define the pre-mentioned fuel.
- Once the liquid fuel is defined, the default methodology can be used for the estimation of emissions, using the ammonia production data.
- The fuel quantities estimated will be reallocated from the Energy to the IP sector.

In case that any other gaps in activity data time series shall be observed, it will be filled in as soon as new data become available.

4.7 Nitric acid production (CRF Source Category 2.B.2)

4.7.1 Description

Emissions of nitrous oxide are generated during nitric acid production and specifically from the process of catalytic oxidation of ammonia under high temperature.

Nitric acid production (N_2O emissions) is a key category by trend assessment. Nitrous oxide emissions from nitric acid production in 2009 (***Table 4.13***), account for 4.01% of total GHG emissions from *Industrial Processes* and for 0.30% of total national emissions (without *LULUCF*). Emissions have decreased by 66.87% from 1990 to 2009.

Table 4.13 ***Nitric acid production (in kt) and N_2O emissions (in kt) for the period 1990 – 2009***

Year	HNO_3 production (kt)	N_2O emissions (kt)
1990	511.08	3.58
1991	421.38	2.95
1992	440.65	3.08
1993	418.45	2.93
1994	406.84	2.85
1995	404.84	2.83
1996	462.31	3.24
1997	406.04	2.84
1998	334.13	2.34
1999	346.99	2.43
2000	355.33	2.49
2001	298.65	2.09
2002	287.53	2.01
2003	265.39	1.86
2004	252.32	1.77
2005	251.52	1.76
2006	204.01	1.43
2007	202.55	1.42
2008	194.61	1.36
2009	169.32	1.19

4.7.2 Methodology

N_2O emissions from nitric acid production are estimated according to the following equation (default methodology, IPCC 2000):

$$E = P \cdot EF \cdot (1 - D \cdot U)$$

where, E is N_2O emissions, P is nitric acid production, EF is the emission factor, D is the N_2O destruction factor and U is the abatement system utilisation factor on an annual basis

The following are noted in relation to the application of the above equation:

- The emission factor used is the average of the default values suggested by the IPCC Guidelines (IPCC GPG, 2000) for units operating under medium pressure (7 kg N_2O / t HNO_3).
- Nitric acid production data derive from El.Stat and the individual industrial units for 1990-2009. Actually in the recent years there is only one unit producing nitric acid in Greece therefore, data are sent directly to the inventory team by the unit.
- The abatement system used by the Greek installations for reduction of NO_x emissions is the absorption tower. This technology does not affect the N_2O emissions (IPCC 2000), and for this reason D and U parameters in the above mentioned equation are not considered.

4.7.3 Uncertainty and time-series consistency

The uncertainty arisen by the currently implemented methodology has been considered equal to 20% for the emission factor and 2% for the production data used. The high value of the emission factor's uncertainty is attributed to the fact that the default EF has been used that is prone to be different from the actual value. In specific, the plant has communicated to the inventory team that no further knowledge of the possibility of the unintentional N_2O production is available at the time being. As regards to the AD accuracy, the uncertainty value accounts mainly from the uncertainty of the produced nitric acid quantity.

The time-series consistency of emissions is assured by applying consistent methodologies and verified activity data in line with IPCC guidelines. In the case of nitric acid production, the default methodology has been used for the whole time-series.

The trend of the time-series can be seen in ***Figure 4.6***. As it can be seen from the Figure, the trend is generally decreasing. Since the same emission factor has been used for all the years of the time series, according to the information provided by the plant, the decrease of the emissions indicates the general decrease of the production level. This decrease has been quite intense in 2009, indicating the effects of the economical recession (decrease by 13% from 2008 level of emissions).

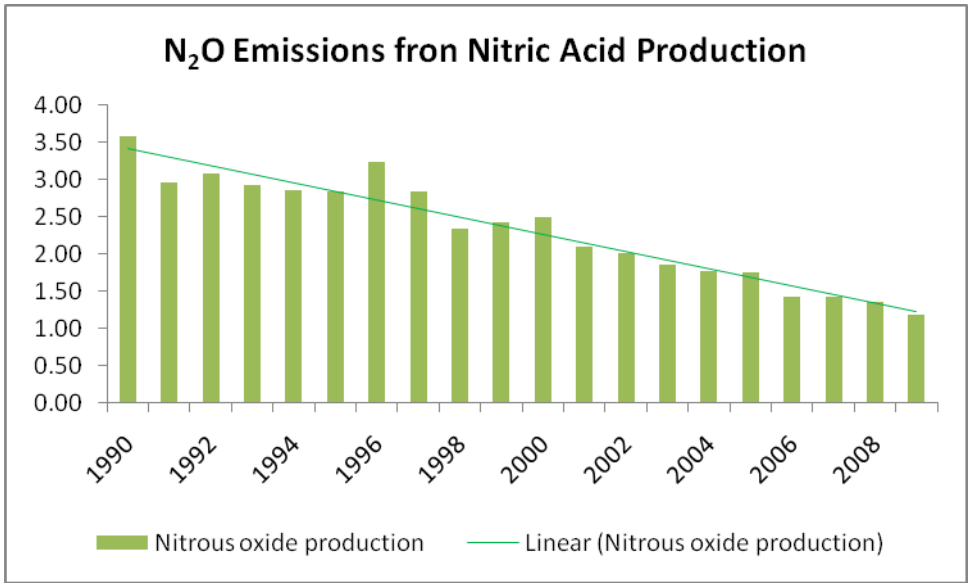


Figure 4.6 N_2O emissions (in kt) from Nitric Acid Production for the period 1990 – 2009

4.7.4 Source-specific QA/QC and verification

According to the QA/QC procedures, all the information received by the plants is archived in the Input File of the Greek Inventory system. For the time being, the available data does not allow the estimation of the emissions with an alternative Tier.

Additionally, the plant specific data are being cross-checked with confidential data collected by the ElStat and the Ministry of Economy, Competitiveness and Shipping, depending on data availability.

In specific, the main source for the estimation of emissions is the data received directly by the one plant operating in Greece. Additional Quality Control Checks make use of confidential information provided by the ElStat, regarding HNO_3 production. Although PRODCOM data are provided each year, they may not be finalized by the annual submission of the inventory to the UNFCCC, following the QC procedures of the Service (however, even in that case the Service unofficially provides the Inventory Team with the provisional data). In that case the final QC checks may take place in the following year, and the respective results are presented in the next submission.

The Ministry of Economy, Competitiveness and Shipping is also collecting information on the production of HNO_3 in the context of Industrial Activity Reports; however the frequency of the reporting is not always standard. As a result, the use of the specific source for the running of additional QC checks is performed on the basis of data availability.

4.7.5 Recalculations

During the 2009 data collection in came into the attention of the Inventory Team that the 2008 value has been also provided by the plant for 2009. Following the QC System the Inventory Team has filed this in the Correction Files and during the Inventory Preparation the issue has been addressed to the plan. Indeed the plant has given the mistakenly reported the 2009 value for 2008, thus the corrected value has been replaced in the inventory files and emissions have been recalculated for this year.

The difference between the previous and the current estimates and the impact on total emissions is 14.94% and 0.04% respectively.

4.7.6 Planned improvements

Although this category is a trend key one, it has not been included in the 2011 Improvement Plan. This is justified by the fact that the current category is trend key one due to the continuous decrease of nitric acid production and, thus, the bearing of cost of additional measurements, which are required by higher tier methodologies, seems quite irrational to the plant. The inventory team would also like indicate that the implementation of the default methodology is in line with the IPCC GPG, and emissions have been estimated using information regarding the categorization of the plant type and the selection of the appropriate N_2O generation factor.

For these reasons, the current submission can be considered satisfactory. In case that any gaps in activity data time series shall be observed, it will be filled in as soon as new data become available.

4.8 Production of organic chemicals (CRF Source Category 2.B.5)

4.8.1 Description

CH_4 and NMVOC emissions from the production of ethylene and 1,2 dichloro-ethane as well as NMVOC emissions from the production of polyvinylchloride and polystyrene are included in this category.

The contribution of this category to total GHG emissions from Industrial processes is negligible (less than 0.01% for the period 1990 – 2009).

4.8.2 Methodology

CH_4 emissions from the production of ethylene and 1,2 dichloro-ethane are estimated according to the equation:

(Emissions) = (Production) * (Emission factor)

The following are noted in relation to the application of the above equation:

- Default emission factors (IPCC Guidelines) are used.

- Activity data (production of ethylene and 1,2 dichloro-ethane) are confidential and provided by the ElStat. The available data cover the period 1990 – 2007, whereas the ethylene and 1,2 dichloro-ethane production has ceased in 1998 and 2000 respectively.

4.8.3 Uncertainty and time-series consistency

The inventory team has used the default emission factor as reported in IPCC Guidelines, whereas the production data are provided by the ElStat. To account for both uncertainties type the value of 5% has been considered.

The time-series consistency is ensured by the fact that the same EF and methodology has been used for all the inventory years. The time-series show an important decrease from year 1998 to1999 due to the cease of the ethylene production. After 2000 CH_4 emissions have been zeroed, as a result of the production cease.

4.8.4 Source-specific QA/QC and verification

No sector-specific QA/QC control procedures have been performed.

4.8.5 Recalculations

No recalculations have been performed. Moreover, the ERT have not made any reference to the current subcategory.

4.8.6 Planned improvements

The current submission can be considered satisfactory. In case that any gaps in activity data time series shall be observed, it will be filled in as soon as new data become available.

4.9 Iron and steel production (CRF Source Category 2.C.1)

4.9.1 Description

Steel production in Greece is based on the use of electric arc furnaces (EAF). There are no integrated iron and steel plants for primary production as no units for primary production of iron exist, but there are several iron and steel foundries.

Carbon dioxide emissions from steel production in 2009 (***Table 4.14***) accounted for 1.49% of total GHG emissions from *Industrial production* and for 0.11% of total national emissions (without *LULUCF*). Emissions have increased by 47.83% from 1990 to 2009, following the increasing trend of the production. It should be noted, however, that emissions in 2009 have significantly decreased from 2008 by 33.95%, as a result of the decreased economic activity of the sector (decrease of almost 19% of the production level in 2009).

Methane emissions are considered negligible and account for 0.005% of emissions from *Industrial Processes* in 2009.

Table 4.14 ***Steel production, CO_2 emissions and CH_4 emissions (in kt) for the period 1990 – 2009***

Year	Steel production (kt)	CO_2 Emissions (kt)	CH_4 Emissions (kt)
1990	999.10	92.70	0.01
1991	980.00	90.93	0.01
1992	924.00	85.73	0.01
1993	980.00	90.93	0.01
1994	848.00	78.68	0.01
1995	939.00	87.12	0.01
1996	809.82	75.14	0.01
1997	1,015.67	94.24	0.01
1998	1,108.29	102.83	0.01
1999	951.53	88.29	0.01
2000	1,104.78	102.50	0.01
2001	1,281.51	118.90	0.02
2002	1,839.80	170.70	0.02
2003	1,700.90	157.81	0.02
2004	1,966.24	182.43	0.02
2005	2,296.40	221.66	0.02
2006	2,415.80	222.02	0.02
2007	2,554.52	229.71	0.03
2008	2,468.10	207.49	0.02
2009	1,999.35	137.04	0.02

4.9.2 Methodology

The methodology used for the estimation of carbon dioxide emissions is based on tracked carbon oxidation throughout the production processes in electric arc furnace operation. For the estimation the following equation has been used:

$$E_{CO_2} = (SC + AN + C + GR + EL - SLB - SLG - D - CL) \cdot \frac{44}{12},$$

where SC=quantity of scrap*carbon content of scrap, AN=quantity of anthracite*carbon content of anthracite, C=quantity of coke*carbon content of coke, GR=quantity of graphite*carbon content of graphite, EL=quantity of electrodes*carbon content of electrodes, SLB=quantity of slab*carbon content of slab, SLG=quantity of furnace and vat slug*carbon content of slug, D=quantity of dust in the dust filter*carbon content of dust and CL=quantity of calamine*carbon content of calamine.

In relation to the estimation of CO_2 emissions from iron and steel production, it should be noted that:

- Activity data for 2005-2009 are plant specific and are based on the verified reports under the EU ETS context.
- For the period 1990-2004, information has been collected through questionnaires developed according to the guidelines described in the Commission Decision 2004/156/EC from all individual plants in Greece in the framework of the formulation of the NAP, according to the EU Directive 2003/87/EC.
- Data regarding steel production are provided by the ElStat for the years 2004-2009 (in the previous years the relevant Prodcom code did not exist). These data are reported as activity data.
- According to information received by the ElStat, all the iron and steel plants of the country are included in the EU ETS.
- In 2009 the average carbon content of the scrap and steel produced has been estimated at 0.39% and 0.19% respectively.
- Electrodes consumption is estimated at 1.77 kg/t steel produced.

The emission factor used for the estimation of methane emissions is the default CORINAIR (SNAP 040207) emission factor (10g/Mg of iron produced).

4.9.3 Uncertainty and time-series consistency

The uncertainty associated with the CO_2 EF is quite low (5%) since all the carbon content is reported by the plants. The same value has been used for the uncertainty of the activity data, accounting mainly for the weighting error in the plant specific reports of the ETS system. As regards to the CH_4 emissions, the uncertainty values are at the same level, in absence of any other data.

The methodology used for the CO_2 emissions is country specific and is the same for the whole time-series. In order to ensure the consistency of the time-series, a recalculation of the previous years has been implemented in 2009.

In specific and following the suggestions of the ERT in-country review of Greece that took place in September 2008, the fraction of total carbon consumption used for the estimation of emissions accounted as residual carbon in slag has been estimated. This was found to be 0.29%. However, the quantities of furnace and vat slag are quite insignificant (0.05% of the overall). According to the same suggestions, once the above mentioned fraction has been found to be insignificant, the CO_2 IEF of years 2005-2007 should be used for the estimation of the entire time-series. In order to do so, the inventory team has collected data on steel production by the ElStat for the years 2004-2006, and used it to estimate the IEF and recalculate emissions. All the information regarding the procedure has been provided in the 2009 NIR. It should be also noted that, in the 2009 centralised review, the ERT have concluded that the recalculation methodologies used are in line with the IPCC good practice guidance.

In general, CO_2 emissions from steel production follow an increasing trend, reaching a maximum value of 229.71 kt in 2007. Then and in the next two years emissions are decreased by 9.67%, as

result of the decreased production. This has been also cross-checked with the general trends in the constructions area, which is safe to be considered as a driver since according to the "2008 Sustainability Report of the world steel industry", published by the World Steel Association, the Infrastructures sector seems to be the main application of the steel production (50% of steel use in 2007 is destinated for use in infrastructure).

On the basis of the completed and detailed data of 2005-2007 a country specific CO_2 emission factor is estimated (0.093 t/t). This emission factor has been calculated a little lower in 2008 (0.080 t/t), and quite more low in 2009 (0,069 t/t). However in any case it is close to the default emission factor of 0.080 t/t indicated for electric arc furnaces.

4.9.4 Source-specific QA/QC and verification

In order to ensure the quality of the estimation, each plant's reports are checked in two ways: first following the time-series trend of the specific plant and secondly by comparing each plant's report with the general trend for the current year. The data reported in each year are calculated in the specific spreadsheet of the year, while all the data are gathered in the Input File of the Inventory at the end of the annual inventory circle.

As an additional quality assurance procedure, plant specific production data are also collected by the inventory team whenever available. In 2009 the production data reported by the plants and the one provided by the national statistics differ by 1% (the ElStat value has been used in order to ensure time-series consistency with the values used in the previous years). Also, less detailed data are collected by international sources, such as the World Steel Association. These data are also used to as additional sources and for years 1999-2008 the average difference between the two values has been considered quite low (0.28%).

4.9.5 Recalculations

The right value for 2008 steel production has been used in the current inventory. This has not caused any change in CO_2 emissions, that have been estimated using the country- specific methodology described in paragraph 4.9.2, however leaded to a recalculation in CH_4 emissions. The difference from last year is 13,48% and the impact of total emissions is negligible (0.00%).

4.9.6 Planned improvements

The current submission can be considered satisfactory. The production values of 2009 are prone to be re-evaluated whenever the finalised data of the National Statistics Authority will be made available.

4.10 Ferroalloys production (CRF Source Category 2.C.2)

4.10.1 Description

Ferroalloy production involves a metallurgical reduction process that results in CO_2 emissions. The carbon in the electrodes captures the oxygen from the metal oxide to form CO_2. In addition, the calcination of carbonates fluxes such as limestone or dolomite contributes to these emissions.

The CO_2 emissions in 2009 account for the 3.89% of total emissions from *Industrial Processes*, and for the 0.30% of the total national emissions (excl LULUCF). As there is only one unit operating in Greece data is plant specific and are characterized by fluctuations. This is probably the reason why the ferroalloys production is considered a key category by trend assessment.

4.10.2 Methodology

The estimation of CO_2 emissions from ferroalloys production is based on the laterite consumption and the carbon content of it, as well as on the consumption of fuels used as reducing agents and their carbon content.

- Activity data are considered as confidential since there is only one industry operating in Greece.
- Activity data for 2005-2009 derive of the annual verified reports of the industry under the EU ETS.
- Activity data for the period 2000-2004 derive of the reports of the plant during the formulation of the NAP and from additional information concerning the primary fuels and their carbon content for the years 2000-2008. The above mentioned data are combined with supplementary information relevant to the plant production in order to complete the missing data for the all period 1990-1999. For the same period of estimation, the carbon content of laterite used is less than 2%, according to plant specific information. Also, detailed information on the emissions from both laterite and reducing agents' use for the years 2000-2009 has been provided by the plant.

4.10.3 Uncertainty and time-series consistency

The uncertainty estimates for both activity data and emission factor are decreased by the fact that plant-specific fuel requirement, laterite consumption and carbon content have been provided by the specific industry. However, this uncertainty should take into account the fact that the provided data cover the years 2000-2009 and for the rest years of the time series the Ni production has been used as a driver. The uncertainty estimate in both cases (AD and EF) ha been considered, therefore 7%.

As regards to the time-series consistency, as it has been already mentioned, years 1990-1999 have been estimated using the Ni production as a driver, in absence of any other available data by the industry, whereas years 2000-2009 are reported on the basis of plant specific data. This assures that the same method has been used for the whole time series, enabling the achievement of time-series consistency.

Figure4.7 presents the emission levels for the whole time-series. As it can be seen the trend follows the trend of other production sectors, indicating an important decrease in 2009, as a result of the economical crisis.

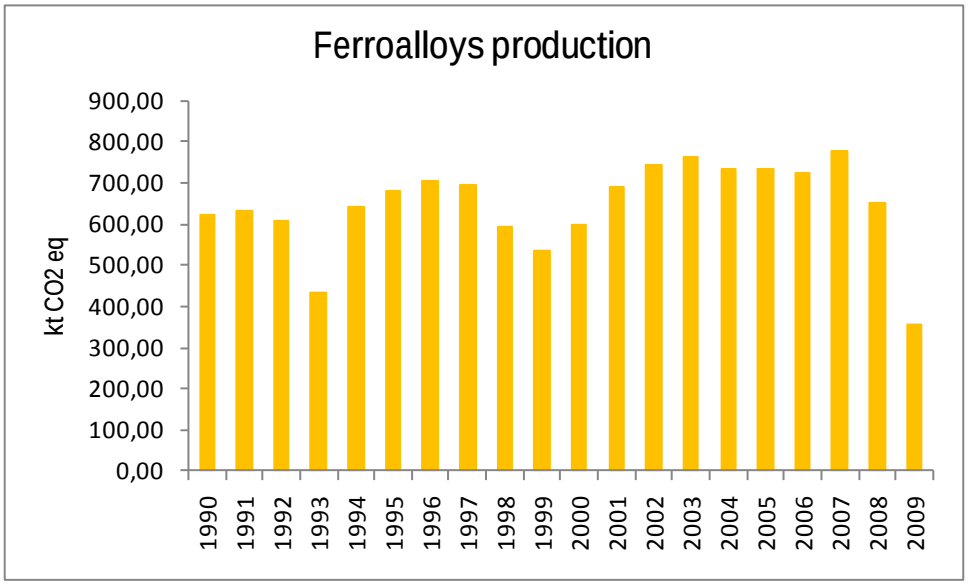


Figure 4.7 CO_2 emissions (in kt) from Ferroalloys Production for the period 1990 – 2009

4.10.4 Source-specific QA/QC and verification

In absence of any other data available, the QC tests include the collaboration with the experts from the energy sector, in order to make sure that the emissions from fuels used as reducing agents are not double counted and the estimation of emissions using the average country-specific EF and the Ni production to make sure that the emissions calculated in both ways do not differ to a high level. It should be also noted that default EF values are not easy to be found in literature for Ni production, making more difficult the estimation with different tiers.

The QC procedures refer to the checking of the IEF in order to ensure that in general the factor is stable. Indeed the IEF is between 35 and 43 kt CO2/kt Ni produced with a mean value of 39.30 t/t, and is not characterised by intense fluctuations in the time-series. The differences of the IEFs is attributed to the different percentages of the raw material mixtures throughout the years of the time-series.

4.10.5 Recalculations

No recalculations have been performed in the current submission.

4.10.6 Planned improvements

The current submission can be considered satisfactory. In case that any gaps in activity data time series shall be observed, it will be filled in as soon as new data become available.

4.11 Aluminium production (CRF Source Category 2.C.3)

4.11.1 Description

Primary aluminium production is responsible for emissions of CO_2 and PFC. Carbon dioxide is produced when, during electrolysis, the carbon of the anode reacts with alumina (Al_2O_3). Two PFC (CF_4 and C_2F_6) are formed during the phenomenon known as the anode effect, when the aluminium oxide concentration in the reduction cell electrolyte is low.

Emissions of CO_2 and PFC from aluminium production in 2009 (***Table 4.15***) accounted for 2.12% and 0.39%, respectively, of total GHG emissions from *Industrial processes*. The average annual rate of decrease of CO_2 emissions during the period 1990 – 2009 was -0.68 %. Respectively, the average annual rate of decrease of PFC emissions is estimated at -4.24%, while emissions have decreased by 57.87%, compared to base year emissions (1995). PFCs emissions have been considered as a trend key category of the year 2009.

Emissions of CO_2 depend directly on aluminium production, while PFC emissions are influenced as well from actions on the restriction of the anode effect.

Table 4.15 CO_2 emissions (in kt) and PFC emissions (in kt CO_2 eq) from primary aluminium production for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2	231.96	236.17	237.37	228.92	213.93	202.87	202.86	205.60	226.40	247.89
PFC	263.38	264.27	258.36	156.56	93.05	85.78	73.61	169.64	208.53	135.49

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2	251.99	251.16	254.05	257.84	258.29	256.26	255.70	257.32	254.14	194.66
PFC	151.70	93.42	90.66	80.01	73.22	73.05	62.43	60.19	76.08	36.13

4.11.2 Methodology

Carbon dioxide emissions from primary aluminium production are calculated on the basis of aluminium production and the default emission factor for prebaked anode process (1.5 t/t aluminium produced, Revised 1996 IPCC Guidelines). The used production technology of the plant is Centre Worked Prebake with Feed Point System (PFPB methodology).

It should be noticed that data on aluminium production are confidential and therefore are not presented in the current report. During the reviews of previous years, including 2010, Greece has been recommended to provide this information in the NIR and the CRF files, using publicly available data provided by the UN Commodity Statistics and/or other available sources. In order to explore such a perspective Greece has resourced the United Nations Industrial Commodity Statistics Database. Up to the time of writing of the report, the available data for Greece concern the years 1995-2004 and are considered as incomplete in means of coverage for 2003,while the estimates are provided by the US Geological Survey for years 2000-2004. In view of the inconsistency of the data sources and the incompleteness of the time-series, the Inventory Team has decided to use the production quantity provided directly by the plant, and to use alternative sources as additional data sources for the running of QC tests. Therefore, production continues to be reported as confidential, respecting the industry's will to maintain the confidentiality of the reported data.

PFC emissions estimates are based on anode effect performance by calculating the anode effect overvoltage statistic (Overvoltage method). This methodology concerns measurements and recordings that are being performed concerning the parameters of the equation used for the CF_4 emission's calculation, namely the overvoltage and the aluminium production process current efficiency. The C_2F_6 emissions are then calculated by using the following formula:

$$C_2F_6 = 0.1 \bullet CF_4$$

The estimations are provided directly by the plant to the inventory team.

4.11.3 Uncertainties and time-series consistency

The uncertainties regarding the CO_2 emissions relate mainly to the uncertainty of the production activity data provided by the plant, as well as to the uncertainty of the emission factor. Both values are quite low, at 5%, since the production data are plant-specific and the emission factor used is the default. Especially as regards to the EF, evidence suggests that there is little variation in CO_2 emissions from plants utilising similar technologies (*Revised 1996 IPCC Guidelines*).

As regards to PFCs emissions, the associated uncertainty is, again, not very high. All the data and EF are plant-specific and the methodology takes into account the smelter-specific operating conditions.

Emissions have been calculated in the same way throughout the time series. The IEF regarding PFCs emissions is not stable throughout the time-series, mainly because PFCs emissions are not directly associated to the aluminium production but to the anode effect.

The trend of the emissions is depicted in the ***Figure 4.8***. PFC emissions from primary aluminium production presented a continuous decrease from 1990 to 1996. Then and for a four years period (1997 – 2000) emissions almost doubled compared to 1996. Since 2001, this trend changes again and emissions were about the same as in 1995 – 1996. The next increase has happened in 2008, followed by a decreased level of emissions in 2009.

According to the Greek QA/QC procedures, information has been provided by the plant, concerning the above mentioned trend. This information includes the following:

- During the period 1993-1998, one aluminium series did not operate leading to the decrease of PFCs emissions (it should be mentioned that the plant disposes three operating aluminium series. All the aluminium series were in place in 1990 and continue to be operating since).
- During 1998-2000, the plant was facing some operational problems.
- Since 2000, the accuracy is improved by estimating the over voltage in mV.
- The difference between 2000 and 2001 is attributed in the exemption of negative overvoltage values.
- Since 2001 the production process has been significantly improved leading to a decrease in emissions.
- The plant has also communicated that the increased emissions of 2008 is attributed to the operational crisis of the electrolysis procedure in August-September of the same year. The problem has been caused by the grain size of alumina.

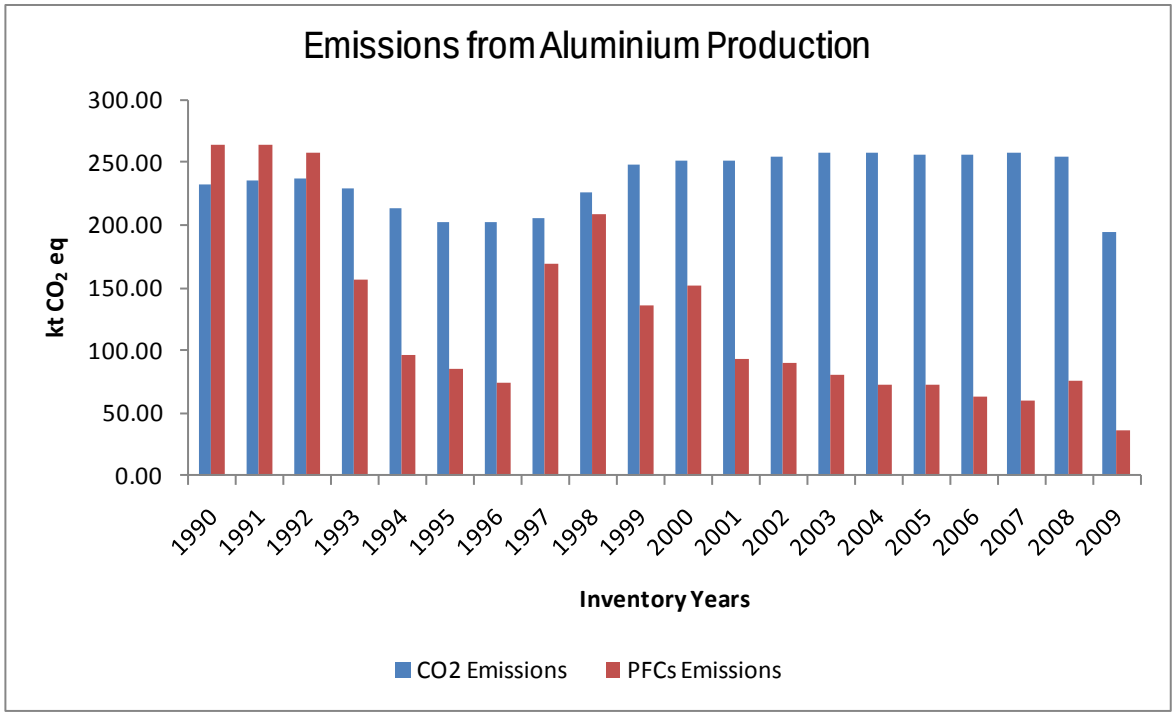


Figure 4.8 ***CO_2 and PFCs emissions (in kt CO_2 eq) from aluminium production for the period 1990 – 2009***

4.11.4 Source-specific QA/QC procedures and verification

In the recent years, the estimations of emissions from aluminium production are being conducted in close cooperation with the respective Greek plant, enabling the improvement of the transparency of the inventory, especially regarding PFCs emissions. Moreover, additional information, such as the Environmental Study of the plant, has enabled the inventory team to better understand the operating situation of the aluminium series and anode effect. In that context, the plant has informed the inventory team on the internal QA/QC procedures undertaken and which include the internal archiving of information, compatible with the Quality Management Procedure of their Internal Quality System, which has been certified to ISO 9001. It should be also noted that, according to information received by the plant, in 2003 the methodology used for the PFCs emissions' calculation has been approved by independent auditors of the PricewaterhouseCoopers (PwC).

Since PFCs emissions constitute a key category of the current submission, the Inventory Team's source specific QA/QC procedures include the following:

- The archiving of the all information received in line with the procedures of the QC system.
- Comparison of the emission factors with the default ones and communication with the plant, if needed in order to ensure the quality of the emissions.
- Collection of information / explanation of the trend of the time series, in cooperation with the above mentioned plant.

As a supplementary QA/QC test the IEF of the PFCs has been compared to the default reported in the IPCC Guidelines. The two values are quite close to the default values reported in the study of the Canadian aluminium plants, for Centre Worked Prebaked Technology (*Revised 1996 IPCC Guidelines*).

External sources are being used as alternative information providers in order to validate the production reported by the plant. These sources include the Greek Mining Enterprises Association, and the United Nations Industrial Commodity Statistics Database. Data have been also seeked in the US Geological Survey and they are the same as the ones reported by the Greek Mining Enterprises Association. As already reported during previous reviews there has been a pressure on Greece to publish the confidential data reported by plant. In the 2010 review Greece has also been recommended to report the publicly available data instead of the plant specific ones. However, the Inventory Team noticed that there was a low difference in the values, at least for the recent years of the inventory (the average difference is about 0.13%). Respecting the accuracy principle of the inventory preparation processes, the plant specific production data has been used and it is reported as confidential respecting the plant's right not to publish this kind of information. The inventory team would also like to notice that the respective information is being used in the estimation of CO_2 emissions, which are not characterised as key source category in the current submission.

4.11.5 Recalculations

In September 2010 the plant has informed the Inventory Team that there has been a change in the calculation methodology for PFCs emissions, after the harmonization of the plant to the Directive 2009/29/EC. In specific, the previous implemented equation for the estimation of PFCs (which has been proposed by the Research Centre of ex. PECHINEY (LFR) and implemented by the plant) has been replaced by the methodology described in paragraph 4.11.2.

The difference between the previous and the current estimates and the impact on total emissions is presented in ***Table 4.16***.

Table 4.16 Recalculations of HFCs emissions from ODS substitutes [1990-2007]

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Difference (%)	2.24	2.60	2.40	2.60	2.60	3.39	2.60	2.60	2.35	2.86	2.24
Impact on total emissions (excl LULUCF) (%)	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Year	2001	2002	2003	2004	2005	2006	2007	2008
Difference (%)	2.23	2.64	3.51	2.58	2.45	-12.27	2.60	2.58
Impact on total emissions (excl LULUCF) (%)	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00

4.11.6 Planned improvements

In general, the current submission can be considered quite satisfactory. In case that any other gaps in activity data time series shall be observed, it will be filled in as soon as new data become available.

4.12 Production of halocarbons and SF_6 (CRF Source Category 2.F.1)

4.12.1 Description

HFC-23 is generated as a by-product during the manufacture of HCFC-22 and emitted through the plant condenser vent.

HFC-23 emissions from HCFC-22 manufacture used to be a key category by level and trend in the past years. However, the HCFC-22 production has ceased in January 2006 and emissions do not occur ever since.

HFC-23 emissions are shown in ***Table 4.17***.

Table 4.17 HFC-23 emissions (in kt CO_2 eq) from HCFC-22 production for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
HFC-23 (kt CO_2 eq)	935.06	1,106.82	908.39	1,606.64	2,143.91	3,253.07	3,746.34	3,960.22	4,359.89	5,023.04
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
HFC-23 (kt CO_2 eq)	3,735.11	3,181.46	3,194.57	2,661.05	2,550.60	2157.48	NO	NO	NO	NO

4.12.2 Methodology

According to the IPCC Good Practice Guidance, the analytical methodology (Tier 2) should have been applied for the calculation of HFC-23 emissions from HCFC-22 production, as it used to be a key source. This methodology is based on the collection and elaboration of onsite measurement data. However, due to the lack of such data, calculation of emissions has based on production statistics and a reference emission factor. It should be noticed that data on the production of HCFC-22 are confidential and therefore are not presented in the current report. The reference emission factor used is suggested by the IPCC GPG.

4.12.3 Uncertainty and time-series consistency

The estimated uncertainty is estimated at 50% for both activity data and emission factor, as suggested in the IPCC GPG for Tier 1 methodology.

The implemented methodology is in line with the IPCC Guidelines, while no changes or refinements are to be expected in the current category. The estimation methodology used is the same for the whole time-series.

4.12.4 Source-specific QA/QC and verification

In order to ensure the quality control, all the collected data regarding emissions are kept in the Input file of the inventory system. Other QA/QC procedures described in the IPCC GPG are not applicable.

4.12.5 Recalculations

No recalculations have been performed. The ERT have made no reference to the current sub-category.

4.12.6 Planned improvements

The current submission can be considered satisfactory. In case that any gaps in activity data time series shall be observed, it will be filled in as soon as new data become available.

4.13 ODS (Ozone Depleting Substances) Substitutes (CRF Source Category 2.F.1 to 2.F.6)

4.13.1 Description

According to the IPCC Good Practice Guidance there are five categories accounting for emissions from the use of ODS substitutes. In specific, emissions of F-gases are generated during the manufacturing, operation/maintenance and final disposal of the following materials/equipment:

- Refrigerating and air conditioning equipment (2.F.1)
- Foam blowing (2.F.2)
- Fire extinguishers (2.F.3)
- Aerosols / metered dose inhalers (2.F.4)
- Solvent uses (2.F.5)
- Other applications using ODS substitutes (2.F.6)

In order to obtain a reliable estimation of F-gases emissions, the collection of detailed data for all the activities mentioned above (e.g. number of refrigerators, type and amount of refrigerant used by each market label, substitutions of refrigerants that took place the late years etc.) is required. The availability of official data in Greece is limited and, therefore, in some cases the estimations presented hereafter involve the application of country specific methodologies.

In order to resolve any remaining completeness issues, and given the fact that there has not been any opposite indication for the use of the PFCs in Fire Extinguishers and f-gases in Solvent Uses up to now,in September 2010 Greece has decided to use information from inventories of neighbouring countries. To this end, the inventory of Italy has been used, on the grounds that the climatic and socio-economic conditions between Greece and Italy are quite similar. According to the reported data of Italy, the respective emissions are considered Not Occurring. As a result the above mentioned notation keys have changed from NE to NO in the current resubmission.

Emissions from ODS substitutes constitute a key category in the Greek inventory system. Emissions in 2009 (***Table 4.18***) accounted for 28.02% of total GHG emissions from *Industrial processes* and for 2.10% of total national emissions (without *LULUCF*). The average annual rate of emissions' increase for the period 1995 – 2009 is estimated at 60.05%. The significant increase of emissions is attributed to the increased emissions from large commercial applications of refrigeration are also important, mostly due to the high value of the equipment's charge. Also there is an increase in the use of air conditioning equipment, because of the living standards improvement and the restriction in CFCs use, according to the provisions of the Montreal Protocol for ozone depleting substances. Apart from emissions due to refrigeration and air conditioning equipment, emissions from aerosols and metered dose inhalers are also significant (5.41% contribution to the emissions from ODS substitutes in the 2009 inventory). ***Figure 4.9*** shows the contribution from each subcategory to the total emissions from ODS substitutes.

The demand of A/C equipment is highly dependent on the climate conditions. Generally, the raise of temperature and the occasional extreme heat waves increase the demand. The price is no longer a decisive factor, due to multiple credit systems made available by electrical stores and supermarkets. The demand of refrigerating equipment usually is driven by the need to replace existing equipment. The replacement depends on the product life, which is usually a factor of the quality and the conditions of use. Also, an important part of the demand derives of the generation of new households. The value of refrigerating equipment can have a positive or negative effect on demand. Usually the competition between importing and producing companies and the competitive pricing can drive the sales of products. It should be also noted that in the recent inventory years sales are decreased as a result of the economical recession of the country.

According to information provided by the National Association of Refrigerating and Cooling Technicians the use of F-gases started in 1993 as regards refrigeration equipment, in 2000 as regards stationary air-conditioning, in 1995 for mobile air-conditioning and in 2000 for transport refrigeration. On the basis of the same information the use of F-gases covers the whole refrigeration, mobile air-conditioning market and stationary air-conditioning market. It should be noted that as regards transport refrigeration usually the import concerns already used vehicles; therefore the import of each year is corresponded to a 2-5 year previous manufacture.

As regards to the rest of the categories, the use of f-gases in MDIs has been in place since 1995, according to information received by the National Organization of Medicines, while emissions from foam blowing and fire extinguishers have been more recent (2001 and 1999 respectively).

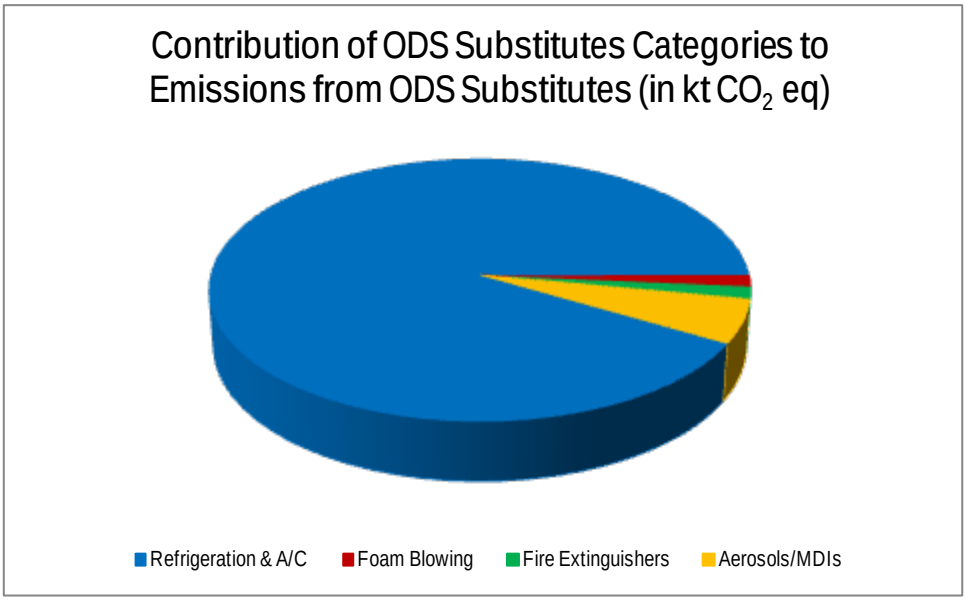


Figure 4.9 HFCs emissions from ODS substitutes in 2009 (in kt CO_2 eq)

Table 4.18 HFC emissions (in kt CO_2 eq) per gas from the consumption of F-gases for the period 1990 - 2009

Year	HFC-32	HFC-125	HFC-134a	HFC-152a	HFC-227ea	TOTAL
1990						
1991						
1992						
1993						
1994						
1995			6.90			8.97
1996			19.96			25.95
1997			58.35			75.85
1998			131.79			171.33
1999			243.01		1.44	320.09
2000	3.64	3.95	400.01		2.06	539.41
2001	6.41	6.94	587.45	11.96	2.67	796.72
2002	13.02	14.10	713.38	217.18	3.51	1,015.92
2003	21.67	23.48	955.10	292.13	4.57	1,375.61
2004	30.15	32.66	1,159.05	251.34	6.19	1,670.97
2005	40.12	43.45	1,224.56	269.23	7.68	1,799.64
2006	56.40	61.09	1,347.09	333.76	9.09	2,032.02
2007	64.37	69.67	1,375.41	294.45	11.04	1,098.19
2008	81.80	88.07	1,621.00	292.25	12.15	2,482.95
2009	92.68	100.21	1,656.70	256.32	13.29	2,568.96

4.13.2 Methodology

Refrigeration and air-conditioning

F-gases emissions are estimated according to the Tier 2a methodology described in the IPCC Good Practice Guidance. This is a bottom-up approach based on detailed equipment data and emission factors representing various types of leakage per equipment category. It should be noted that the application of the Tier 1 methodology (calculation of potential emissions based on imports, exports and domestic consumption of each gas) and Tier 2b (calculation of actual emissions based on detailed sales data per gas and activity) is not possible for the time being, as the available information is not reported in the way required by these methodologies.

Total emissions are calculated as the sum of ***assembly*** emissions (emissions associated with product manufacturing, even if the products are eventually exported), ***operation*** emissions that include annual leakage from equipment stock in use (regardless of where they were manufactured) as well as servicing emissions and ***disposal*** emissions that include the amount of refrigerant

released from scrapped systems, regardless of where they were manufactured, according to the following equation:

$$E_C = DOM \cdot CH \cdot k$$

$$E_O = \left(\sum_{t_0}^{T} (DOM + IMP - EXP)_t \cdot CH \right) \cdot x$$

$$E_D = (DOM + IMP - EXP)_{T-n} \cdot CH \cdot y \cdot (1 - z) - DES$$

where, E_C is emissions related to the production, *DOM* is domestic production, *CH* is the initial charge, *k* is the leakage rate during manufacturing, E_O is emissions during operation, t_0 is the year of F-gases introduction in the market, *T* is the current year, *IMP* is imports, *EXP* is exports, *x* is the leakage rate during operation, E_D is emissions during disposal, *n* is lifetime, *y* is the remaining percentage from the initial charge of the equipment by the time of disposal, *z* is the percentage of recycling and *DES* is the amount of F-gases destroyed.

Assembly emissions are related to the number of units produced in the country (domestic production) that use F-gases as refrigerants, the amount of refrigerant used per unit and the losses during assembly. Operation emissions are related to the total number of equipment with F-gases as refrigerant (domestic production and imports minus the exports) and the leakage rate per equipment type. Disposal emissions depend on the available amount of refrigerant in the equipment, as well as on the existence of disposal practices. Since no data on the disposal practice is available, at the moment the assumption of total emission of remaining refrigerant in the retiring equipment is being made. Also, in absence of any activity data, for the time being all the equipment exceeding lifetime is considered as removed from the system.

The sources of emissions included in the category refrigeration and air conditioning equipment, are the following:

- Refrigeration
  - Residential applications
  - Large commercial applications
  - Small commercial applications
  - Transport refrigeration
- Air conditioning
  - Split unit systems and semi-central systems.
  - Central air conditioning – Chillers
  - Other applications of central air conditioning
  - Mobile air conditioning

Regarding the activity data (number of equipment, ***Table 4.19-4.20***) the following should be mentioned:

- Data on the air conditioning equipment stock for the period 1993 – 2008 are provided by market surveys (ICAP 2000, 2002, 2003, 2005, 2008, 2009). For 2009 emissions are estimated using the trend of the more recent years 2005-2008, as the respective survey has not been published up to the time of writing of the current report.
- Data residential refrigeration equipment stock for the period 1993 – 2009 are provided by market surveys (ICAP 2000, 2002, 2006, 2008, 2010).
- Data on the commercial refrigeration equipment stock are provided from the elaboration of ElStat and EUROSTAT data. Refrigerated show cases and counters are included in the category of large commercial applications while the rest refrigeration equipment (except residential refrigeration) is considered as small commercial installations.
- Data on the number of new vehicles are provided by the Ministry of Infrastructure, Transport and Networks.
- Data on the number of transport refrigeration for 2000-2009 are provided by the Ministry of Infrastructure, Transport and Networks.

The values of the basic parameters used for the estimation of emissions, as well as the type of refrigerant used in each category are presented in ***Table 4.21***. These values are based on expert judgement performed by members of the National Association of Refrigerating and Cooling Technicians, in combination with the default values provided in the IPCC GPG. It should be noted that IEFs used for MAC and transport refrigeration have been changed in September 2010, following the ERT's recommendation, in order to be in the default range proposed by the IPCC Guidelines.

HFC emissions from the above mentioned applications are presented in ***Table 4.22*** for the period 1993-2009.

With regards to residential refrigeration, according to the data provided by ICAP SA, the majority of the equipment concerns small capacities (lower than 150 lt), with a contribution oscillating between 22 and 35% during the years 2003-2008. Other important categories include combinations of refrigerators and freezers characterised by individual external doors, residential refrigerators with compression of a capacity above 340 lt and also refrigerators of medium capacity (between 250-340 lt). The respective contribution percentages in 2008 are 18.87%, 15.96% and 20.23%.

With reference to a/c equipment, the following can be noted:

- The production trend for the years 1994-2008 is a decreasing one. Production has experienced a decrease of 3% in 2008 and according to experts of the A/C industry the country's production is projected to fall by a level of 20% in 2009 following the decreasing trend of infrastructure, investing projects etc due to the economical recession.
- Fan coils have covered about 72.7% of the market in 2008, followed by central units (23.1%). Split units have fallen significantly since 1996 (about 50 units per year in the more recent years). Chillers production is about 500 units per year in the recent years.

- Total imports of a/c equipment are characterised by a general increasing trend in the years 1995-2007, while imports in 2008 are at the same level with 2007. Imports in 2009 are reduced by about 22% as a result of the economical recession (see also comment above).
- The exports time-series generally present intense fluctuations. In general the trend is increasing, while the main category is split units.
- Split units (lower than 24,000 BTU) & semi-central units (split units above 24,000 BTU and limited number of packaged and VRV systems): In the Greek market, this category shows an increasing trend until 2000, while this changes in the period 2001-2005. This is attributed to the lower temperatures in 2004-2005. Then and for the years 2006-2008 emissions are increased due to the favourable climate conditions.
- Chillers: They have presented an important increase, characterised by high rates of change in the years 2000-2003 (about 20-40%). This is attributed to the development of the infrastructures sector in the years close to the Olympic Games of 2004. In the following years the trend is decreasing, being at the about the same levels for the years 2005-2009. Chillers of efficiency up to 14 RT are estimated to be responsible for 44.4% of the market in 2008, while chillers with screw compressor cover the 87% of the market in the same year.
- Central A/C Units are characterised by an increasing trend in the years 1994-2003 which is then followed by a decrease in the next years. The majority of the country's production and consumption refers to small size units (<8000 m3/h).
- Finally, fan coils follow the same pattern, showing a generally increasing trend until 2004, followed by an abrupt decrease in 2005 and being at about the same levels in years 2006-2009.

It should be noted that these observations refer to the movement of the Greek market based on the production, sales, imports and exports of the units. However emissions in each year concern the use of the corresponding equipment, and therefore the effects of these facts are made visible in the following years of the inventory.

Table 4.19 Refrigeration and air conditioning equipment for the years 1993 – 2002

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Refrigeration										
Residential	*311000*	*320000*	*335000*	*350000*	*355000*	*365000*	*360000*	*387000*	*376000*	*375000*
Domestic production	80000	82000	90000	120000	185000	235000	260000	327000	324000	335000
Imports	283000	315000	325000	350000	340000	340000	335000	340000	342000	340000
Exports	52000	77000	80000	120000	170000	210000	235000	280000	290000	300000
Large commercial applications			*31556*	*25832*	*24480*	*20284*	*26665*	*22852*	*15151*	*567*
Domestic production			20820	14800	20520	17680	20200	16080	13050	7254
Imports			14908	17410	13519	9532	18634	14795	17568	26114
Exports			4172	6378	9559	6928	12169	8023	15467	32801
Small commercial applications			*73642*	*74179*	*79243*	*67761*	*79885*	*73586*	*79347*	*48352*
Domestic production			58640	71680	63730	57140	69090	61900	67168	51759
Imports			16195	11062	24111	21231	19160	19868	20218	16835
Exports			1193	8563	8598	10610	8365	8182	8039	20242
Transport Refrigeration								*517*	*479*	*633*
In circulation								517	479	633
Stationary air-conditioning										
Split unit systems and semi-central systems	*89570*	*126730*	*154200*	*150880*	*188900*	*229550*	*330655*	*431385*	*617800*	*305750*
Domestic production	12320	17550	22000	21200	2800	2250	1750	1750	1400	1250
Imports	82250	115180	141200	137380	189700	240000	342205	445035	647000	341000
Exports	5000	6000	9000	7700	3600	12700	13300	15400	30600	36500
Chillers	1100	1080	1120	1180	1140	1240	1315	1585	2350	2850
Domestic production	350	380	400	430	420	500	600	950	1600	1800
Imports	750	700	740	770	780	840	835	945	1500	1450

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Exports	0	0	20	20	60	100	120	310	750	400
Other applications of air conditioning	*28800*	*31500*	*32000*	*35700*	*39850*	*43250*	*44830*	*48300*	*53800*	*67400*
Domestic production	32900	33500	35200	34300	34500	37730	37900	39300	40100	37900
Imports	4900	5300	6300	9300	9600	12120	12130	14200	18900	37300
Exports	9000	7300	9500	7900	4250	6600	5200	5200	5200	7800
Mobile air-conditioning			*133757*	*141589*	*166778*	*183857*	*268716*	*302620*	*289943*	*277567*
Domestic production										
Imports			133757	141589	166778	183857	268716	302620	289943	277567
Exports										

Table 4.20 Refrigeration and air conditioning equipment for the years 2003 – 2009

	2003	2004	2005	2006	2007	2008	2009
Refrigeration							
Residential	*390000*	*406000*	*402000*	*410000*	*433000*	*452000*	*401000*
Domestic production	368000	408000	431000	507200	390700	307400	257000
Imports	342000	320000	340000	313400	350000	390000	335000
Exports	320000	322000	369000	410600	307700	245400	191000
Large commercial applications	*25825*	*4738*	*4738*	*12312*	*2049*	*3677*	*3677*
Domestic production	20310	23004	23004	17117	16383	12214	12214
Imports	21357	30000	30000	23306	17712	11385	11385
Exports	15842	48266	48266	28111	32046	19921	19921
Small commercial applications	*64395*	*51667*	*51781*	*62596*	*87362*	*102827*	*102827*
Domestic production	56461	54886	55000	57862	85689	96873	96873
Imports	18000	15000	15000	17487	12500	12496	12496
Exports	10066	18219	18219	12753	10827	6541	6541
Transport Refrigeration	*649*	*826*	*460*	*731*	*817*	*747*	*765*
In circulation	649	826	460	731	817	747	765
Stationary air-conditioning							
Split unit systems and semi-central systems	*503950*	*493100*	*430800*	*489520*	*574310*	*574090*	*630543*
Domestic production	500	700	300	220	210	190	177
Imports	626350	644500	522000	611000	726000	726100	802800
Exports	122900	152100	91500	121700	151900	152200	172433
Chillers	2400	1950	1770	1580	1860	1800	*1967*
Domestic production	1100	700	520	480	560	530	573
Imports	1650	1450	1400	1300	1600	1650	1867

	2003	2004	2005	2006	2007	2008	2009
Exports	350	200	150	200	300	380	473
Other applications of air conditioning	*73200*	*48250*	*42100*	*44100*	*45950*	*45400*	*46450*
Domestic production	34500	26000	19350	16700	17100	16600	16700
Imports	48350	29600	25400	32000	36600	37000	40200
Exports	9650	7350	2650	4600	7750	8200	10450
Mobile air-conditioning	*273870*	*317508*	*344339*	*346551*	*316721*	*296201*	*296201*
Domestic production							
Imports	273870	317508	344339	346551	316721	296201	296201
Exports							

Table 4.21 Basic assumptions for the calculation of HFC emissions

	Charge	Leakage rate (%)		Lifetime	Refrigerant
	(kg/unit)	Charge	Operation	(years)	used
Refrigeration - Residential	0.18	0.6	0.02	15	HFC-134a
Refrigeration – Large commercial applications	100	0.5	10	10	HFC-134a
Refrigeration – Small commercial applications	1.5	1.75	10	10	HFC-134a
Transport Refrigeration	2.38(a)	0.6	25	8	HFC-134a
Air conditioning – Split units and semi central systems	2	0.6	0.33	15	R-410a
Air conditioning – Chillers	50	0.6	20	10	R-407c
Air conditioning - Other applications of central air conditioning	12	0.6	20	10	R-407c
Mobile Air conditioning	1	0.5	12	8-10	HFC-134a

(1) In Greece, small transport refrigerators (for domestic transfer of products) are charged by 1 kg HFC134a/unit, while large transport refrigerator's charge (for international transfer of products) is 6 kg HFC134a/unit. Provided that the number of transport refrigerators given by the ministry of Transport includes both categories, and given the fact that the majority concerns small transport refrigerators, the charge used in the calculations is 2.38 kg HFC134a/unit.

Table 4.22 HFC emissions (in kt CO_2 eq) from refrigeration and air conditioning equipment for the period 1995 – 2009

Year	Residential Refrigeration	Refrigeration - Commercial applications	Transport Refrigeration	Stationary air-conditioning	Mobile air-conditioning
1995	0.01	5.80			3.13
1996	0.02	17.31			8.59
1997	0.05	58.53			17.24
1998	0.10	141.91			29.30
1999	0.17	266.80			48.85
2000	0.33	378.18	0.28	23.79	130.75
2001	0.46	508.90	0.65	41.75	232.01
2002	0.54	601.45	1.14	84.66	275.31
2003	0.61	858.85	1.64	141.05	318.04
2004	0.68	1045.98	2.28	196.11	371.48
2005	0.73	1031.78	2.64	260.48	413.30
2006	0.86	1018.20	3.20	366.37	457.87
2007	0.71	965.60	3.83	416.10	495.22
2008	0.62	1186.22	4.13	525.02	547.54
2009	0.57	1062.24	4.35	595.27	692.00

Foam blowing

Emissions from foam blowing refer to emissions from hard foam production. The implemented methodology is described by the equation 3.38 of the IPCC GPG:

Emissions from closed-cell foam = [(Total HFCs and PFCs used in manufacturing of new closed-cell foam in year t) · (first-year Loss emission factor)]
+ [(Original HFC or PFC charged blown into closed-cell foam manufacturing between year t and year t-n) · (annual loss emission factor)]
+ [(Decommissioning losses in year n)-(HFC or PFC destroyed)

In order to perform the estimation of the emissions, data have been collected using information by the questionnaires filled by the industries of the sector for this reason. According to the information received, the following remarks can be made:

1. No industry makes any use of PFCs, while one of the industries reported no use of HFCs neither.
2. The use of HFCs has begun in 2001.
3. HFC-134a has been used for years 2000-2001 by one plant, while all the others plants of the sector use HFC-152a.
4. All the HFCs used concerns the manufacturing of XPS panels.
5. For the first year's emissions an emission factor of 40% has been selected, while the annual loss emission factor was 3%. Both values are the default suggested in the IPCC GPG.

Emissions of foam blowing are presented in ***Table 4.23***.

Fire extinguishers

According to the IPCC Good Practice Guidance, emissions should be estimated using the following equation:

Emissions = Annual sales of HFCs/PFCs for Fire Protection
– (HFCs/PFCs used to Charge new fire protection equipment
– HFCs or PFCs originally used to charge retiring fire protection equipment)

Although it is good practice to use the above mentioned equation, data in Greece are very scarce and the specific methodology could not be implemented. However, in order to improve the completeness of the inventory, a country-specific estimation of the emissions has been performed, based on the assumption that the use of HFCs in fire equipment in Greece is similar to the one of other Mediterranean countries (Italy, Portugal, Spain), taking into account the country's population.

More specifically the assumption made concludes that since 1999 the use of HFC-227ea for fire protection equipment has been made. The estimated emissions are presented in ***Table 4.24***.

Table 4.23 HFCs emissions (in kt CO_2 eq) from foam blowing for the period 1995 – 2009

Year	First Year Emissions (HFC-134a)	Annual Emissions (HFC-134a)	First Year Emissions (HFC-152a)	Annual Emissions (HFC-152a)	TOTAL
1995					
1996					
1997					
1998					
1999					
2000					
2001	3.38	0.00	1.67	0.00	5.05
2002	11.86	0.25	30.28	0.13	42.51
2003	0.00	1.14	38.50	2.40	42.04
2004	0.00	1.14	29.90	5.28	36.33
2005	0.00	1.14	30.16	7.53	38.83
2006	0.00	1.14	36.94	9.79	47.87
2007	0.00	1.14	28.66	12.56	42.37
2008	0.00	1.14	26.21	14.71	42.06
2009	0.00	1.14	19.21	16.67	37.03

Table 4.24 HFC-227ea emissions (in kt) from fire protection equipment for the period 1999 – 2009

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
HFC-227ea	1.44	2.06	2.67	3.51	4.57	6.19	7.68	9.09	11.04	12.15	13.29

Aerosols/MDIs

More aerosol packages contain hydrocarbons as propellants, but in a small fraction of the total HFCs and PFCs may also be used as propellants or solvents. Emissions from aerosols usually occur shortly after the production while 100% of the chemical is emitted. According to 2000 IPCC Good Practice Guidance, the 5 main sources of aerosols are:

- Metered Dose Inhalers (MDIs)
- Personal Care Products
- Household Products
- Industrial Products and
- Other General Products

According to the IPCC GPG, emissions are estimated using the following equation:

Emissions in year t = [Quantity of HFC and PFC contained in aerosol products sold in year t) · (EF)]

+ [(Quantity of HFC and PFC contained in aerosol products in year (t-1)] · (1 – EF)]

Data derive of the National Organization of Medicines and the Hellenic Aerosol Association, while plant-specific questionnaires have been sent to all the known private companies of the sector in 2010, based on information received by the President of the Hellenic Aerosol Association. The characteristics of the categories can sum up to the following:

- The use of HFC-134a in manufactured and imported metered dosed inhalers is quite common. Most of the emissions concern imported material, while there are three MDIs brands that have been produced in the country.
- As regards to the other categories on MDIs, only one plant has reported HFCs emissions. This is in line with the information received by the President of the Hellenic Aerosol Association.
- According to the information received by the National Organization of Medicines, the quantity of HFC-134a by piece oscillates between 25 and 75 mg, while the usual quantity is between 47-55 mg.
- The assumption of the total emission of the HFC-134a during the first year after sale has been made. This assumption is in line with the IPCC GPG.
- As regards to other aerosol products, there is only one plant that has reported the use of HFC-134a. The respective manufacturing process covers the inventory years 2005-2009. The plant has also reported the production, exports and zero imports of the respective products (products that contain HFCs) for all the years of the time-series. The consumption to production ratio oscillates between 65 and 100%.

Emissions from the aerosols category can be viewed in ***Table 4.25***.

Table 4.25 HFC-134a emissions from aerosols (in kt CO_2 eq) for the period 1995 - 2009

Year	Emissions (kt CO_2 eq)
1995	0.03
1996	0.03
1997	0.03
1998	0.03
1999	0.09
2000	0.10
2001	0.14
2002	0.13
2003	0.12
2004	0.14
2005	29.59
2006	111.30
2007	142.35
2008	142.13
2009	138.96

4.13.3 Uncertainty and time-series consistency

The uncertainty related to emissions from ODS substitutes is characterized by high values. This is due to the fact that both activity data and the emission factor estimates are quite uncertain. In order to improve the estimation, the uncertainty has been estimated for each subcategory separately, while the category's uncertainty value is the combination of the individual estimations.

For the refrigeration and A/C equipment (CRF 2.F.1) the activity data uncertainty has been estimated at 100% whereas an EF uncertainty of 200% is used, due to the fact that the emission factors are suggested based on expert's opinion (National Association of Refrigerating and Cooling Technicians).

In the rest two categories (foam blowing and aerosols) the uncertainty associated is quite lower. More specifically, in the foam blowing subcategory (2.F.2) the uncertainty values suggested by the IPCC GPG have been used. Therefore, activity data uncertainty is at about 40%, which is the proposed value for regional estimates. As regards to the uncertainty associated with the emission value, the value of 50% has been chosen, mainly because the default values have been chosen while no data are available in order to develop country specific values. Finally, as regards to aerosol products, the activity data derive from a National Organization and the estimated uncertainty value used is at 15%, whereas the emission factor used has been characterized by a typical uncertainty of 5%. It should be noted that the National Organization of Medicines provided the inventory team with detailed data (brand name, charge and consumption per year) of MDIs sold per year.

As regards to time-series consistency, the methodology used is the same for the whole time series, while the main data providers remain also the same. Minor inconsistencies derive from the absence of the 2009 values for the air conditioning equipment.

In ***Figures 4.10*** and ***4.11***, the trend of each subcategory is presented.

As regards the first chart, although the general trend is increasing, a decrease in emissions from commercial refrigeration can be observed for the years 2004-2007, while in 2008 the trend is increasing again. This is partially due to the large commercial applications production but mainly due to the fact that the number of operating equipment is decreased due to the removal of the equipment that has surpassed the respective product's lifetime (10 years). It should be noted also that emissions of 2008 and 2009 are lower than the ones of the previous years. This is due to the removal of equipment, as explained above, but also to the lowering of the production levels as a result of the economical crisis.

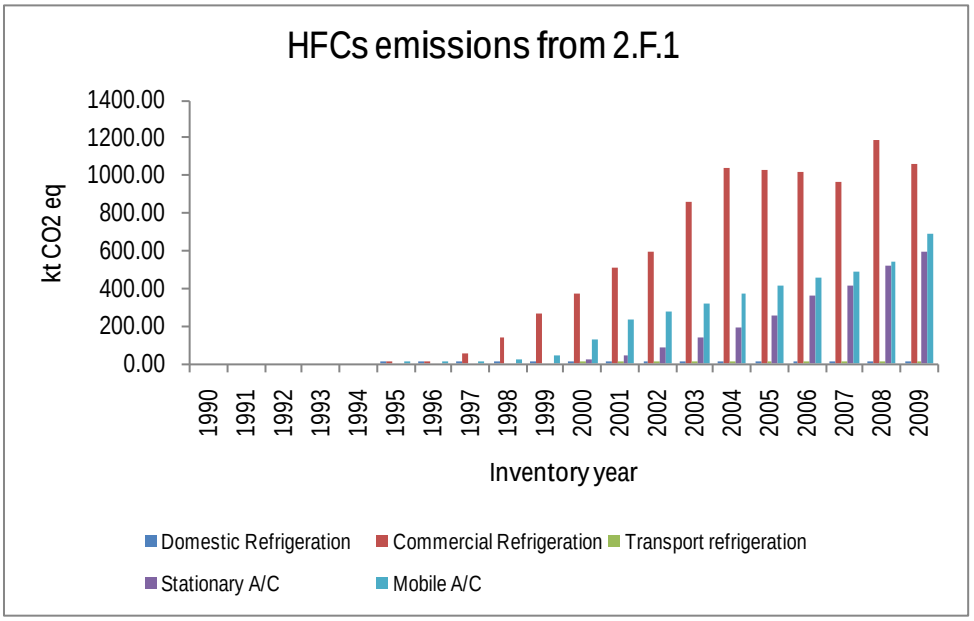


Figure 4.10 HFCs emissions from Refrigeration and A/C equipment for the period 1990-2009 (in kt CO_2 eq)

The second chart regards emissions from the other subcategories of the ODS substitutes sector. As it can be seen from the figure, the increase of the MDIs is the more important in the recent years, mainly due to the inclusion of new MDIs brands in the recent years. As regards to emissions from foam blowing, the observed fluctuation is due to the fact that there are only three companies using HFCs and the trend depends on the substitution of HFCs with other blowing agents and on the different year of first use of HFCs for the production process.

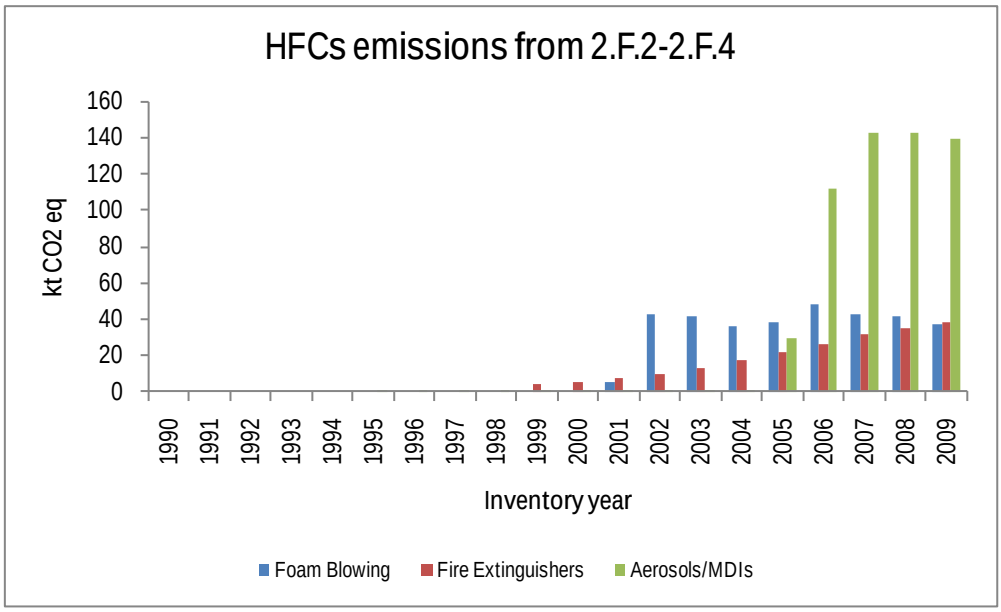


Figure 4.11 HFCs emissions from Foam blowing, Fire extinguishers and Aerosols/MDIs for the period 1990-2009 (in kt CO_2 eq)

4.13.4 Source-specific QA/QC and verification

Source specific QA/QC procedures have been performed whenever available. However it is important to note that in most cases this is not feasible due to the absence of official data or even data sources. The estimation using data from different sources has been feasible only in the case of aerosols and MDIs, since data have been collected by the National Organization of Medicines and private pharmaceutical companies as well, enabling the inventory team to perform cross-checking procedures. Also, the Hellenic Aerosols Association has provided a gross estimation of the HFCs level used that is in line with the plant specific information, enabling the inventory team to draw the conclusion that this subcategory is complete.

Other QA/QC procedures include the examination and verification of the trend. This has been performed and the results have been already presented in the previous paragraph (4.13.3). As it can be concluded from the previous, the trend is not easily cross-checked due to the high inertia of the sector (the input data of each year are responsible for the emissions in the following years). With regards to the improvement plan that has been announced in the previous NIR (2009), the progress has not been enough in order to report updated data/QA/QC results up to the time of writing of this report.

4.13.5 Recalculations

In the current submission the following recalculations have been performed:

- Update of activity data for 2007-2008 in domestic refrigeration due to the ICAP sectoral study that was made available in 2010

- Update of the working files in fire extinguishers for years 2003-2008.
- Update of the reported data from the National Organization of Medicines regarding years 2006-2008 (Emissions from MDIs).

The difference between the previous and the current estimates and the impact on total emissions is presented in ***Table 4.26***.

Table 4.26 Recalculations of HFCs emissions from ODS substitutes [2003-2008]

Year	2003	2004	2005	2006	2007	2008
Difference (%)	0.01	0.01	-0.01	-0.18	-0.56	-0.32
Impact on total emissions (excl LULUCF) (%)	0	0	0	0	-0.01	-0.01

4.13.6 Planned improvements

Greece continues to implement the planned improvements that have been already announced in the previous NIR and in the ERT Centralised Reviews. The results of the implemented activities have considerably improved the completeness and the accuracy of the current inventory report in relation to the previous ones.

Improvement plans that are currently under consideration to be implemented in the following inventory years, or that are already implemented, include the following:

- Concerning fire extinguishers, the use of f-gases is expected to be very low, according to Greek experts of the area. At the present, the inventory team has made an estimation of the emissions using data from other Mediterranean countries and the population as a driver. Since 2009 the inventory team has come to close cooperation with the office of the Ministry of Environment, Energy and Climate Change that is in charge of the implementation of the EC Regulation No 842/2006 on Certain Fluorinated Greenhouse Gases, and a general attempt is being performed in order to achieve the reporting of the fire protection companies on the annual emissions of HFCs.
- In view of the uncertainty on the activity data and the emission factor regarding A/C and refrigeration equipment, and provided that the current category is a key one, the inventory team has planned the closer cooperation with the manufacturing and importing companies. In order to do so, all available information existing in the market surveys will be used. The purpose of such an activity is the improvement of the quality assurance of the report. For the time being the list of companies has been prepared by the inventory team; however the contacting of the companies has to be implemented in next steps. The inventory team shares the belief that the information provided by the above mentioned companies will help

to move to justified national EFs that will ensure a more realistic representation of the market.

4.14 Electrical equipment (CRF Source Category 2.F.8)

4.14.1 Description

The use of $SF_{6,}$ as dielectric, in the transmission and distribution system of electricity, is considered as the main source of SF_6 emissions. Emissions arise in cases of leakages and during the maintenance of sub-stations and circuit breakers, especially when the equipment is old.

4.14.2 Methodology

In the context of the present inventory, emissions are estimated on the basis of information provided by PPC regarding losses in the transmission and the distribution system. The data provided cover the period 1995 – 2009. Emissions estimates are being performed on the basis of the quantity of SF_6 consumed during the year, by the Directorate of Strategy and Planning of the PPC. According to the information received by the Public Power Corporation (PPC), the methodology is the same for the reported emissions from both transmission and distribution activities, and it actually refers to direct measurements of the SF_6 used to fill in any escape of the gas. The measurement procedure involves the weighting of the compressed SF_6 cylinder before and after the filling of the equipment. The difference in the weight corresponds to the kg of SF_6 that has escaped (and therefore needed to be re-filled). The personnel has reassured the inventory team that all the amount reported by the PPC each year refers only to gas escape and not to the filling of new equipment, since this is not performed by PPC. Moreover, the PPC has kindly informed the inventory team that in 2009 a new SF_6 mass-flow meter has been purchased in the department of Distribution, in order to ensure the higher accuracy of the weighting. As regards to the rest of the emission, namely for the years 1990 – 1994, they are estimated (by the inventory team) by means of a linear extrapolation.

SF_6 emissions from electrical equipment are presented in ***Table 4.27***. Emissions in 2009 have been increased by 63.47% from 1990, whereas they have decreased by 33.33% from 2008. The contribution of emissions from electrical equipment is insignificant (lower than 0.00 % for the whole time-series).

Table 4.27 SF_6 emissions (in kg) from electrical equipment for the period 1990 - 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Transmission						115	118	120	122	125
Distribution						35	36	36	36	37
Total	128	132	136	140	144	150	154	156	158	162

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Transmission	130	132	140	140	148	230	310	375	280	175
Distribution	37	38	38	38	39	40	40	40	35	35
Total	167	170	178	178	187	270	350	415	315	210

4.14.3 Uncertainty and time-series consistency

The uncertainty concerning the activity data is estimated at 100%, since the exact methodology for the emissions is not provided by the PPC. Regarding the EF, the estimated uncertainty 50% and is close to the default one suggested in the IPCC GPG.

The time-series is in general consistent, since the activity data is collected by the same provider for all the inventory years, apart 1990-1994 where the linear extrapolation method has been used. Emissions refer to the escape of the gas due to old, used insulating parts of equipment (mainly gaskets) and, far more rarely, to a failure of the system. In the first case the insulating parts have to be changed. In the second case, the SF_6 has to be removed in pressurized cylinders and then be re-filled to the equipment (after the fixing of the latter).

Any fluctuation to the time-series depicts the maintenance issues that may have risen in the particular year. In general fluctuations are more intense in the Transmission system (375kg in 2007 versus 280 kg in 2008). The contact persons in the Transmission system have indicated that many times experience is used as a driver and therefore, a particular type of gasket that has been reported for unsuccessful insulating operation has been replaced in the systems, leading to a decrease of the escaped SF_6 in the next year.

4.14.4 Source-specific QA/QC and verification

For the time being the available data do not permit the implementation of any source-specific QA/QC procedure. QA/QC verification could be performed using information of the GIS providers in Greece; however the issue is quite complicated because the filling of new equipment may be performed from different companies than the ones that cover the filling of equipment in use. The total quantities are only available by PPC and this is why the verification from external sources is not easy to be performed.

For the time being, all the available information is kept in the Input File of the inventory, according to the Greek QA/QC plan.

4.14.5 Recalculations

No recalculation has been performed. In addition there has been no reference to the respective category during the previous reviews of the Greek inventory.

4.14.6 Planned improvements

During the 2010 ERT Centralized Review the Expert Team has recommended that Greece reports separately emissions from the installation of GIS equipment. The Inventory Team has contacted PPC in order to seek information on how this could be performed. In answer, the PPC has informed the Inventory Team that new GIS equipment has been introduced to the system in 2001 (1 station) and in 2004 (4 stations). The company has also provided the filling quantities of the equipment, however was not able to provide the information concerning the nameplate capacity of the equipment as required by the IPCC Guidelines for the estimation of emissions. It was decided therefore that the Inventory Team, in cooperation with the Climate Team of the MEECC shall officially address the issue to PPC in order to enable the Corporation to collect all available information from the GIS suppliers. This improved refinement of the methodology will probably be completed until the next submission.

Any gaps in activity data time series will be filled in as soon as new data become available.

5. Solvents and other products use (CRF sector 3)

5.1 Overview of sector

Most solvents are part of a final product, e.g. paint, and will sooner or later evaporate to the atmosphere. This evaporation of solvent and other products containing volatile organic compounds represents a major source of NMVOC emissions that, once released into the atmosphere, will react with reactive molecules (mainly HO-radicals) or high energetic light to finally form CO_2. This sector also includes evaporative emissions of greenhouse gases arising from other types of product use (e.g. N_2O emissions from medical use).

According to the IPCC Guidelines, the following source categories are included in this sector:

- Paint application
- Degreasing and Dry Cleaning
- Chemical products, manufacture and processing
- Other, including use of other products as well as uses of solvents not listed above.

The remainder of this chapter is organised as follows. Paragraph 5.1 continues with the presentation of emissions trends from the sector of solvents and use of other products, the assessment of the completeness of the GHG inventory for the sector of solvents and use of other products and the presentation of planned improvements. Then in Paragraph 5.2 methodological issues are addressed.

5.1.1 Emissions trends

Table 5.1 presents CO_2, N_2O and NMVOC emissions from the sector *Solvents and other products use*. GHG emissions in 2009 were 315.60kt (0.26% of the total GHG emissions in Greece, without *LULUCF*), while NMVOC emissions have been estimated at 54.24 kt, accounting for approximately 26% of the total NMVOC emissions in the country.

Table 5.1 NMVOC, N_2O and CO_2 emissions (in kt) from Solvents and other products use for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2	169.71	175.78	172.84	170.12	163.22	154.65	152.16	153.07	152.39	159.96	157.33	154.67	155.12	155.50	155.87	157.70	159.64	160.34	160.68	161.38
N_2O	0.45	0.45	0.46	0.46	0.47	0.47	0.47	0.47	0.48	0.48	0.48	0.48	0.48	0.49	0.49	0.49	0.49	0.49	0.49	0.50
Total GHG (ktCO2eq)	308.34	315.54	314.37	312.95	307.39	299.82	298.22	300.20	300.40	308.73	306.61	304.28	305.13	305.93	306.75	309.29	311.92	313.41	314.13	315.60
NMVOC	56.65	58.27	57.45	56.16	54.31	51.64	51.05	51.43	51.36	53.75	53.20	52.35	52.49	52.61	52.73	53.05	53.68	53.90	54.01	54.24

It should be mentioned that the emissions estimates presented in this section are associated with a high level of uncertainty that is related to both emission factors and available activity data used.

5.1.2 Completeness

The main problem concerning the estimation of emissions from this sector is the availability of reliable activity data. ***Table 5.2*** gives an overview of the IPCC source categories included in this chapter and presents the status of emissions estimates from all sub-sources in the sector.

Table 5.2 Solvents and other products use -Completeness

Solvents and Other Products Use	NMVOC	CO_2	CH_4	N_2O	HFC	PFC	SF_6
A. Paint application	☒	☒					
B. Degreasing and dry cleaning	☒	☒					
C. Chemical Products. Manufacture and Processing	☒						
D. Other							
1. Domestic solvent use	☒	☒					
2. Wood preservation	☒	☒					
3. Fat edible and non edible oil extraction	☒	☒					
4. Printing industry	☒	☒					
5. Use of N_2O in medicine [1)]				☒			
6. N_2O from fire extinguishers				NO			
7. N_2O from aerosol cans [1)]				☒			
8. Other use of N_2O				NO			

NO: Not Occurring

[1)] Lack of appropriate methodology

5.1.3 Planned improvements

The possibility (a) to collect the necessary activity data for the whole time period (1990 to date) in order to estimate the emissions from all possible sources in Greece and (b) to develop national emission factors, representative for the practices followed and weather conditions, is being examined.

5.2 Methodological issues

The calculation of NMVOC emissions requires a very detailed analysis of the use of solvents and other products containing volatile organic compounds. There are two basic approaches for the estimation of emissions from Solvent and Other Product Use, which depend on the availability of data on the activities producing emissions and the emission factors.

- **Production-based**. In cases that solvent or coating use is associated with centralised industrial production activities (e.g. automobile and ship production), it is generally possible to develop NMVOC emission factors based on unit of product output. Next, annual emissions are estimated on the basis of production data.
- **Consumption-based**. In many applications of paints, solvents and similar products, the end uses are too small-scale, diverse, and dispersed to be tracked directly. Therefore, emission

estimates are generally based on total consumption (i.e. sales) of the solvents, paints, etc. used in these applications. The assumption is that once these products are sold to end users, they are applied and emissions generate relatively rapidly. Emission factors developed on the basis of this assumption can then be applied to data from sales for the specific solvent or paint products.

The application of both approaches needs detailed activity data, concerning either e.g. the amount of pure solvent consumed or the amount of solvent containing products consumed. The availability of such activity data in Greece is limited and as a result the default CORINAIR methodology is applied for the estimation of NMVOC emissions.

It should be mentioned that evaporative emissions of GHG arising from other types of product use (e.g. N_2O emissions from medical use), are not estimated since appropriate methodologies have not been developed yet.

Carbon dioxide emissions are calculated from NMVOC emissions, assuming that the carbon content of NMVOC is 85%.

Paint application

Data availability concerning the use of products containing solvents for "Vehicle manufacture and Vehicle refinishing" is limited and as a result the respective emissions are not estimated.

Emissions from "Domestic use and construction" are estimated on the basis of population figures and default emission factors from CORINAIR (0.5 kg / capita).

Metal Degreasing and Dry Cleaning

Emission estimates are given only for the dry cleaning sector. These estimates are based on population figures and default emission factors from CORINAIR (0.25 kg /capita) that is applicable to all types of dry cleaning equipment.

Other Use of Solvents and Related Activities

The emission factors used for some of the activities defined in CORINAIR and for which it was possible to obtain the corresponding activity data from the Hellenic Statistical Authority, are:

- Production and processing of PVC: 40 kg / t of product produced or processed.
- Production of pharmaceutical products: 14 g /capita.
- Ink production: 30 kg / t of product.
- Glue production, applied emission factor: 20 kg /t of product
- For the wood preservation: 24 kg / t of wood preserved
- For fat edible and non edible oil extraction: 14 kg NMVOC/ t of seed processed
- For domestic solvent use (except paint application): 2.6 kg NMVOC/capita/year

In the case of **printing industry**, the estimation of emissions was based on the consumption of ink. Printing ink is mostly used for the publishing of newspapers, books and various leaflets. According to the estimations of one publishing organisation, the amount of ink used for the printing of a daily newspaper is approximately 3.7 g of ink. The quantity of ink used for printing books etc. was calculated by subtracting the total quantity used for the newspapers from the total ink consumed. The emission factor applied (260 kg / t ink) is the average of emission factors for newspaper printing (54 kg /t ink) and for books and other leaflets printing (132-800 kg / t ink).

Solvent and other product use - N2O emissions (source categories 3D1 & 3D3)

For source categories 3D1 and 3D3, neither national activity data nor IPCC methodology are available for the estimation of N2O emissions. The inventory team in order to provide emissions for these source categories proceeded as follows:

1. The inventory team started by investigating the NIRs and ERT audit reports of other Annex I parties, as concerns the estimation of emissions for the 3D1 and 3D3 source categories.
2. The ratio of N2O emissions per population (ktN2O/1000s capita) for a cluster of Annex I parties was computed. Four European countries were selected: Italy and Spain (which have similarities with Greece as concerns climate etc), Austria and Netherlands (in order to be conservative in the estimation of emissions).
3. The mean value of the above mentioned ratios was calculated.
4. By using the population of Greece as a driver (activity data) and the above calculated ratio as “Emission factor”, the emissions for the whole time series 1990-2009 of the 3D1 and 3D3 were estimated.

6. Agriculture (CRF sector 4)

6.1 Overview

In this chapter, GHG emissions estimates from the sector *Agriculture* are presented and the calculation methodologies per source category are described.

According to the IPCC Guidelines, the following source categories are included in this sector:

- Enteric fermentation
- Manure management
- Rice cultivation
- Agricultural soils
- Field burning of agricultural residues

The remainder of this chapter is organised as follows. Paragraph 6.1 continues with the presentation of emissions trends from agriculture, a brief description of the methodology applied for the calculation of GHG emissions and the assessment of the completeness of the GHG inventory for agriculture. Then (Paragraphs 6.2 – 6.6) detailed information on the methodologies applied (including references on the activity data and the emission factors used) for the calculation of GHG emissions per source category is presented.

6.1.1 Emissions trends

GHG emissions from *Agriculture* decreased by 22.2% between 1990 and 2009 (***Figure 6.1***), with an average annual rate of decrease of 1.17%. The steep decrease observed for the years 1993 and 1994 is due to the cut backs in public incentives for the use of synthetic fertilizers.

Emissions from *Agriculture* and especially N_2O emissions from agricultural soils are characterized by intense fluctuations during the period 1990 – 2009. The annual variations of agricultural production and the amount of synthetic fertilizers applied are the main causes for these fluctuations. Agricultural production data were derived from the Hellenic Statistical Authority (ELSTAT), while confirmed data for the quantities of synthetic fertilizers applied in soils derive for the first time from the Pan-Hellenic Association of Professional Fertilizers Producers & Dealers (PHAPFPD).

GHG emissions estimated from *Agriculture* in the current submission have been been recalculated after the recommendations of 2010 centralized ERT review and the improvement of the estimation method for the emissions from cattle enteric fermentation. However, the new estimations show small deviations in comparison with the estimations of the previous submission.

Agriculture is responsible for methane and nitrous oxide emissions. Emissions per gas from agriculture are presented in ***Table 6.1***.

Table 6.1 ***GHG emissions (in kt CO_2 eq) per gas from Agriculture, for the period 1990 – 2009***

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N_2O	7803	7664	7451	6600	6400	6679	6779	6630	6632	6490	6271
CH_4	3680	3659	3635	3620	3635	3658	3701	3705	3715	3705	3685
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
N_2O	6174	6106	6037	6113	5810	5657	5925	5260	5229		
CH_4	3686	3723	3728	3734	3745	3731	3721	3715	3711		

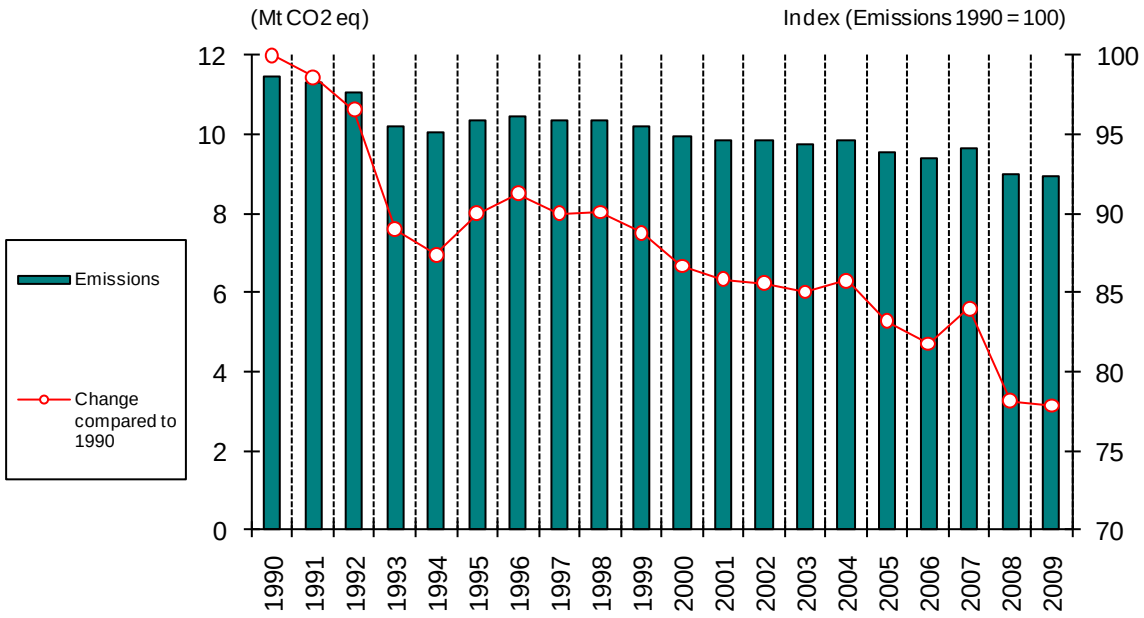


Figure 6.1 ***Total GHG emissions (in kt CO_2 eq) from Agriculture for the period 1990 – 2009***

Nitrous oxide represents the main GHG from *Agriculture*, with a contribution ranging from 58% to 68%. Nitrous oxide emissions in 2009 decreased by 33.0% compared to 1990 levels with an average annual rate of decrease estimated at 1.74%.

Agricultural soils are the main source of emissions from *Agriculture* (***Figure 6.2***), accounting for 55% - 65% of the total emissions from the sector.

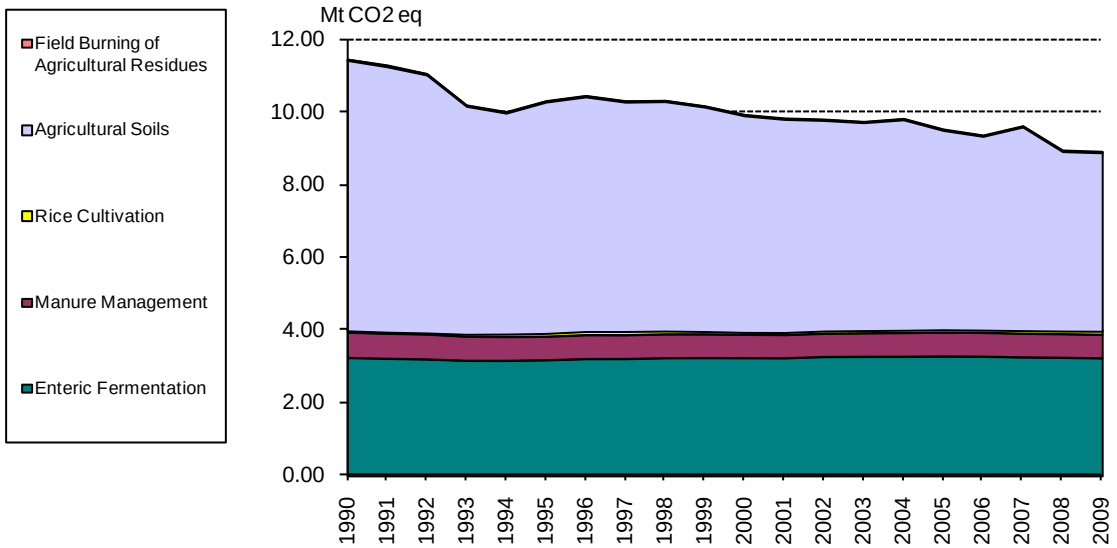


Figure 6.2 ***GHG emissions (in kt CO_2 eq) from Agriculture per source category, for the period 1990 – 2009***

6.1.2 Methodology

The calculation of GHG emissions from *Agriculture* is based on the methodologies and emission factors suggested by the IPCC Guidelines and the IPCC Good Practice Guidance.

Data on animal population, agricultural production and cultivated areas used for the emissions calculation were provided by the ELSTAT, while data on the amount of synthetic fertilizers applied to soils derive from Pan-Hellenic Association of Professional Fertilizers Producers & Dealers. Data on animal population, agricultural production and areas for 2008 and 2009 are provisional estimations, due to delay from the time the relative statistical data are collected until their elaboration and publication as final estimations.

The methodology applied for the calculation of emissions per source category is briefly presented in ***Table 6.2***, while a detailed description is given in the corresponding paragraphs (Paragraphs 6.2 – 6.6).

Key categories

If enteric fermentation is considered as a common source, following the suggestion by IPCC good practice guidance, this source is determined as a key category. However, after the recommendations of 2010 centralized ERT review the emissions from enteric fermentation were disaggregated by the significant animal types. The consequences of this improvement were the determination of enteric fermentation of sheep and other animal as key categories sources while the enteric fermentation of non dairy cattle and dairy cattle source were determined as non key category sources.

Table 6.2 Methodologies for the estimation of emissions from Agriculture

	CH_4		N_2O	
	Method	Emission factor	Method	Emission factor
Enteric fermentation - Dairy cattle	T2	CS, D		
Enteric fermentation – Non dairy cattle	T2	CS, D		
Enteric fermentation – Sheep	T2	CS, D		
Enteric fermentation – Other animal	T1	D		
Manure management	T2, T1	CS, D	D	D
Rice cultivation	D	D		
Agricultural soils			D,T1a, T1b	D
Field burning of agricultural residues	D	D	D	D

T1, T2, T1a and T1b: IPCC methodology Tier 1, 2, 1a and 1b respectively

D: IPCC default methodology and emission factor, CS: Country specific emission factor

Agricultural soils (animal production, indirect emissions and direct emissions) are key categories. (see Paragraph 1.5 for a complete presentation of the results of the key categories analysis and Annex I for the presentation of the relevant calculations) The key categories from agricultural sector (excluding LULUCF) are presented ***Table 6.3*** .

According to the IPCC Good Practice Guidance, emissions from key categories should be estimated using the most rigorous methodologies. In the case of enteric fermentation, Tier 2 methodology is applied for enteric fermentation of non dairy cattle, for dairy cattle and for sheep which are responsible for 70% of methane emissions from this source and therefore the. Tier 2 methodology is being used for non dairy cattle and dairy cattle for the first time in this submission. For the rest of the animal the improvement of of emissions estimation's methodology is planning, especially for the most important of these, like goats.

Concerning agricultural soils both simple and detailed methodologies (Tier 1a and Tier 1b) as well as their combination are proposed, depending on data availability.

Table 6.3 Key categories from the Waste sector (excluding LULUCF)

Source category	Gas	Level assessment	Trend assessment
Enteric fermentation – Sheep	CH_4	☒	☒
Enteric fermentation – Other animal	CH_4	☒	
Direct emissions	N_2O	☒	☒
Animal production	N_2O	☒	☒
Iindirect emissions	N_2O	☒	☒

Uncertainty

The results of the uncertainty analysis undertaken for the Greek GHG emissions inventory are presented in Paragraph 1.7, while the detailed calculations are presented in Annex IV.

6.1.3 Completeness

Table 6.4 gives an overview of the IPCC source categories included in this chapter and presents the status of emissions estimates from all sub-sources in agriculture.

Table 6.4 Agriculture – Inventory completeness

	CO_2	CH_4	N_2O
A. Enteric fermentation		☒	
B. Manure management		☒	☒
C. Rice cultivation		☒	
D. Agricultural soils			
1. Direct emissions		NE	☒
2. Animal production		NE	☒
3. Indirect emissions		NE	☒
F. Field burning of agricultural residues		☒	☒

NE: Not estimated

Methane emissions from agricultural soils are not estimated since appropriate methodologies have not been developed yet.

6.2 Enteric fermentation (CRF Source Category 4A)

6.2.1 Description

Methane is produced during the normal digestion of food by herbivorous animals and the amount emitted depends on the animal species, their digestive system and feed intake.

Enteric fermentation (CH_4 emissions) of sheep and other animal are key categories. As already mentioned, the Tier 2 methodology is applied for the estimation of methane emissions from enteric fermentation of cattle and sheep, according to the recommendation of the IPCC Good Practice Guidance. The Tier 1 methodology and the default emission factors suggested by the IPCC Guidelines are used for the rest of the animal species.

Methane emissions from enteric fermentation in 2009 account for 36% of total GHG emissions from *Agriculture* and for 2.6% of total national emissions (excluding *LULUCF*). The average annual rate of decrease of emissions from enteric fermentation for the period 1990 – 2009, is estimated at 0.02% (decrease by 0.35% in 2009 compared to 1990). Emissions from enteric fermentation are presented in ***Table 6.5***.

Table 6.5 CH_4 emissions (kt) from enteric fermentation for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CH_4 emissions (kt)	154.58	153.49	152.63	150.85	150.81	151.58	153.12	153.16	154.29	154.42	154.31
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
CH_4 emissions (kt)	154.18	155.83	156.06	156.12	156.48	156.17	155.32	154.78	154.07		

6.2.2 Methodology

Enteric fermentation of dairy cattle

In the current submission, methane emissions from the enteric fermentation of dairy cattle are estimated for the first time according to the Tier 2 IPCC methodology, as it is described in the IPCC Good Practice Guidance,.

The calculation of the emission factors for each activity is based on the following equation:

$$EF_i = \frac{GE_i \cdot Ym_i \cdot 365}{55.65}$$

where *i* is the activity, EF_i is the estimated emission factor for CH_4 (kg CH4/head/yr), GE_i is the gross energy intake (MJ/head/day) and *Ym* is the methane conversion rate which is the fraction of the gross energy in feed converted to CH_4.

The calculation of gross energy for sheep is based on the following equation:

$$GE = \left[\left(NE_m + NE_a + NE_l + NE_p \right) \Big/ \left(NE_{ma} / DE \right) + \left(NE_g \right) \Big/ \left(NE_{ga} / DE \right) \right] / \left[DE / 100 \right]$$

where:

NE_m is the net energy required for animal maintenance, MJ/day

NE_a is the net energy for animal activity, MJ/day

NE_l is the net energy for lactation, MJ/day

NE_p is the net energy required for pregnancy, MJ/day

NE_g is the net energy for growth, MJ/day

DE is the digestible energy expressed as a percentage of gross energy

NEma/DE is the ratio of net energy available in a diet for maintenance to digestible energy consumed

NEga/DE is the similar ratio for growth.

The number of dairy cattle used for the calculation of methane emissions is a three-year average centred at the year of reference and it is presented in ***Table 6.6*** for the period 1990-2009. In the same table the annual average milk production (for 365 days) is presented while milk production yield during suckling estimated at 0.6 kg/day (estimated for 365 days). The data for population of dairy cattle was updated in the current submission following the results of a survey of ELSTAT.

The average bodyweight of dairy cattle is estimated at 600 kg. Portion of cows giving birth is estimated at 0.9 while milk fat content is considered at 4%, digestibility of feed at 60% and methane conversion rate at 6% as suggested by IPCC Good Practice Guidance. For the estimation of net energy for dairy cattle activity, it was considered that they are confined to a small area thus no energy is required to acquire feed (C_a = 0).

Table 6.6 ***Number of dairy cattle in 1000s (three-year average) and milk production yield in kg/head/day, for the period 1990 – 2009***

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Dairy cattle (1000s)	212	209	212	197	193	181	186	180	170	169	169
Milk prod. yield (kg/head/day)	7.50	7.63	8.15	9.38	9.57	10.44	10.17	10.50	11.22	11.19	11.38
Year	2001	2002	2003	2004	2005	2006	2007	2008†	2009†		
Dairy cattle (1000s)	168	158	152	153	153	153	148	149	147		
Milk prod. yield (kg/head/day)	11.57	12.72	12.52	13.12	14.02	13.74	13.90	14.29	14.49		

† Provisional data

Finally, in ***Table 6.7*** information regarding gross energy (Gei) and emissions factors (EFs) for the whole of period 1990-2009 is presented.

Table 6.7 ***Gross energy (GE) and emissions factor (EF) for dairy cattle for the period 1990 - 2009***

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
GE (MJ/head/day)	224	225	231	243	245	254	252	255	262	262	264
EF (kg CH_4/head/yr)	88.1	88.6	90.7	95.8	96.5	100.1	99.0	100.3	103.2	103.1	103.9

Year	2001	2002	2003	2004	2005	2006	2007	2008†	2009†
GE (MJ/head/day)	266	278	276	282	291	288	290	294	296
EF (kg CH_4/head/yr)	104.7	109.3	108.5	111.0	114.7	113.5	114.1	115.7	116.6

Enteric fermentation of other cattle

Similar with the dairy cattle, methane emissions from the enteric fermentation of other cattle are estimated according to the Tier 2 IPCC methodology, as it is described in the IPCC Good Practice Guidance, for the first time in the current submission.

The characterization and classification of other cattle was based on data from ELSTAT and the statistics department of the Ministry of Agriculture, as well as on estimates by experts in agricultural issues. The population of other cattle for each sub-category is presented in ***Table 6.8***. for the period 1990-2009.

The calculation of the emission factors for each activity is based on the equation presented above for the diary cattle (Equation 4.14 of IPCC Good Practice Guidance). In ***Table 6.9*** parameters used for the estimation of emissions from other cattle is presented as well as the gross energy (Ge) and the emissions factors (EFs) for the 2009. Portion of female cattle, >2 year old, giving birth is estimated at 0.9 while milk production yield estimated at 0.1 kg/day (estimated for 365 days) and milk production yield during suckling estimated at 1.0 kg/day (estimated for 365 days). Milk fat content is estimated at 4%, digestibility of feed at 60% and methane conversion rate at 6%, as suggested by IPCC Good Practice Guidance. For the estimation of net energy for other cattle activity, it was considered that they are confined in areas with sufficient forage requiring modest energy expense to acquire feed. (C_a = 0.17).

Table 6.8 Number of other cattle (in 1000s) for each sub-category (three-year average), for the period 1990 – 2009

Sub-categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
< 1 year											
For slaughter as calves	100	101	93	80	66	58	59	52	69	66	69
Females	65	62	56	54	57	57	58	55	52	63	50
Males	43	42	39	44	52	59	59	59	55	55	51
1-2 years											
Females	54	53	52	47	45	43	45	45	46	44	45
Male	65	64	59	52	50	53	56	57	59	57	52
> 2 year											
Females	143	139	129	118	114	121	126	135	145	142	142
Males	7	7	7	6	6	6	7	8	11	13	13
Total	479	468	436	402	390	397	411	410	438	440	422

Sub-categories	2001	2002	2003	2004	2005	2006	2007	2008†	2009†
< 1 year									
For slaughter as calves	53	58	66	69	71	70	67	66	66
Females	56	57	61	60	59	60	59	59	58
Males	56	59	63	65	64	67	61	62	59
1-2 years									
Females	47	52	56	56	57	56	58	57	57
Males	45	49	60	70	74	72	67	65	66
> 2 year									
Females	142	161	171	174	180	180	187	182	184
Males	12	13	13	13	13	14	15	15	14
Total	411	450	490	506	517	519	515	506	504

† Provisional data

Table 6.9 ***Mean Weight, Gross energy (Gei), CH_4 conversion rate (Ym) value and emissions factor (EFs) for each subcategory of other cattle for 2009***

	Mean Weight (kg)	Gross Energy (Gei) MJ/day/head	Conversion rate (Ym)	Emissions factors (EF) $KgCH_4$/head/yr
< 1 year				
For slaughter as calves	200	95.5	0.06	37.6
Females	180	100.9	0.06	39.7
Males	230	111.7	0.06	44.0
1-2 years				
Females	450	147.0	0.06	57.8
Males	500	160.2	0.06	63.0
> 2 year				
Females	550	166.2	0.06	65.4
Males	750	181.9	0.06	71.6
Average	411.6	140.5	0.06	55.28

Enteric fermentation of sheep

Methane emissions from the enteric fermentation of sheep are estimated according to the Tier 2 IPCC methodology, as it is described in the IPCC Good Practice Guidance. In the current submission some improvements were made in order to meet the the recommendations of 2010 centralized ERT review. These improvements concern better applying of "enhanced" livestock characterization for the estimation of emission using data by the same annual statistical survey performed by the ELSTAT and used for the estimation of emissions from the enteric fermentation of dairy and other cattle.

For the calculation of the net energy required for each animal sub-category and activity, the appropriate in each case factors suggested in the IPCC Good Practice Guidance were used. The calculation of the emission factors for each animal sub-category and activity is based on the following equation:

$$EF_i = \frac{GE_i \cdot Ym_i \cdot 365}{55.65}$$

where *i* is the activity, EF_i is the estimated emission factor for CH_4 (kg CH4/head/yr), GE_i is the gross energy intake (MJ/head/day) and *Ym* is the methane conversion rate which is the fraction of the gross energy in feed converted to CH_4.

The calculation of gross energy for sheep is based on the following equation:

$$GE = \left[\left(NE_m + NE_a + NE_l + NE_p \right) \Big/ \left(NE_{ma} / DE \right) + \left(NE_g + NE_{wool} \right) \Big/ \left(NE_{ga} / DE \right) \right] / \left[DE / 100 \right]$$

where:

NE_m is the net energy required for animal maintenance, MJ/day

NE_a is the net energy for animal activity, MJ/day

NE_l is the net energy for lactation, MJ/day

NE_p is the net energy required for pregnancy, MJ/day

NE_g is the net energy for growth, MJ/day

NE_{wool} is the net energy for growth, MJ/day

DE is the digestible energy expressed as a percentage of gross energy

NEma/DE is the ratio of net energy available in a diet for maintenance to digestible energy consumed

NEga/DE is the similar ratio for growth.

The characterization and classification of sheep was based on data from ELSTAT and the statistics department of the Ministry of Agriculture, as well as on estimates by experts in agricultural issues. The estimation of sheep population for each sub-category is presented in ***Table 6.10***.

The average bodyweight of sheep at weaning is estimated at 15 kg while the average weights of female and male mature sheeps (>1 year) are estimated at 53 kg and 70 kg respectively.

The average milk production for domestic and in flock and for nomadic sheep was considered equal to 0.22 kg/day and 0.20 kg/day respectively estimated for 365 days, while the milk production of mothers during suckling estimated at 0.12 kg/day (for 365 days). Wool production is estimated for all the mature sheep at 4 kg/sheep/year.

Due to lack of data concerning the births of lambs the following assumption was adopted. It was considered that all milked mature sheep give birth. Some of the milked sheep give single birth while the other one give a double such the total number of lambs to be equal with these obtained by the ELSTAT as born (Table 6.10). In the previous submission, it was assumed that all births were single, however after the recommendations of 2010 centralized ERT review, this new approach was made.

Default methane conversion rates (*Ym*) which correspond to high digestibility were selected from the IPCC Good Practice Guidance, based on experts' estimates regarding the types of feed intake for Greece. In ***Table 6.11*** information regarding gross energy (Gei), CH_4 conversion rate (Ym) values and emissions factors (EFs) for each subcategory of sheep (such as grazing, lactation and growth) is presented for 2009.

The duration of lamb's growth is estimated at 315 days, which correspond to the period between effective weaning and one year of age, suckling lasts 50 days, while pregnancy lasts 147 days.

Table 6.10 Number of sheep (in 1000s) for each sub-category (three-year average), for the period 1990 – 2009

Sub-categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Milking ewes											
Milk production	5254	5243	5252	5274	5315	5353	5370	5382	5393	5415	5454
Only suckling	395	395	395	397	400	403	404	405	406	408	411
Other female sheep > 1 year	734	733	734	737	743	748	751	752	754	757	762
Males > 1 year old	395	395	395	397	400	403	404	405	406	408	411
Female lambs	1530	1526	1529	1536	1547	1559	1563	1567	1570	1577	1588
Male lambs	382	382	382	384	387	390	391	392	393	394	397
Total	8692	8673	8688	8725	8792	8856	8883	8904	8922	8958	9023
Born sheep	8490	8487	8590	8664	8728	8787	8841	8855	8882	8910	8966

Sub-categories	2001	2002	2003	2004	2005	2006	2007	2008†	2009†
Milking ewes									
Milk production	5476	5478	5418	5364	5329	5330	5332	5324	5313
Only suckling	412	412	408	404	401	401	401	401	400
Other female sheep > 1 year old	765	766	757	750	745	745	745	744	743
Males > 1 year old	412	412	408	404	401	401	401	401	400
Female lambs	1594	1595	1577	1562	1552	1552	1553	1550	1547
Male lambs	399	399	394	390	388	388	388	388	387
Total	9059	9062	8962	8874	8816	8818	8821	8808	8790
Born sheep	9005	9039	9038	9024	9008	8998	8995	8988	8979

† Provisional data

Table 6.11 Gross energy (Gei), CH_4 conversion rate (Ym) value and emissions factor (EFs) for each subcategory of sheep for 2009

	Gross Energy (Gei) MJ/day/head	Conversion rate (Ym)	Emissions factors (EF) $KgCH_4$/head/yr
Female lamb	16.2	0.05	5.3
Female sheep - milking ewes	21.4	0.07	10.3
Female sheep – other	17.4	0.07	8.0
Male lamb	21.1	0.05	6.9
Male sheep	22.7	0.07	10.4
Average	20.3	6.63	9.06

Methodology for enteric fermentation for the other animals

Methane emissions from enteric fermentation for the other animals are estimated according to the Tier 1 IPCC methodology. For first time, methane emissions from enteric fermentation for poultry are estimated based on country specific emission factor.

The application of this methodology requires livestock population data and emission factors per animal species. Population data were obtained from the ELSTAT. Emission factors used were the ones suggested by IPCC Guidelines (Developed countries, Table 4-3, IPCC 1997).

The number of animals used for the calculation of methane emissions (***Table 6.12***) is a three-year average centred at the year of reference.

Table 6.12 Number of animals (in 1000s) by category (three-year average), for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Buffalo	0.827	0.865	0.910	0.827	0.765	0.709	0.741	0.796	0.843	0.906	0.954
Goats	5339	5345	5360	5395	5449	5513	5565	5595	5610	5623	5640
Horses	46	42	40	38	36	35	33	32	31	30	29
Mules and ashes	187	174	161	150	140	130	122	114	108	101	95
Swine	994	994	1000	1008	1005	997	993	995	990	979	957
Poultry	28747	28648	28972	29151	29231	29198	29266	29482	30005	30480	30150
Year	2001	2002	2003	2004	2005	2006	2007	2008†	2009†		
Buffalo	1.003	1.048	1.141	1.212	1.305	1.338	1.361	1.345	1.343		
Goats	5658	5652	5600	5517	5444	5409	5372	5325	5267		
Horses	29	28	28	27	27	27	27	27	26		
Mules and ashes	90	84	79	74	69	66	62	58	53		
Swine	946	937	939	942	930	918	906	907	906		
Poultry	29937	29312	29936	30429	31251	31592	31572	31592	31592		

† Provisional data

6.2.3 Uncertainties and time-series consistency

The combined uncertainty of CH_4 emissions of enteric fermentation sector as % of total emissions is estimated by 0.8%. The uncertainty associated with activity data is 5% according to uncertainty given by NSSG for the livestock population data. On the other hand, the uncertainty associated with emission factors is 30% as it is estimated according to Good Practice Guidance. The results of uncertainty analysis are presented in Table 1.9. The detailed calculations of uncertainty are presented in Annex IV (Tables IV.1 – IV.3).

The time-series consistency of emissions is controlled by applying consistent methodologies and verified activity data inline with IPCC guidelines. In case of changes or refinements in methodologies and EFs based on country-specific data, time-series consistency is ensured by performing recalculations according to the IPCC good practice guidance.

6.2.4 Source-specific QA/QC and verification

Quality control and source-specific quality control is carried out based on the principles of inventory Quality Assurance / Quality Control (QA/QC) plan (National Systems under Article 5 Paragraph 1 of the Protocol as described in Decision 20/CP.7). The special procedures followed in the enteric fermentation source are:

- Cross checking information provided by the Hellenic Statistical Authority and by the Ministry of Rural Development regarding the animal population and the agricultural crop production.
- Animal population is also checked by comparison with two different works provided by the ELSTAT. The first one is annual statistical survey while the second one is a census of livestock population. The results of the first one were used for the estimation of emissions for cattle while the results of the other for the rest of animals.
- Comparison of information regarding animal population, agricultural crop production and emissions factors with this of other neighbour countries.
- Estimations were checked with several calculation tools such as emissions trends and sum deviations.

6.2.5 Recalculations

CH_4 emissions from enteric fermentation have been recalculated for dairy cattle, for other cattle and for sheep for the whole of 1990-2008 period. CH_4 emissions from enteric fermentation of dairy cattle and for other cattle were recalculated due to applying of Tier 2 methodology.

CH_4 emissions from enteric fermentation of sheep were recalculated following the recommendations of 2010 centralized ERT review in order for estimations to be consistent with the IPCC good practice guidance:

- Estimation of energy for growth for all growing sheep considering that in mature age (1 year old) sheep obtain their mature weight (70 kg for males and 53 kg for females).
- Estimation of energy for wool for all mature sheep.
- Reconsidering of the number of milking ewes and births type considering that except of single births, double births occur based on the number of sheep born.

CH_4 emissions from enteric fermentation of poultry were recalculated for using country specific emission factors the first time. Emissions for 2007 and 2008 of othen animall where not recalculated, although provisional data had been used in the previous submission due to lack of updated data. According to ELSTAT, upadated data for both 2007 and 2008 will be provided for the estimations of the next submission.

The deviation of the emissions from enteric fermentation in the present submission compared to the emissions estimated in the previous submission and the impact on total emissions (excl LULUCF) of recalculations are presented in ***Table 6.13***.

Table 6.13 Recalculations of CH_4 emissions from enteric fermentation (%)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Difference	12.819	13.243	12.666	10.971	10.627	10.489	11.285	11.146	11.444	10.919	9.778
Impact on total emissions (excl LULUCF)	0.353	0.363	0.342	0.300	0.284	0.277	0.291	0.276	0.272	0.261	0.229

Year	2001	2002	2003	2004	2005	2006	2007	2008
Difference	9.032	9.822	11.116	12.391	13.067	12.470	12.046	11.727
Impact on total emissions (excl LULUCF)	0.210	0.230	0.251	0.275	0.283	0.278	0.263	0.265

6.2.6 Planned improvements

The possibility of applying Tier 2 methodology for the estimation of methane emissions from the enteric fermentation of goats is under examination. Moreover, updated data for the population of animals is expected to be disposed in the next submission.

6.3 Manure management (CRF Source Category 4B)

6.3.1 Description

Manure management is responsible for methane and nitrous oxide emissions. Methane is produced during the anaerobic decomposition of manure, while nitrous oxide is produced during the storage and treatment of manure before its use as fertilizer.

CH_4 and N_2O from manure management in 2009 accounted for 3.7% and 3.4% of total GHG emissions from *Agriculture* respectively, and for 0.27% and 0.25% of total national emissions respectively (without *LULUCF*). CH_4 emissions in 2009 decreased by 3.2% compared to 1990 levels, with an average annual rate of decrease estimated at 0.17% for the period 1990 - 2009. N_2O emissions in 2009 decreased by 11.6% compared to 1990 levels, with an average annual rate of decrease estimated at 0.61%. CH_4 and N_2O emissions from manure management for the period 1990 – 2009 are presented in ***Table 6.14***.

Table 6.14 CH_4 and N_2O emissions (in kt) from manure management, for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CH_4 (kt)	16.07	16.00	16.08	16.07	16.03	15.96	16.00	16.01	16.04	16.00	15.81
N_2O (kt)	1.10	1.08	1.07	1.00	0.97	0.95	0.98	0.97	0.97	0.96	0.95
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
CH_4 (kt)	15.70	15.60	15.65	15.75	15.80	15.73	15.58	15.59	15.56		
N_2O (kt)	0.94	0.95	0.97	0.98	1.00	1.00	0.99	0.98	0.97		

6.3.2 Methodology

CH_4 emissions from manure management were estimated using IPCC Tier 2 approach for dairy cattle and other cattle and sheep, following the recommendations of 2010 centralized ERT review. For the rest of the animals, Tier 1 approach was used (IPCC 1997, Tables 4-5 and 4-6). Livestock population has been already presented in Tables 6.6, 6.8, 6.10 and 6.12..

For the estimation of EF of dairy and other cattle and sheep the equation suggested by IPCC (1997) guidelines was used:

$$EF_i = VS_i \cdot 365 \cdot Bo_i \cdot 0.67 \cdot \sum_{ijk} MCF_{jk} \cdot MS_{ijk}$$

where:

EF_i is the annual emission factor for defined livestock population i, in kg

VS_i is the daily VS excreted for an animal within defined population i, in kg

Bo_i is the maximum CH_4 producing capacity for manure produced by an animal within defined population i, m^3/kg of VS

MCF_{jk} is the CH_4 conversion factors for each manure management system j by climate region k

MS_{ijk} is the share of animal species/category i's manure handled using manure system j in climate region k

The daily VS excretion rates for dairy cattle, other cattle and sheep was estimated using the feed intake estimated through the CH_4 emissions' calculation from enteric fermentation. The proposed equation by IPCC guidelines (Equation 4.16, IPCC 1997) was used:

$$VS = GE / 18.45 \cdot (1 - DE/100) \cdot (1 - ASH/100)$$

where:

GE is the estimated daily average feed intake in MJ/day

DE is the digestible energy of the feed in percent

ASH is the ash content of the manure in percent (8%)

In ***Table 6.15*** the parameters used for the estimation CH_4 emissions from manure management of dairy cattle, other cattle and sheep are presented for 2009. As it is shown, Bo values proposed by IPCC Rev. 1996 (Appendix B) and default MCF values provided by IPCC Guidelines for different manure management systems were used.

Table 6.15 Parameters for the estimation CH_4 emissions from manure management of dairy cattle, other cattle and sheep for 2009

	Dairy cattle	Other cattle	Sheep
DE, %	60	60	65
ASH, %	8	8	8
VS, kg/day	6.42	2.80	0.36
Bo, m^3/kg of VS	0.24	0.17	0.19
MCF	1.5	1.5	1.5
EF, kg/year/head	9.31	1.68	0.25

The shares of manure management systems per animal species for dairy cattle, other cattle and sheep are presented in ***Table 6.16*** along with the rest of animal type considering 100% conditions of temperate climate region for Greece. These values are estimated on the basis of proposed (IPCC

1997, Table 4-21) and country-specific values, depending on the availability of national data, and are kept constant for the period 1990 – 2009.

In order to calculate N_2O emissions from manure management, the default IPCC methodology was used, according to the following equation.

$$E = \sum_S \left(\sum_T \left(N_T \cdot Nex_T \cdot MS_{(T,S)} \right) \right) \cdot EF_S$$

where E is N_2O emissions, T is the animal species index, S is the manure management system index, $N_{(T)}$ is the livestock population, $Nex_{(T)}$ the annual average N excretion per head of species, $MS_{(T,S)}$ the fraction of total annual excretion for each livestock species that is managed in system S, $EF_{(S)}$ is the N_2O emission factor for system S.

The shares of manure management systems per animal species have already been presented in Table 6.16 considering 100% conditions of temperate climate for Greece.

Generally, the assumption of utilized values referring to Near East and Mediterranean category on IPCC (1997) guidelines for the allocation of manure to animal waste management systems per animal species was followed. However, in some cases country-specific data was used based on the judgement of experts from several institutes, including the Agricultural University of Athens, the Ministry of Rural Development and Food, the Department of Animal Production at the School of Agricultural Technology (the Technological Educational Institute of Epirus) and the Office of Rural Development of the Prefecture of Thessaloniki. Greece continues efforts to improve the country-specific data.

Table 6.16 Manure management systems

Manure management systems	Anaerobic lagoon	Liquid system	Daily spread	Solid storage and dry lot	Pasture/ range/ paddock	Other system
Dairy cows	0%	0%	2%	90%	8%	0%
Other cattle	0%	0%	3%	62%	33%	2%
Buffalo	0%	0%	3%	62%	33%	2%
Poultry	0%	0%	0%	0%	72%	28%
Sheep	0%	0%	0%	0%	100%	0%
Swine	0%	90%	0%	10%	0%	0%
Horses	0%	0%	0%	0%	100%	0%
Mules and ashes	0%	0%	0%	0%	100%	0%
Goats	0%	0%	0%	0%	100%	0%

Country-specific data for dairy cattle, other cattle, buffalo and swine was considered. Dairy cattle are mainly stall or housed and they are used for milk production. Only for a small share of their life

they are in pasture. Thus the manure produced from them is mainly managed in Solid storage and dry lot systems.

The allocation of manure to animal waste management systems of other cattle and buffalo results as follows. Almost the 60% of them, the animal in age of 1 year and older, remain in pasture for about seven months per year while the young animal remain mainly in stall. For the rest of the time, all the other cattle are in stall. Thus, it is estimated that about 33% of the produced manure by other cattle fall in pasture while the rest is mainly managed in Solid storage and dry lot systems.

The majority of swine in Greece remain in properly designed building infrastructures and their manure is managed with liquid systems according to Greek legislation. A small share of swine's manure, about 10%, is managed with solid systems. This share mainly represents the manure produced by swine live in small production units.

The allocation of manure to animal waste management systems of other animal, like sheep, goats and poultry is similar with this referring to Near East and Mediterranean category on IPCC (1997) guidelines. For example sheep and goats are in pasture in Greece.

The emission factors for N excretion and N_2O-N/N are those suggested by the IPCC Guidelines. N excretion for dairy cattle value referring to West Europe countries was used taking into account that the dairy milk production in Greece has increased to levels similar to those of Western Europe. Moreover, for other cattle and buffalo N excretion values for dairy cattle referring to West Europe countries were used. For the rest of the animals N excretion value referring to Mediterranean countries was used.

Finally, for the estimation of other cattle and sheep N excretion, the adjustment factors for young animals proposed by IPCC guidelines (Table 4.14, IPCC 1997) were used.

6.3.3 Uncertainties and time-series consistency

The combined uncertainty of CH_4 emissions of manure management sector as % of total emissions is estimated at 0.1%. The uncertainty associated with activity data is 5% according to uncertainty given by NSSG for the livestock population data. On the other hand, the uncertainty associated with emission factors is 50% as it is estimated according to Good Practice Guidance.

The combined uncertainty of N_2O emissions of manure management sector is estimated by 0.3%. The uncertainty associated with activity data estimated by 50% (country specific value) taking into account that in Greece there is a wide variety of management systems used usage. The uncertainty associated with emission factors is 100% as it is estimated according to Good Practice Guidance.

The results of uncertainty analysis are presented in Table 1.9. The detailed calculations of uncertainty are presented in Annex IV (Tables IV.1 – IV.3).

The time-series consistency of emissions is controlled by applying consistent methodologies and verified activity data inline with IPCC guidelines. In case of changes or refinements in

methodologies and EFs based on country-specific data, time-series consistency is ensured by performing recalculations according to the IPCC good practice guidance.

6.3.4 Source-specific QA/QC and verification

Quality control and source-specific quality control is carried out based on the principles of inventory Quality Assurance / Quality Control (QA/QC) plan (National Systems under Article 5 Paragraph 1 of the Protocol as described in Decision 20/CP.7). The special procedures are followed in the manure management source are:

1. Investigation for information related to manure management systems applied in Greece per animal species and cross-checking. Information has already sought from the Agricultural University of Athens, the Ministry of Rural Development and Food, the Department of Animal Production at the School of Agriculture Technology (the Technological Educational Institute of Epirus) and the Office of Rural Development of the Prefecture of Thessaloniki and other research institutes.

2. Comparison of information regarding animal population, agricultural crop production and emissions factors with this of other neighbour countries.

3. Estimations were checked with several calculation tools such as emissions trends and sum deviations.

6.3.5 Recalculations

CH_4 and N_2O emissions from manure management have been recalculated because of the updated emissions factors use on the estimation of emissions from manure management of dairy cattle, other cattle, buffalo and sheep. Tier 2 approach was used for the estimation of methane emissions of dairy cattle, other cattle and sheep. Moreover, Western Europe values for the Nex of dairy cattle, other cattle and buffalo were used following the recommendations of ERT of 2010 review, while adjustment factors for young animals (other cattle, sheep) were applied as it is proposed by IPCC guidelines (Table 4.14, IPCC 1997).

The deviation of the emissions estimated in the current submission compared to the emissions estimated in the previous submission the impact on total emissions (excl LULUCF) of recalculations are presented in ***Table 6.17*** for CH_4 and for N_2O.

Table 6.17 Recalculations of CH_4 and N_2O emissions from manure management (%)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
						CH_4					
Difference	-32.067	-31.317	-30.563	-30.482	-30.507	-30.658	-30.437	-30.505	-30.712	-31.229	-32.004
Impact on total emissions (excl LULUCF)	-0.153	-0.147	-0.141	-0.142	-0.138	-0.136	-0.131	-0.126	-0.122	-0.125	-0.124
						N_2O					
Difference	13.374	14.637	14.975	8.346	6.533	4.304	7.553	6.650	5.700	3.779	1.633
Impact on total emissions (excl LULUCF)	0.039	0.041	0.041	0.023	0.017	0.011	0.019	0.016	0.013	0.009	0.004

Year	2001	2002	2003	2004	2005	2006	2007	2008
				CH_4				
Difference	-32.516	-32.668	-32.308	-31.818	-31.603	-32.002	-32.380	-32.254
Impact on total emissions (excl LULUCF)	-0.125	-0.125	-0.120	-0.117	-0.114	-0.119	-0.117	-0.121
				N_2O				
Difference	-0.313	0.386	2.939	5.276	6.607	6.229	5.041	4.688
Impact on total emissions (excl LULUCF)	-0.001	0.001	0.007	0.012	0.014	0.014	0.011	0.011

6.3.6 Planned improvements

The available official information related to manure management systems applied in Greece per animal species is not sufficient to allow for the characterization of the existing situation, especially as new techniques are being introduced. For this reason, the availability of relevant information is examined in collaboration with other research institutes (e.g. Agricultural University). However, difficulties arose while obtaining data due to high number of small units in Greece.

6.4 Rice cultivation (CRF Source Category 4C)

6.4.1 Description

Rice cultivated in Greece is grown in continuously flooded fields. This process results in methane production from anaerobic decomposition of organic matter, and consequently leads to the release of the gas in the atmosphere through the rice plants.

CH_4 emissions from rice cultivation in 2009 account for 1.32% of total GHG emissions from *Agriculture* and for 0.1% of total national emissions (without *LULUCF*). CH_4 emissions increased by 70.2 % in 2008 compared to 1990, with an average annual rate of increase of 3.7% for the period 1990 - 2009. CH_4 emissions from rice cultivation for the period 1990 – 2009 are presented in ***Table 6.18***.

Table 6.18 CH_4 emissions (in kt) from rice cultivation for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CH_4	3.29	2.95	2.94	4.05	4.74	5.22	5.72	5.82	5.25	4.67	3.98
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
CH_4	4.22	4.48	4.52	4.55	4.62	4.46	5.00	5.00	5.60		

The fluctuations in emissions trends are attributed to the annual changes in the amount of the cultivated areas as provided by the NSSG.

6.4.2 Methodology

In order to estimate methane emissions from rice cultivation, the default methodology suggested by the IPCC Good Practice Guidance was followed. The cultivated areas provided by the NSSG and the default emission factor (20 g CH_4 / m^2) were used for the emissions calculation.

Rice cultivated in Greece is grown in continuously flooded fields without the use of organic amendments and one cropping period is considered annually.

6.4.3 Uncertainties and time-series consistency

The combined uncertainty of CH_4 emissions of rice cultivation sector as % of total emissions is estimated by 0.04%. The uncertainty associated with activity data is 2% according to uncertainty given by NSSG for the for the rice cultivation data. On the other hand, the uncertainty associated with emission factors is 40% as it is estimated according to IPCC Rev. 1996. The results of uncertainty analysis are presented in Table 1.9. The detailed calculations of uncertainty are presented in Annex IV (Tables IV.1 – IV.3).

The time-series consistency of emissions is controlled by applying consistent methodologies and verified activity data inline with IPCC guidelines. In case of changes or refinements in methodologies and EFs based on country-specific data, time-series consistency is ensured by performing recalculations according to the IPCC good practice guidance.

6.4.4 Recalculations

No recalculations were performed.

6.5 Agricultural soils (CRF Source Category 4D)

6.5.1 Description

Agricultural soils constitute the largest anthropogenic source of nitrous oxide emissions. N_2O is produced naturally in soils through the microbial processes of nitrification and denitrification. Agricultural activities add nitrogen to soils, increasing the amount of N_2O released in the atmosphere. Anthropogenic N_2O emissions from agriculture are produced either directly from nitrogen inputs to soils or indirectly, after the removal of nitrogen from soils. The N_2O emissions sources examined are the following:

- Pasture, range and paddock (animal production)
- Direct N_2O emissions
- Indirect N_2O emissions

Emissions from animal manure deposited to soils during pasture, range and paddock accounted for 20% of total GHG emissions from *Agriculture* and for 1.45% of total national emissions (without *LULUCF*) in 2009. Emissions decreased in 2009 by 2.3% compared to 1990 levels, with an average annual rate of decrease of 0.12% for the period 1990 – 2009. Direct N_2O emissions from agricultural soils in 2009 accounted for 15.2% of total GHG emissions from *Agriculture* and for 1.1% of total national emissions (without *LULUCF*). Direct emissions in 2009 decreased by 50.7% compared to 1990 levels, with an average annual rate of decrease of 2.67% for the period 1990 - 2009. Finally, indirect N_2O emissions in 2009 accounted for 20% of total GHG emissions from agriculture and for 1.45% of total national emissions (without LULUCF). Indirect emissions in 2009 decreased by 38.14% compared to 1990 levels, with an average annual rate of decrease estimated at 2.0% for the period 1990 – 2009. Emissions from agricultural soils for the period 1990 – 2009 are presented in ***Table 6.19***.

Table 6.19 N_2O emissions (in kt) from agricultural soils for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Animal production	5.87	5.84	5.83	5.82	5.84	5.87	5.90	5.91	5.93	5.95	5.96
Direct emissions	8.91	8.74	8.34	6.83	6.46	6.95	7.10	6.82	6.79	6.53	6.13
Indirect emissions	9.25	9.02	8.76	7.61	7.33	7.74	7.86	7.65	7.67	7.47	7.16
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Animal production	5.96	5.96	5.92	5.87	5.84	5.82	5.81	5.78	5.74		
Direct emissions	5.96	5.82	5.71	5.90	5.37	5.08	5.59	4.43	4.39		
Indirect emissions	7.02	6.93	6.84	6.93	6.51	6.31	6.70	5.74	5.72		

The reduction of N_2O emissions from agricultural soils is mainly due to the reduction in the use of synthetic nitrogen fertilizers. The decrease in the use of synthetic nitrogen fertilizers could probably be attributed to an increase in organic farming, the price of fertilizer and the impact of initiatives to promote good practice in fertilizer use. Additionally, the annual changes in the amount of fertilizers used and the agricultural production are the basic factors that account for the fluctuation of emissions during the period 1990 – 2009.

6.5.2 Methodology

Animal production

The estimation of N_2O emissions from pasture, range and paddock was based on the methodology used for the calculation of N_2O from manure management, using the default factors suggested by IPCC Guidelines (see Paragraph 6.3). Nitrogen input from pasture, range and paddock and N_2O emissions for the period 1990 – 2009 are presented in ***Table 6.20***.

Table 6.20 Nitrogen input (in kt) and N_2O emissions (in kt) from pasture, range and paddock, for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N input	186.93	185.89	185.38	185.12	185.82	186.89	187.71	188.13	188.77	189.16	189.52
N_2O emissions	5.87	5.84	5.83	5.82	5.84	5.87	5.90	5.91	5.93	5.95	5.96
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
N input	189.67	189.68	188.51	186.81	185.68	185.33	184.79	183.78	182.66		
N_2O emissions	5.96	5.96	5.92	5.87	5.84	5.82	5.81	5.78	5.74		

Direct N_2O emissions from agricultural soils

Direct N_2O emissions from agricultural soils derive from:

- The use of synthetic fertilizers
- Animal manure used as fertilizers
- The cultivation of N-fixing crops
- Crop residues that remain in soils
- Organic soils cultivation
- Sewage sludge used in agriculture (Estimation for first time in the current submission)

For the estimation of N_2O emissions from the use of synthetic fertilizers, Tier 1a methodology suggested by the IPCC Good Practice Guidance was applied. The data regarding the annual

quantities of synthetic fertilizers consumed in the country derive from Pan-Hellenic Association of Professional Fertilizers Producers & Dealers. As a part of the nitrogen contained in the fertilizer is volatised in ammonia and nitrogen oxides, the relevant conversion factor suggested by IPCC was used (IPCC 1997, Table 4-19). The amount of synthetic nitrogen applied to soils and the subsequent N_2O emissions for the period 1990 – 2009 are presented in ***Table 6.21***.

Table 6.21 Synthetic nitrogen applied (in kt) and N_2O emissions (in kt) from synthetic fertilizers, for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N input	381.60	367.20	351.00	276.30	257.40	284.40	290.70	276.30	277.20	263.70	243.00
N_2O emissions	7.50	7.21	6.89	5.43	5.06	5.59	5.71	5.43	5.45	5.18	4.77
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009†		
N input	234.00	227.70	222.30	229.50	201.60	189.00	216.00	153.00	153.00		
N_2O emissions	4.60	4.47	4.37	4.51	3.96	3.71	4.24	3.01	3.01		

† Provisional data

The basic methodology was also applied for the estimation of N_2O emissions from the use of animal manure as a fertilizing agent. Specifically, the total nitrogen excretion from animals was calculated, as in the case of manure management, and then corrected to account for the fraction that volatises in ammonia and nitrous oxides and the fraction that is deposited in soils through pasture, range and paddock, by using the default emission factors (IPCC 1997, Table 4-19). In ***Table 6.22*** nitrogen input to soils from animal manure and subsequent N_2O emissions are presented, for the period 1990 – 2009.

Table 6.22 Nitrogen input to soils from animal manure (in kt) and N_2O emissions (in kt) from animal manure used as fertilizers, for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N input	42.90	42.40	42.03	40.22	39.63	38.94	39.65	39.48	39.46	39.21	38.67
N_2O emissions	0.84	0.83	0.83	0.79	0.78	0.76	0.78	0.78	0.78	0.77	0.76
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
N input	38.26	38.35	38.95	39.46	39.76	39.72	39.28	39.13	38.98		
N_2O emissions	0.75	0.75	0.77	0.78	0.78	0.78	0.77	0.77	0.77		

For the estimation of N_2O emissions from N-fixing crops and crop residues, the Tier 1b methodology suggested by the IPCC Good Practice Guidance has been followed, using the default factors per crop regarding residue to crop product ratio, dry matter fractions and nitrogen content (IPCC 2000, Table 4-16). The fraction of residue dry biomass that is N ($FRAC_{NCRO}$) was estimated to be about 0.005. This figure is a little lower than the IPCC default value (0.015). This occurred due to the fact that cereal production of Greece consists mainly of wheat (36 per cent of cereal production) and maize (52 per cent of cereal production) crops, whose $FRAC_{NCRO}$ is significamnt lower than 0.015, 0.0028 of wheat and 0.0081 of maize according to IPCC Good Practice Guidance. As far as the fractions of residues used as fuel and for construction, there has not been any estimation yet due to the lack of relevant data.

The fraction of residues that is burned on-site in fields, which needs to be subtracted, was assumed to be 10% according to IPCC Good Practice Guidance (IPCC 2000, Appendix 4A-2). Data on agricultural crop production used for the calculation of emissions was obtained from the annual national statistics of the NSSG.

N_2O emissions from N-fixing crops and crop residues for the period 1990 – 2009 are presented in ***Table 6.23***.

Table 6.23 N_2O emissions (in kt) from N-fixing crops and crop residues, for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N-fixing crops	0.022	0.025	0.024	0.023	0.021	0.022	0.024	0.022	0.021	0.022	0.022
Crop residues	0.463	0.581	0.516	0.504	0.520	0.490	0.502	0.515	0.466	0.470	0.491
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
N-fixing crops	0.021	0.021	0.020	0.019	0.019	0.019	0.020	0.016	0.017		
Crop residues	0.506	0.493	0.474	0.512	0.525	0.485	0.470	0.552	0.517		

N_2O direct emissions from the sewage sludge used in agriculture were estimated for first time during the 2010 centralized ERT review and estimation's methodology is presented for first time in the current NIR. The default emission factor of 1.25% N_2O-N per kg N (IPCC Good Practice Guidance) was applied while the annual amount of sewage sludge used in agriculture in Greece for the period 1990-2009 was provided by the Waste Management Sector of the Ministry of Environment, Energy and Climate Change (MEECC). As it is shown, the application of sewage sludge in agriculture as fertilizer was started in 2004 and it remains limited, mainly in the frame of research projects and pilot studies. The N content of sewage sludge (dry matter) used in agriculture is assumed to be 3.0%. This value was obtained from the report 'Disposal and recycling routes for

sewage sludge Part 3 – Scientific and technical report', Table 3, Page 24, European Commission, 2001.

Nitrogen input to soils from Sewage sludge used in Agriculture and N_2O emissions from sewage sludge used in Agriculture for the period 1990 – 2009 are presented in ***Table 6.24***.

Table 6.24 Nitrogen input to soils from Sewage sludge used in Agriculture (in kg) and N_2O emissions (in t) for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N-Sewage sludge	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N_2O emissions	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
N-Sewage sludge	0.0	0.0	0.0	781	830	1354	7.2	7.2	7.2		
N_2O emissions	0.0	0.0	0.0	15.35	16.30	26.59	0.14	0.14	0.14		

Estimation of N_2O emissions from the organic soils (0.084 kt) was based on the cultivated area (6.7 kHa, constant for the entire period examined in North Greece) and the updated default emission factor suggested in the IPCC Good Practice Guidance for mid-latitude organic soils. Data for the areas of organic soils derive from a relevant research conducted by the Soil Science Institute of Athens (SSIA, 2001).

Indirect N_2O emissions from agricultural soils

Indirect N_2O emissions from agricultural soils derive from:

- Volatilisation of nitrogen included in synthetic fertilizers, animal manure (used as fertilizer) and sewage sludge (used also as fertilizer) as NO_x and NH_3, followed by atmospheric deposition as NO_x, HNO_3 and NH_4 on soils and surface waters and subsequent N_2O formation.
- Leaching and runoff of nitrogen contained in applied fertilizers (synthetic, animal manure and sewage sludge).

For all sources of N_2O emissions, the Tier 1a methodology suggested by IPCC Good Practice Guidance has been applied. The activity data on the amount of nitrogen from synthetic fertilizers, animal manure and sewage sludge are those used for the calculation of direct emissions. The emission factors used are the default ones suggested by IPCC (IPCC 1997, Table 4-23). The emission factor for atmospheric deposition reflects the fraction of nitrogen that volatiles as ammonia and nitrous oxides, while for leaching and runoff it reflects the fraction of nitrogen that

leaks from synthetic fertilizers and animal manure. The amount of nitrogen deposited and the indirect N_2O emissions for the period 1990 – 2008 are presented in ***Table 6.25***.

For the estimation of the fraction of nitrogen that volatilizes as NH_3 and NOx from the input to soils due to the application of sewage sludge in agriculture, the default value suggested by the IPCC Good Practice Guidance, i.e. 20%, was used.

Table 6.25 Deposited nitrogen (in kt) and indirect N_2O emissions (in kt) from agricultural soils, for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Atmospheric deposition											
N deposited	90.51	88.58	86.58	77.78	75.67	78.71	79.76	78.20	78.42	76.94	74.57
N_2O emissions	1.42	1.39	1.36	1.22	1.19	1.24	1.25	1.23	1.23	1.21	1.17
Leaching/ Runoff											
N deposited	199.37	194.07	188.38	162.72	156.41	165.47	168.08	163.34	163.83	159.35	152.36
N_2O emissions	7.83	7.62	7.40	6.39	6.14	6.50	6.60	6.42	6.44	6.26	5.99
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Atmospheric deposition											
N deposited	73.50	72.82	72.14	72.73	69.48	67.99	70.78	63.54	63.28		
N_2O emissions	1.15	1.14	1.13	1.14	1.09	1.07	1.11	1.00	0.99		
Leaching/ Runoff											
N deposited	149.25	147.19	145.26	147.34	137.81	133.49	142.17	120.81	120.41		
N_2O emissions	5.86	5.78	5.71	5.79	5.41	5.24	5.59	4.75	4.73		

6.5.3 Uncertainties and time-series consistency

The combined uncertainty of N_2O emissions of direct emissions as % of total emissions is estimated by 4.4%. The uncertainty associated with activity data is estimated 20% according to uncertainty given by NSSG for the crop production and the Pan-Hellenic Association of Professional Fertilizers Producers & Dealers for the synthetic fertilizers consumed in the country while the uncertainty associated with emission factors is 400 % (country specific value).

The combined uncertainty of N_2O emissions of indirect emissions as % of total emissions is estimated by 0.8%. The uncertainty associated with activity data is 20% according to uncertainty given by NSSG for the crop production while the uncertainty associated with emission factors is 50 % as it is estimated according to Good Practice Guidance.

The combined uncertainty of N_2O emissions of animal production as % of total emissions is estimated by 1.6%. The uncertainty associated with activity data is 50% (country specific value) taking into account that in Greece there is a wide variety of management systems used usage while the uncertainty associated with emission factors is 100 % as it is estimated according to Good Practice Guidance.

The results of uncertainty analysis are presented in Table 1.9. The detailed calculations of uncertainty are presented in Annex IV (Tables IV.1 – IV.3).

The time-series consistency of emissions is controlled by applying consistent methodologies and verified activity data inline with IPCC guidelines. In case of changes or refinements in methodologies and EFs based on country-specific data, time-series consistency is ensured by performing recalculations according to the IPCC good practice guidance.

6.5.4 Source-specific QA/QC and verification

Quality control and source-specific quality control is carried out based on the principles of inventory Quality Assurance / Quality Control (QA/QC) plan (National Systems under Article 5 Paragraph 1 of the Protocol as described in Decision 20/CP.7). The special procedures are followed in the agricultural soils source are:

1. Cross checking information provided by the Hellenic Statistical Authority and by the Pan-Hellenic Association of Professional Fertilizers Producers & Dealers regarding the amount of synthetic fertilizers. Moreover, data provided by FAO for the period 1990-2002 were compared with these provided by PHAPFPD,

2. Comparison of activity data and emissions factors with these of other neighbour countries.

3. Estimations were checked with several calculations tools such as emissions trends and sum deviations.

6.5.5 Recalculations

N_2O emissions from agricultural soils have been recalculated for the period 1990-2008 because of the updating of nitrogen excretion (Nex) for dairy cattle, other cattle, buffalo and sheep as it is explained in the Section 6.3.2. The recalculations due to estimation of N_2O from the sewage sludge use in agriculture are of minor importance. The deviation of the emissions estimated in the current submission compared to the emissions estimated in the previous submission and the impact on total emissions (excl LULUCF) of recalculations are presented in ***Table 6.26***.

Table 6.26 Recalculations of N_2O emissions from agricultural soils (%)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Difference	-1.524	-1.488	-1.574	-2.205	-2.425	-2.419	-2.204	-2.281	-2.271	-2.471	-2.762
Impact on total emissions (excl LULUCF)	-0.110	-0.106	-0.108	-0.136	-0.141	-0.145	-0.130	-0.126	-0.120	-0.128	-0.134
Year	2001	2002	2003	2004	2005	2006	2007	2008			
Difference	-2.965	-2.836	-2.573	-2.346	-2.353	-2.474	-2.423	-2.800			
Impact on total emissions (excl LULUCF)	-0.141	-0.133	-0.116	-0.106	-0.098	-0.104	-0.104	-0.111			

6.6 Field burning of agricultural residues (CRF Source Category 4F)

6.6.1 Description

The generation of crop residues is a result of the farming practices used. Disposal practices for residues include ploughing them back into the ground, composting, landfilling and burning on-site. According to the IPCC Good Practice Guidance, 10% constitutes an indicative value of the residues burned annually on the field. Burning of agricultural residues is responsible for emissions of CH_4, N_2O, CO and NO_x.

CH_4 and N_2O emissions from field burning of agricultural residues in 2009 accounted for 0.48% of total GHG emissions from *Agriculture* and for 0.035% of total national emissions (without *LULUCF*). Emissions in 2009 increased by 15.1% compared to 1990 levels with an average annual rate of increase estimated at 0.8%. CH_4 and N_2O emissions from field burning of agricultural residues for the period 1990 – 2009 are presented in ***Table 6.27***.

Table 6.27 GHG emissions (in kt) from field burning of agricultural residues, for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CH_4 emissions	1.29	1.81	1.47	1.41	1.53	1.44	1.41	1.43	1.34	1.32	1.39
N_2O emissions	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03
Year	2001	2002	2003	2004	2005	2006	2007	2008	2008		
CH_4 emissions	1.42	1.38	1.27	1.42	1.43	1.32	1.28	1.54	1.48		
N_2O emissions	0.04	0.03	0.03	0.04	0.04	0.03	0.03	0.04	0.04		

6.6.2 Methodology

For the estimation of CH_4 and N_2O emissions from field burning of agricultural residues the default methodology suggested in IPCC Guidelines has been applied. In order to calculate the biomass that is burned agricultural production per crop (as in the sector of agricultural soils) and

the default factors proposed by IPCC (IPCC 2000, Table 4-16 and IPCC 1996, Table 4-17) related to the residues to crop product ratio, the dry matter fraction and the oxidation factor, as well as to the fraction of residues burned were used. The emission factors used are the default ones suggested by IPCC Guidelines (IPCC 1997, Table 4-16).

6.6.3 Uncertainties and time-series consistency

The combined uncertainty of CH_4 emissions of field burning of agricultural sector as % of total emissions is estimated by 0.01%. The combined uncertainty of N_2O emissions of field burning of agricultural sector as % of total emissions is estimated by 0.003%. The uncertainty associated with activity data is 20% according to uncertainty given by NSSG for for the crop production data while the uncertainty associated with emission factors is 20% as it is estimated according to Good Practice Guidance.

The results of uncertainty analysis are presented in Table 1.9. The detailed calculations of uncertainty are presented in Annex IV (Tables IV.1 – IV.3).

The time-series consistency of emissions is controlled by applying consistent methodologies and verified activity data inline with IPCC guidelines. In case of changes or refinements in methodologies and EFs based on country-specific data, time-series consistency is ensured by performing recalculations according to the IPCC good practice guidance.

6.6.4 Recalculations

No recalculations were performed.

7. Land Use, Land Use Change and Forestry (CRF sector 5)

7.1 Overview

In this chapter emissions and removals of greenhouse gases from the sector *Land Use, Land Use Change and Forestry* are presented, and methodologies used to estimate emissions / removals by each source / sink category are described. Emissions and removals from this sector have been calculated according to the IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry (henceforth in this chapter GPG LULUCF), adopted at COP9 (Decision 13/CP.9) for use in preparing annual inventories due in 2005 and beyond. The GPG LULUCF introduced new categories for estimating and reporting emissions and removals of CO_2 and other greenhouse gases, based on six top-level land-use[16] categories:

- Forest land
- Cropland
- Grassland
- Wetlands
- Settlements
- Other land

The 2005 inventory submission included the results of Greece's first attempt to comply with the reporting requirements of Decision 13/CP.9 for the LULUCF sector. Carbon stock changes in five the carbon pools (Aboveground Biomass, Belowground Biomass, Dead Wood, Litter and Soil Organic Matter) and emissions of non-CO_2 gases were assessed and reported. Specific quality assurance and quality control procedures outlined in GPG LULUCF were followed in the preparation of this inventory, uncertainties were estimated and key categories were identified.

The 2011 submission, as the 2010 submission, incorporates some major improvements undertaken by Greece in order to improve accuracy and completeness of the reported estimates, to minimize uncertainties and to be compliant with the reporting requirements of both UNFCCC and the KP.

The remainder of this chapter is organized as follows. Paragraph 7.1 continues with a presentation of emissions / removal levels and trends from the sector, a brief discussion on the methodology used in this inventory, an assessment of the completeness of the GHG inventory for the LULUCF sector and the presentation of recalculations and improvements in the sector since the previous submission. Then (in Paragraphs 7.2 – 7.7) detailed information (descriptions, references and sources of specific methodologies, assumptions, emission factors and activity data used and the rational for their selection) on each category is presented.

[16] The names of these land categories are a mixture of land cover (e.g., Forest land, Grassland, Wetlands) and land use (e.g., Cropland, Settlements) classes, however, for convenience, they are here referred to as land-use categories.

7.1.1 Emissions/Removals trends

The *Land Use, Land Use Change and Forestry* sector was a net sink of greenhouse gases during the period 1990 – 2009. During this period, the LULUCF sector offset about 2.2-3.1% of the total national emissions (without LULUCF). The magnitude of this sink increased from approximately 2.5 Mt CO_2 eq in 1990, to 3.0 Mt CO_2 eq in 2009 (***Figure 7.1***), i.e. an increase of 20.9%. This upward trend in the net removals from the Forest Land is attributed mainly to the reduction in fellings and the afforestation programmes started in 1994.

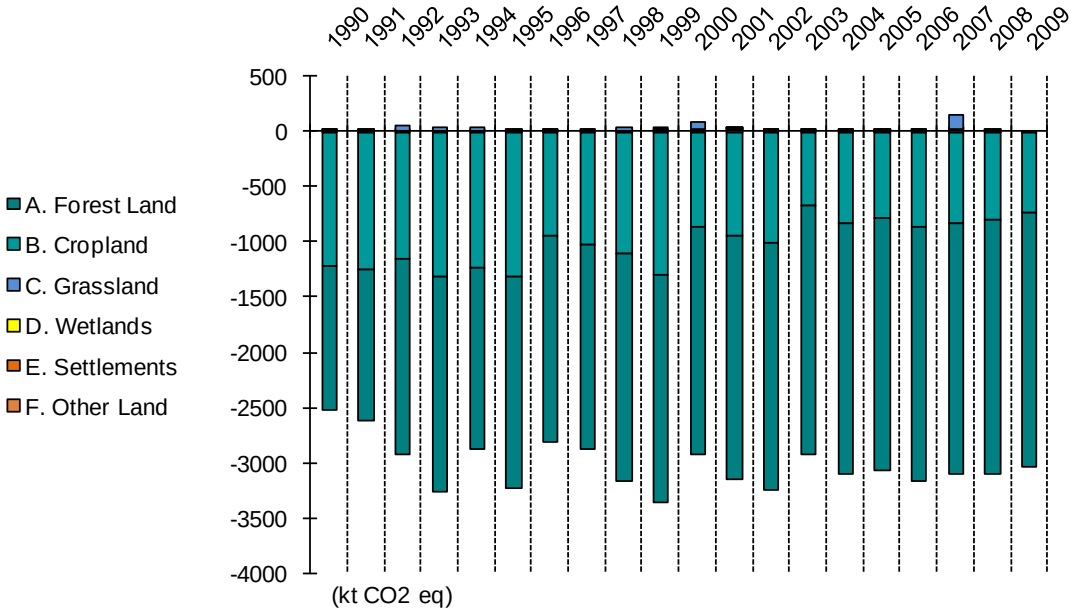


Figure 7.1 ***Net GHG emissions / removals (in kt CO_2 eq) from the Land Use. Land Use Change and Forestry sector by category for the period 1990 – 2009***

CO_2 is the main greenhouse gas emitted and removed to / from the atmosphere following carbon stocks changes in different carbon pools. Non-CO_2 greenhouse gases (CH_4 and N_2O) and indirect GHG (NO_x and CO) are released in relatively small quantities when biomass is burnt.

As shown in Figure 7.1, both Forest Land and Cropland categories act as net carbon sinks during the period 1990 – 2009. Emissions / removals from the Forest Land category are the result of the balance mainly in biomass increment from forest growth and biomass loss due to fellings and wildfires. Net removals from the Forest Land show an upward trend that is attributed mainly to the reduction in fellings and the afforestation programmes started in 1994. The sink capacity of Forest Land has increased from 1.3 Mt CO_2 eq in 1990 to 2.3 Mt CO_2 eq in 2009, i.e. an increase of about 74.5%.

Removals from Cropland, caused by changes in management practices and crop type, fluctuate between 0.67 - 1.3 Mt CO_2 eq yr^{-1}. Grassland category appears as a small source of CO_2 due to conversion of Forest land to Grassland, as well as, source of CH_4 and N_2O due to emissions during

wildfires. Wetlands, Settlements and Other Land categories are small sources of CO_2 when Forest land and Grassland are converted to these land uses. Emissions / removals per gas and category from LULUCF are presented in ***Table 7.1***.

Table 7.1 GHG emissions / removals (in kt) from the Land Use Change and Forestry sector by category and gas for the period 1990 – 2009

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Net CO_2 emissions / removals (in kt)																				
A. Forest Land	-1327	-1360	-1778	-1953	-1658	-1911	-1880	-1847	-2082	-2058	-2092	-2201	-2228	-2252	-2270	-2289	-2306	-2306	-2306	-2306
B. Cropland	-1205	-1251	-1146	-1311	-1230	-1315	-936	-1025	-1104	-1297	-864	-946	-1006	-668	-822	-776	-857	-831	-801	-737
C. Grassland	0.014	0.214	NO	NO	0.491	3.003	NO	0.082	NO	0.314	NO	NO	0.019	2.030	0.366	NO	0.044	0.057	0.053	NO
D. Wetlands	0.003	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.064	NE,NO	NE,NO	NE,NO	NE,NO	0.130	1.894	0.761	0.936	0.179	0.575	0.203	NE,NO	NE,NO
E. Settlements	2.300	1.348	1.919	1.524	1.999	2.209	5.383	1.628	1.256	4.543	4.613	1.983	1.950	1.554	1.500	3.445	5.908	8.429	1.052	NE,NO
F. Other Land	6.769	3.669	13.097	4.502	5.361	2.208	8.758	8.465	6.195	16.624	16.793	25.279	8.447	7.647	8.126	4.622	8.320	19.016	5.963	NE,NO
CH_4 emissions (in kt)																				
A. Forest Land	0.520	0.197	0.572	0.597	0.522	0.343	0.142	0.415	1.301	0.083	1.606	0.170	0.016	0.024	0.064	0.054	0.161	2.121	0.331	0.469
B. Cropland	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Grassland	0.668	0.566	1.713	1.201	1.252	0.530	0.571	0.860	1.689	0.191	2.642	0.532	0.100	0.133	0.331	0.170	0.270	5.466	0.576	0.605
D. Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
E. Settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N_2O emissions (in kt)																				
A. Forest Land	0.004	0.001	0.004	0.004	0.004	0.002	0.001	0.003	0.009	0.001	0.011	0.001	0.000	0.000	0.000	0.000	0.001	0.015	0.002	0.003
B. Cropland	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Grassland	0.005	0.004	0.012	0.008	0.009	0.004	0.004	0.006	0.012	0.001	0.018	0.004	0.001	0.001	0.002	0.001	0.002	0.038	0.004	0.004
D. Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
E. Settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
TOTAL LULUCF (kt CO_2 eq)	-2496	-2589	-2856	-3216	-2839	-3199	-2785	-2833	-3109	-3327	-2836	-3103	-3219	-2904	-3071	-3051	-3139	-2934	-3079	-3019

Note: Negative (-) sign denotes GHG removals and positive sign (+) GHG emissions

7.1.2 Methodology

The calculation of GHG emissions from Land Use, Land Use Change and Forestry is based on the methodologies and assumptions suggested by the IPCC Guidelines and the IPCC Good Practice Guidance for LULUCF.

Activity data and country specific emission / removal factors were obtained from the NSSG, the Ministry of Environment, Energy and Climate Change and relevant studies of research bodies. References to all sources are given in the description of the methodology used in each category.

The methodology applied for the calculation of emissions per source / sink category is summarised in ***Table 7.2,*** while a detailed description is given in Paragraphs 7.2 – 7.7.

Table 7.2 Methodology for the estimation of emissions / removals from LULUCF

IPCC Source / Sink Categories	CO_2		CH_4		N_2O	
	Method	Emission factor	Method	Emission factor	Method	Emission factor
A. Forest Land						
A1. Forest Land remaining Forest Land	T2	CS, D	T1	D	T1	D
A2. Land converted to Forest Land	T1	D	NA	NA	NA	NA
B. Cropland						
B1. Cropland remaining Cropland	T2, T1	CS, D	NA	NA	NA	NA
B2. Land converted to Cropland	T2	CS	NA	NA	NA	NA
C. Grassland						
C1. Grassland remaining Grassland	NA	NA	T1	D	T1	D
C2. Land converted to Grassland	T2	CS	NA	NA	NA	NA
D. Wetlands						
D1. Wetlands remaining Wetlands[1)]						
D2. Land converted to Wetlands	T2	CS	NA	NA	NA	NA
E. Settlements						
E1. Settlements remaining Settlements [1)]						
E2. Land converted to Settlements	T2	CS	NA	NA	NA	NA
F. Other Land						
F1. Other Land remaining Other Land [1)]						
F2. Land converted to Other Land	T2	CS	NA	NA	NA	NA

T1. T2: IPCC methodology Tier 1 and Tier 2 respectively

CS: Country specific methodology and emission factor

D: IPCC default methodology and emission factor

[1)] Parties do not have to prepare estimates for these categories

Key categories

Key categories – a term introduced by GPG LULUCF to expand key source concept and cover both source and sink categories – have been determined following the Tier 1 method described in the GPG LULUCF. The key categories in the *LULUCF* sector determined by this analysis are

presented in ***Table 7.3*** (see Paragraph 1.5 for a complete presentation of the results of the key category analysis and Annex I for the presentation of the relevant calculations).

Table 7.3 Key categories in the LULUCF sector

IPCC source / sink category	Greenhouse Gas	Level assessment	Trend assessment
Forest Land remaining Forest Land	CO_2	☒	☒
Cropland remaining Cropland	CO_2	☒	☒
Land converted to Forest Land	CO_2		☒

Uncertainty

The results of the uncertainty analysis undertaken for the Greek GHG emissions inventory are presented in Paragraph 1.7, while the detailed calculations are presented in Annex IV. However, it is noted that uncertainties in estimates from this sector are possibly higher than these reported, since uncertainties introduced by assumptions made and categories or pools not estimated have not been considered.

7.1.3 Completeness

Table 7.4 summarizes the completeness of the inventory for the sector *Land use, Land Use Change and Forestry*.

Table 7.4 Land Use, Land Use Change and Forestry – Completeness of emission / removal inventory

IPCC source / sink categories	CO_2	CH_4	N_2O
A. Forest Land			
1. Forest Land remaining Forest Land	☒	☒	☒
2. Land converted to Forest Land	☒	NO	NO
B. Cropland			
1. Cropland remaining Cropland	☒	NO	NO
2. Land converted to Cropland	☒	NO	NO
C. Grassland			
1. Grassland remaining Grassland	NO	☒	☒
2. Land converted to Grassland	☒	NO	NO
D. Wetlands			
1. Wetlands remaining Wetlands [1)]			
2. Land converted to Wetlands	☒	NO	NO
E. Settlements			
1. Settlements remaining Settlements [1)]			
2. Land converted to Settlements	☒	NO	NO
F. Other Land			
1. Other Land remaining Other Land [1)]			
2. Land converted to Other Land	☒	NO	NO

[1)] Parties do not have to prepare estimates for these categories

NO: Not Occurring

7.1.4 Representation of land areas

The various forms of land uses in 2009 are presented in ***Figure 7.2***.

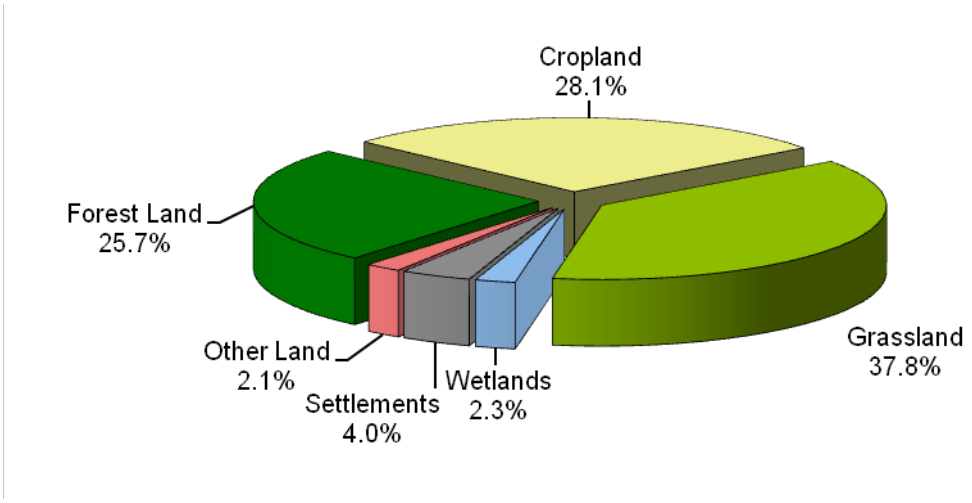


Figure 7.2 Distribution of the area of Greece in 2009 by land-use category

The information used for representation of land areas was the following:

- the first National Forest Inventory (1st NFI) prepared by the General Secretariat of Forests and Natural Environment (GSFNE, 1992, 1994)
- the afforestation registry and statistics of the Ministry of Environment, Energy and Climate Change
- the 'Agricultural Statistics of Greece' of the Hellenic Statistical Authority (NSSG, annual census)
- the 'Distribution of the Country's Area by Basic Categories of Land Use' of the Hellenic Statistical Authority (NSSG, decennial survey)
- the 'Land Use Change Database' recently developed by the Ministry of Environment, Energy and Climate Change, which until today comprise more than 12000 acts of land use change since 1990
- the 'Forest Management Plans Database', recently developed by the Ministry of Environment, Energy and Climate Change

More information on the use of these datasets and the land-use definitions used in the classification of areas is given under the corresponding category in the following chapters. ***Table 7.5*** is the land-use matrix of year 2009.

Table 7.5 Land-Use Matrix of Year 2009 (areas in kha).

2009 \ 2008	Forest Land	Cropland	Grassland	Wetlands	Settlements	Other Land	Total in 2009
Forest Land	3,356.05	33.25					3,389.32
Cropland	0.01	3,732.40	0.05				3,709.21
Grassland	0.18	178.55	4,791.62				4,993.57
Wetlands	0.08		0.00	299.60			299.67
Settlements	0.62		1.66		530.32	0.06	532.66
Other Land	2.26		3.82			265.22	271.30

Art. 3.3 Afforestation / Reforestation

Art. 3.3 Deforestation

7.2 Forest land (CRF Source Category 5A)

7.2.1 Category description

Carbon stock changes in five carbon pools (aboveground biomass, belowground biomass, dead wood, litter and soil organic matter) and emissions of non-CO_2 gases from Forest Lands remained Forest Lands and Lands converted to Forest Lands have been assessed and reported under this category.

Carbon stocks increased during the period 1990 – 2009 due to biomass increment in Forest Land remaining Forest Land and in Land converted to Forest Land (afforestation of croplands), and the increment in soil organic carbon in areas afforested (reported though under Cropland remaining Cropland category for inventory methodological reasons). Non-CO_2 greenhouse gases released to the atmosphere during biomass burning. Estimates of emissions / removals in this category are presented in ***Table 7.6***.

The sink capacity of Forest Land has increased from 1.3 Mt CO_2 eq in 1990 to 2.3 Mt CO_2 eq in 2009, i.e. an increase of about 74.5%. This rising trend is attributed mainly is attributed mainly to the reduction in fellings and the afforestation programmes started in 1994.

Table 7.6 Net GHG emissions / removals (in kt) from Forest Land by subcategory and gas for the period 1990 - 2009

IPCC categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Forest land remaining forest land										
CO_2	-1327	-1360	-1778	-1953	-1633	-1852	-1790	-1695	-1911	-1845
CH_4	0.520	0.197	0.572	0.597	0.522	0.343	0.142	0.415	1.301	0.083
N_2O	0.004	0.001	0.004	0.004	0.004	0.002	0.001	0.003	0.009	0.001
Land converted to forest land										
CO_2	NO	NO	NO	NO	-25.06	-58.48	-89.81	-152.47	-171.26	-213.03
CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (kt CO_2 eq)	-1315.27	-1355.87	-1764.61	-1938.81	-1645.92	-1902.99	-1876.37	-1837.72	-2052.18	-2056.16

IPCC categories	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Forest land remaining forest land										
CO_2	-1855	-1951	-1954	-1961	-1960	-1955	-1956	-1956	-1956	-1956
CH_4	1.606	0.170	0.016	0.024	0.064	0.054	0.161	2.121	0.331	0.469
N_2O	0.011	0.001	0.000	0.000	0.000	0.000	0.001	0.015	0.002	0.003
Land converted to forest land										
CO_2	-237.86	-250.14	-274.17	-290.29	-309.39	-333.67	-350.63	-350.63	-350.63	-350.63
CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (kt CO_2 eq)	-2055.28	-2196.79	-2227.93	-2251.15	-2268.10	-2287.42	-2302.47	-2257.11	-2298.54	-2295.34

NO: Not Occurring

7.2.2 Methodology

The definition of forest land used in this inventory is the definition used to report under the Kyoto Protocol:

- minimum area of 0.3 hectares,
- tree crown cover larger than 25 per cent,
- minimum height of 2 metres, or the potential to achieve it

According to the GPG LULUCF, carbon stock changes and greenhouse gas emissions and removals associated with changes in biomass and soil organic carbon are estimated and reported only for managed forests. Hence, this inventory estimates carbon stock changes and emissions of non-CO_2 gases from forests that have been managed with a forest management plan. Managed forests cover about 35% of the total forest land.

7.2.2.1 Forest land remaining forest land

The section 'Forest land Remaining Forest land (FF)' describes the estimation of changes in carbon stock in the five carbon pools, as well as emissions of non-CO_2 gases from these pools, in forest lands which have been forest lands for at least the past 20 years. The summary equation, which estimates the annual emissions or removals from FF with respect to changes in carbon pools, is given in the following equation:

$$\Delta C_{FF} = (\Delta C_{FF_{LB}} + \Delta C_{FF_{DOM}} + \Delta C_{FF_{Soils}})$$

where, ΔC_{FF} is the annual change in carbon stocks from forest land remaining forest land, t C yr^{-1}, $\Delta C_{FF_{LB}}$ is the annual change in carbon stocks in living biomass (includes above- and belowground biomass) in forest land remaining forest land, t C yr^{-1}, $\Delta C_{FF_{DOM}}$ is the annual change in carbon stocks in dead organic matter (includes dead wood and litter) in forest land remaining forest land, t C yr^{-1} and $\Delta C_{FF_{Soils}}$ is the annual change in carbon stocks in soils in forest land remaining forest land, t C yr^{-1}.

Change in carbon stocks in living biomass

The methodology applied is consistent with the carbon stock change method described in the IPCC Guidelines (Method 2 of GPG LULUCF). According to this method, estimations of carbon stock changes are based on the difference in biomass stocks in a forest area at two points in time. The annual change in the carbon stocks in a forest area is the difference between the carbon stock at time t_2 and time t_1, divided by the number of years between the inventories:

$$\Delta C_{FF_{LB}} = (C_{t_2} - C_{t_1})/(t_2 - t_1)$$

where, $\Delta C_{FF_{LB}}$ is the annual change in carbon stocks in living biomass (includes above- and belowground biomass) in forest land remaining forest land, tonnes C yr^{-1}, C_{t_2} is the total carbon in biomass calculated at time t_2, tonnes C, C_{t_1} is the total carbon in biomass calculated at time t_1, tonnes C.

The total carbon in biomass is calculated according the equation:

$$C_{t_i} = [V_{t_i} \cdot D \cdot BEF] \cdot (1+R) \cdot CF$$

Where, C_{t_i} is the total carbon in biomass calculated at time t_i, tonnes C,$\cdot V_{t_i}$ is the merchantable volume, m_3 ha^{-1}, at time t_i, D is the basic wood density, tonnes dry matter m^{-3} merchantable volume, BEF is the biomass expansion factor for conversion of merchantable volume to aboveground tree volume, dimensionless, R is the root-shoot ratio, dimensionless, and, CF is the carbon fraction of dry matter, , t C $(t\ d.m.)^{-1}$

CO_2 emissions and removals from managed forests are calculated according to the equation above, comparing the carbon stocks in forest biomass that is estimated by the successive forest management plans (FMP). Annual change in carbon stocks in every studied forest during the period of two inventories is estimated by linear interpolation, while for the period before the first and after the last inventory is estimated by linear extrapolation.

The merchantable volume, V, and the area covered by each forest class (subdivision of the forest area defined by the forest species) are obtained from the FMP. Because of lack of national factors, appropriate IPCC default factors for root/shoot ratio R were selected for each forest species from table 3A.1.8 of LULUCF GPG. For the conversion of dry matter to carbon the IPCC default factor (CF = 0.5) was used throughout the inventory.

For the conversion of merchantable volume to aboveground tree biomass it is suggested by the GPG LULUCF the use of Biomass Expansion Factors. Since, national expansion factors have not been developed in Greece, factors developed for Mediterranean species under similar climatic and ecological conditions, in the frame of the Ecological and Forest Inventory of Catalonia, were used instead. In this inventory, biomass expansion factors BEF (for the conversion of merchantable volume to aboveground tree volume) and the wood density D (for the conversion of tree volume to tree biomass) are combined in one factor BEFD that directly converts the merchantable volume to aboveground tree biomass.

Change in carbon stocks in dead organic matter

Changes in carbon stocks in two types of dead organic matter pools have to be considered: a) dead wood and b) litter. The IPCC Guidelines do not require estimation or reporting on dead wood or litter, on the assumption that the time average value of these pools will remain constant, with inputs to dead matter pools balanced by outputs. This Tier1 approach was followed for dead organic matter carbon stocks in all forest land, and is considered as true-to-life since these lands do not experience significant changes in forest types or management regimes. Prescribed fires only take place for fuel load management (mainly pine litter) in urban forests in a very small scale. Greenhouse gas emissions from this activity were therefore considered as negligible. Post logging burning of harvest residues is not practised in Greece.

Table 7.7 Biomass expansion factors BEFD used for biomass estimation

Conifers	BEFD
Abies sp.	0.61
Pinus halepensis	0.74
Pinus pinea	0.73
Pinus brutia	0.73
Pinus nigra – Other conifers	0.64
Pinus sylvestris	0.62
Picea abies	0.44
Cupressus sp.	0.55
Broadleaves	**BEFD**
Fagus sp.	0.81
Deciduous oaks– Other broadleaves	0.89
Quercus ilex – Evergreen oaks	1.28
Castanea sativa	0.75
Betula pendula	0.73
Alnus sp. – Populus sp.	0.62
Ulmus sp. – Platanus sp.	0.90
Fraxinus sp.	0.83

Source: Centro de Investigacion Ecologica y Aplicaciones Forestales (CREAF)

Change in carbon stocks in soils

Two types of forest soil organic pools are considered under this category: a) the organic fraction of mineral forest soils, and b) organic soils. CO_2 emissions / removals from soils are associated with changes in the amount of organic carbon stored in soils. These changes are a function of the balance between inputs to soil of photosynthetically fixed carbon and losses of soil carbon via decomposition. In general, changes in forest type, management intensity and disturbance regime alter the carbon dynamics of forest soils. Under Tier 1, it is assumed that when forest remains forest the carbon stock in soil organic matter of mineral soils does not change, regardless of changes in forest management, forest types, and disturbance regimes, i.e. the carbon stock in mineral soil remains constant so long as the land remains forest. In Greece, forest type and management activities, such as silvicultural system, rotation length, harvest practices, site preparation activities do not change significantly over time, and therefore Tier 1 assumption can be used without introducing significant error in the calculations.

Changes in carbon stocks of organic soils are associated with drainage and management perturbations of these soils. In Greece, areas of organic soils covered by forest are negligible, remain in a natural state and therefore greenhouse gas emissions/removals have not been considered.

Wildfires - Non CO_2 greenhouse gas emissions

According to the GPG LULUCF, parties should estimate emissions and removals of GHG from managed forests only. For non managed forests there are not estimated neither carbon stock changes nor other GHG emissions (e.g. emissions from wildfires).

The carbon stock change method used to estimate emissions and removals from managed forests – and forests under art. 3.4 activity Forest Management – encompasses the loss of carbon in areas affected by wildfires. For this reason no extra emissions of CO_2 from wildfires are reported. The implication of the use of this method on the inventory is the normalisation of the net emissions/ removals of CO_2 from the LULUCF sector, since these emissions are not reported at the year of disturbance – that resulted the high annual fluctuation of emissions – rather than they are distributed over the period between the successive management plans.

However, the biomass burnt annually in managed forests had to be estimated, in order to estimate and report the non- CO_2 GHG emissions. According to IPCC Guidelines, CH_4 and CO emissions from wildfires were estimated as ratios to carbon released during burning (Lw_{oxid}), and N_2O and NO_x emissions as ratios to total nitrogen released. Nitrogen content was calculated based on the nitrogen-carbon ratio (N/C was taken as 0.01, IPCC Guidelines).

$$CH_4 \text{ emissions} = Lw_{oxid} \cdot 0.012 \cdot 16/12$$

$$CO \text{ emissions} = Lw_{oxid} \cdot 0.06 \cdot 28/12$$

$$N_2O \text{ emissions} = Lw_{oxid} \cdot (N/C \text{ ratio}) \cdot 0.007 \cdot 44/28$$

$$NO_x \text{ emissions} = Lw_{oxid} \cdot (N/C \text{ ratio}) \cdot 0.121 \cdot 46/14$$

The IPCC default values for trace gas emission ratios were used, whereas the factors 16/12, 28/12, 44/28 and 46/14 were used to convert emissions to full molecular weights.

The annual carbon loss in living biomass from wildfires was estimated as:

$$Lw_{oxid} = \sum_{i} A_{disturbance\ i} \cdot Bw_{i} \cdot (1 - f_{BL\ i}) \cdot CF$$

where, Lw_{oxid} is the annual decrease in carbon stocks due to biomass oxidation to the atmosphere, t C yr^{-1}, $A_{disturbance\ i}$ is the forest areas affected by wildfires, by forest type (i = 21), ha yr^{-1}, Bw_{i} is the average biomass stock of forest areas, by forest type, t d.m. ha^{-1}, $f_{BL\ i}$ is the fraction of biomass transferred to dead organic matter, by forest type and CF is the carbon fraction of dry matter, t C (t d.m.)$^{-1}$.

It was assumed a complete destruction of forest biomass in area affected, i.e. there was not any biomass left alive in the area. Data on area affected by wildfires were obtained from the statistics of the Ministry of Environment, Energy and Climate Change disaggregated by two general categories –forests and scrublands. A flammability indicator for 21 forest types was developed, based on national statistics of areas burnt stratified by forest type during the period 1990 – 1996, in order to

draw disaggregated activity data. The fraction of biomass transferred to dead organic matter varies with the vegetation type (diameter of fuel). Two general values were selected from Table 3A.1.12 of GPG LULUCF; f_{BL} = 0.55 for forests and f_{BL} = 0.28 for scrublands.

The average biomass stock of each forest type was calculated from the average volume of growing stock given in the 1st NFI and the average biomass stock in the understorey vegetation, with the following equation:

$$B_W = (V \cdot D \cdot BEF_2 + B_{W_{understorey}}) \cdot CF$$

where, V is the average volume of growing stock, overbark, m^3 ha^{-1}, D is the basic wood density, t d.m. m^{-3}, BEF_2 is the biomass expansion factor for converting volumes of growing stock to total aboveground biomass, $B_{W_{understorey}}$ is the average biomass stock of understorey vegetation, t d.m. ha^{-1} and CF is the carbon fraction of dry matter, t C (t d.m.)$^{-1}$.

The average biomass stock of understorey vegetation was acquired from a study reviewing relevant articles and the data of the 1st NFI (Kokkinidis, 1989). Appropriate IPCC default factors for wood density and biomass expansion factor were selected from Tables 3A.1.9-1 and 3A.1.10 of LULUCF GPG respectively.

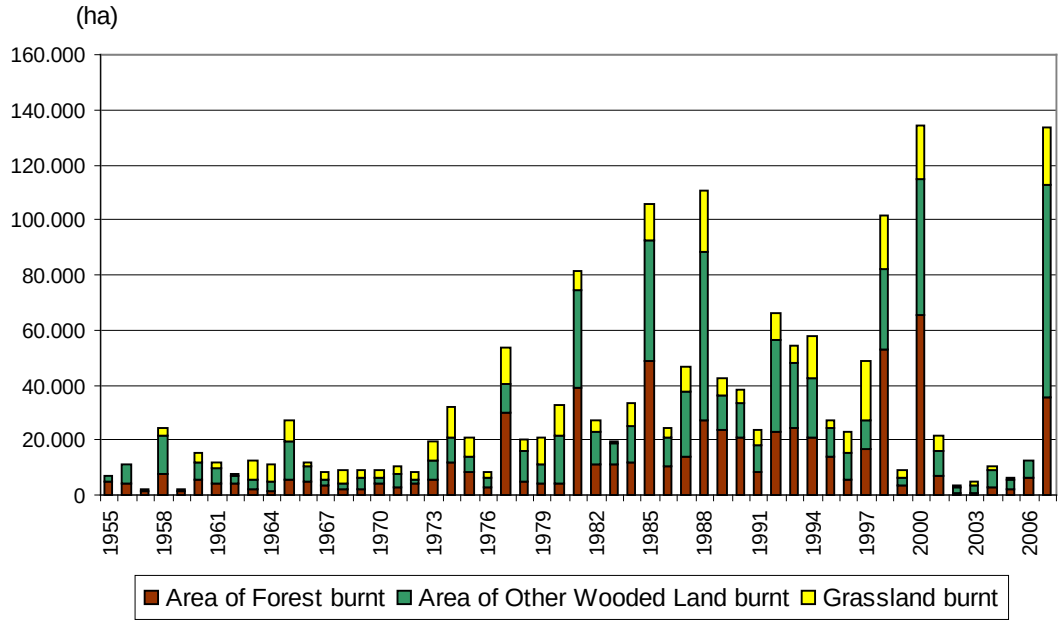


Figure 7.3 Areas of Forest. Other Wooded Land and Grassland burnt since 1955

N_2O and NO_x are also produced in soils as a by-product of nitrification and denitrification. Emissions are stimulated by N fertilisation of forests and drainage of wet forest soils. Such emissions have not been considered since these activities do not occur in forest lands of the country.

7.2.2.2 Land converted to Forest Land

This section describes the estimates of carbon stock changes and greenhouse gas emissions and removals from lands converted to forest land during the last 20 years. Managed land is converted to forest land by afforestation, either by natural or artificial regeneration. In this inventory changes in carbon stocks in croplands converted to forest land since 1994, under the EEC Regulations 2080/92 and 1257/99, have been estimated. The estimation of carbon change was based on the summary equation.

$$\Delta C_{LF} = (\Delta C_{LF_{LB}} + \Delta C_{LF_{DOM}} + \Delta C_{LF_{Soils}})$$

where, ΔC_{LF} is the annual change in carbon stocks in land converted to forest land, t C yr^{-1}, $\Delta C_{LF_{LB}}$ is the annual change in carbon stocks in living biomass (includes above- and belowground biomass) in land converted to forest land, t C yr^{-1}, $\Delta C_{LF_{DOM}}$ is the annual change in carbon stocks in dead organic matter (includes dead wood and litter) in land converted to forest land, t C yr^{-1} and $\Delta C_{LF_{Soils}}$ is the annual change in carbon stocks in soils in land converted to forest land, t C yr^{-1}.

Annual change in carbon stocks in living biomass was estimated using a mix of Tier 1 and Tier 2 method:

$$\Delta C_{LF_{LB}} = (\Delta C_{LF_{GROWTH}} + \Delta C_{LF_{CONVERSION}} - \Delta C_{LF_{LOSS}})$$

where, $\Delta C_{LF_{GROWTH}}$ is the annual increase in carbon stocks in living biomass due to biomass growth in land converted to forest, t C yr^{-1}, $\Delta C_{LF_{CONVERSION}}$ is the annual change in carbon stocks in living biomass due to actual conversion to forest land, tC yr^{-1} and $\Delta C_{LF_{LOSS}}$ is the annual decrease in carbon stocks due to biomass loss in land converted to forest land, t C yr^{-1}.

The annual increase in carbon stocks in living biomass due to biomass growth was calculated using the methods set out in Paragraph 7.2.2 Forest Land remaining Forest Land. Data on area afforested were obtained from the statistics of the Ministry of Environment, Energy and Climate Change (GDPDFNE, 2001), disaggregated by twenty four forest types. Appropriate IPCC default values for the average net annual increment in volume suitable for industrial processing (I_V), wood density (D), biomass expansion factor (BEF_1), annual aboveground biomass increment (G_W) and root-to-shoot ratio appropriate to increments (R) were selected from tables 3A.1.7, 3A.1.9-1, 3A.1.10, 3A.1.5 and 3A.1.8 of GPG LULUCF respectively.

The annual change in carbon stocks in living biomass due to actual conversion ($\Delta C_{LF_{CONVERSION}}$) is estimated by the difference in biomass stocks immediately before and immediately after the conversion. This quantity was assumed to be negligible since the 96% of the cropland afforested consisted of annual crops and only 4% of tree or vine crops with significant biomass stock (GDPDFNE, 2001).

Decreases in carbon stocks due to biomass loss ($\Delta C_{LF_{LOSS}}$) are caused by commercial fellings, fuelwood gathering and disturbances. In lands afforested since 1994 harvest has not taken place yet. Hence, no decreases in carbon stocks due to biomass loss in land converted to forest land are reported.

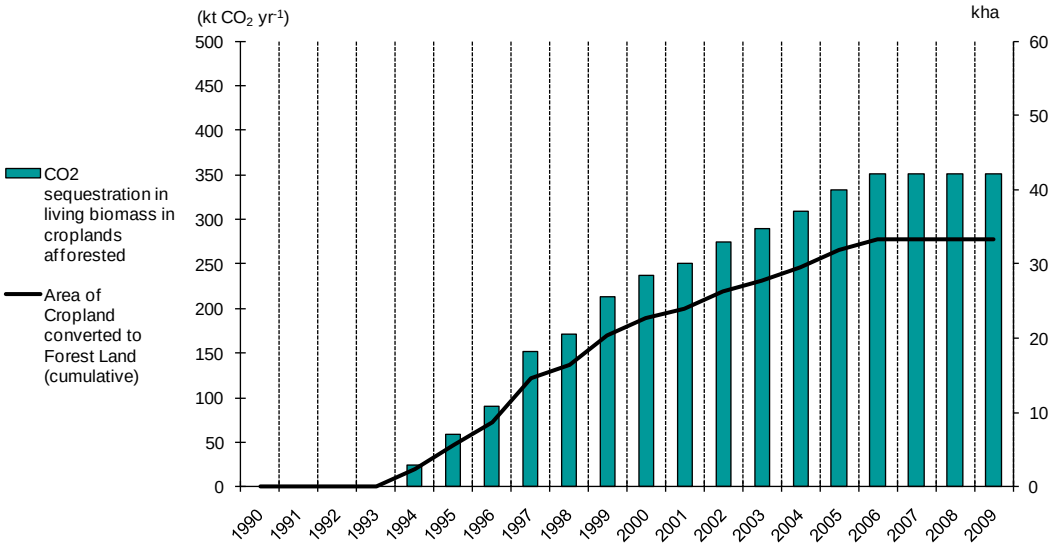


Figure 7.4 Carbon sequestration in living biomass and area of Croplands converted to Forest land during 1990-2009

Dead wood and litter carbon stocks were assumed stable in lands converting to forest land, and thus change in carbon stocks in dead organic matter was taken as zero (Tier 1 assumption).

Soil carbon is generally found to accumulate following afforestation on agricultural areas (Guo, 2002). The changes in soil carbon stocks in these lands were estimated according to Tier 1 as:

$$\Delta C_{LF_{Soils}} = \Delta C_{LF_{Mineral}} = [\sum_{i} (SOC_{REF} - SOC_{Cropland\ i}) \cdot A_{aff\ i}] / T_{aff}$$

where, $\Delta C_{LF_{Mineral}}$ is the annual change in carbon stocks in mineral soils for inventory year, t C yr^{-1}, $SOC_{REF\ i}$ is the carbon stock, under native, unmanaged forest on a given soil, t C ha^{-1}, $SOC_{Cropland\ i}$ is the soil organic carbon stock on previous cropland use, by crop type, t C yr^{-1}, $A_{aff\ i}$ is the area of the cropland afforested, by crop type, ha and T_{aff} is the duration of the transition from $SOC_{Cropland}$ to $SOC_{REF,}$ yr.

However, because available data on areas of cropland were not available stratified by crop type, carbon stocks changes in these lands were estimated and reported aggregated in changes in soil carbon stocks in Cropland remaining Cropland. Further information is given in Paragraph 7.3.2. Croplands on organic soils have not been converted to forest land.

7.3 Cropland (CRF Source Category 5B)

7.3.1 Category description

The total area of cropland in Greece decreased during the last 20 years, and therefore carbon stock changes were estimated and reported only under the category *Cropland remaining Cropland.* Carbon stock changes in living biomass and soil were caused by changes in management practices and crop type. Soil carbon stock changes in cropland converted to Grassland and Forest Land (through abandonment or afforestation) are also reported in the Cropland category (due to inventory methodological reasons). Emissions of CH_4 and N_2O from these lands were estimated as part of *Agriculture* (Chapter 6). The net CO_2 emissions / removals from each subcategory are presented in ***Table 7.8.***

Table 7.8 Net CO_2 emissions / removals (kt CO_2) from Cropland by subcategory for the period 1990 - 2009

IPCC categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Cropland remaining Cropland	-1205	-1251	-1146	-1.311	-1230	-1316	-936	-1025	-1104	-1297	-864
Biomass	-1226	-1272	-1167	-1332	-1251	-1336	-957	-1046	-1124	-1317	-884
Dead Organic matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soils	20.65	20.65	20.65	20.65	20.65	20.65	20.65	20.65	20.65	20.65	20.65
Land converted to Cropland	0.03	0.16	0.11	0.30	0.04	0.09	0.09	0.02	0.04	0.03	0.04
Biomass	0.03	0.16	0.11	0.30	0.04	0.09	0.09	0.02	0.04	0.03	0.04
Dead Organic matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soils	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cropland	-1205	-1251	-1146	-1311	-1230	-1315	-936	-1025	-1104	-1297	-864

IPCC categories	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cropland remaining Cropland	-946	-1006	-668	-822	-776	-857	-831	-801	-737
Biomass	-966	-1027	-689	-842	-797	-878	-852	-822	758
Dead Organic matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soils	20.65	20.65	20.65	20.65	20.65	20.65	.20.65	20.65	20.65
Land converted to Cropland	0.00	0.03	0.12	0.18	0.00	0.00	0.24	0.01	0.00
Biomass	NO	0.03	0.12	0.18	0.00	NO	0.24	0.01	0.00
Dead Organic matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soils	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cropland	-946	-1006	-668	-822	-776	-857	-831	-801	-737

Note: Emissions / removals from changes in soil carbon stocks in Cropland converted to Grassland and Forest land are also included

According to the Agricultural Statistics of the Hellenic Statistical Authority, during the last 40 years tree crops have almost doubled in area, mainly against cereal crops. This considerable change in crops cultivated has resulted in the creation of a sink in the increasing biomass stocks where

carbon is accumulating. The magnitude of this sink is about 0.7-1.3 Mt CO_2 yr^{-1} during the period 1990 – 2009. Carbon sequestration in mineral soils is mostly attributed to the abandonment and afforestation of croplands - and not to changes in crop type - and accounts for an average removal of 224 kt CO_2 per year during the period 1990 – 2009. Cultivation of organic soils resulted in net emissions of 244 kt CO_2 yr^{-1} during the same period, and therefore soils accounted for net emissions of 20 kt CO_2 yr^{-1}.

7.3.2 Methodology

Cropland includes all annual and perennial crops as well as temporary fallow land. The course of the area of different broad crop categories is illustrated in ***Figure 7.5***.

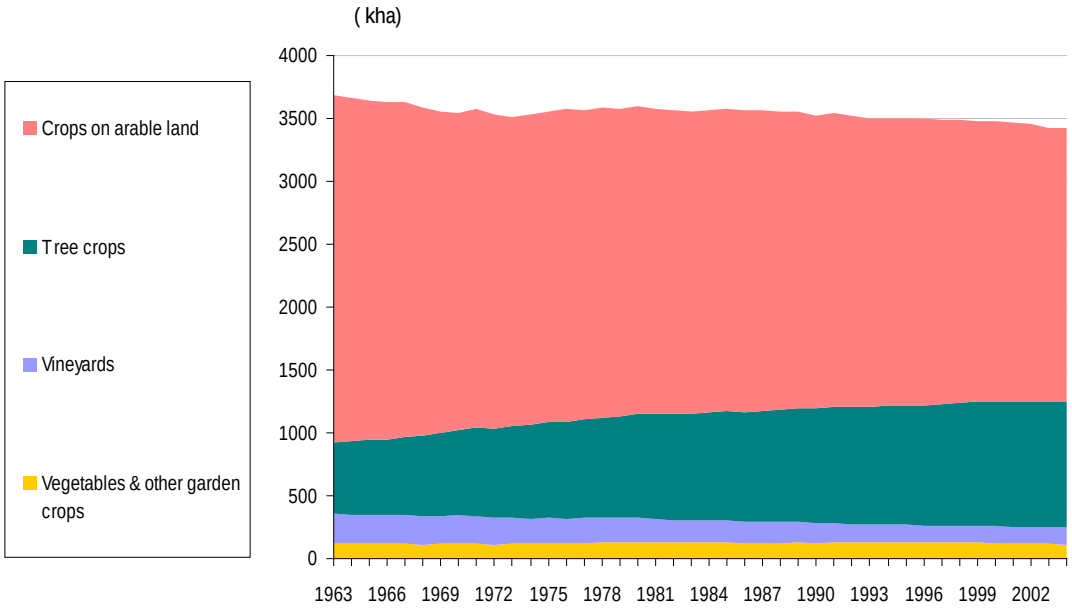


Figure 7.5 Areas of cropland in Greece since 1963 (fallow land excluded)

7.3.2.1 Cropland remaining cropland

The Paragraph 'Cropland Remaining Cropland (CC)' describes the estimation of changes in carbon stock in living biomass and soil pools in croplands which have been croplands for at least the past 20 years. The following summary equation used:

$$\Delta C_{CC} = \Delta C_{CC_{LB}} + \Delta C_{CC_{Soils}}$$

Change in carbon stocks in living biomass

A Tier 2 methodology was used to estimate carbon stock changes in living biomass, with country-specific values for areas and carbon accumulation and loss rates. For annual crops, increase in biomass stocks in a single year was assumed equal to biomass losses from harvest and mortality in

that same year - thus there was no net accumulation of biomass carbon stocks (GPG LULUCF). Perennial woody crops (e.g. tree crops) accumulate biomass for a finite period until they are removed through harvest or reach a steady state where there is no net accumulation of carbon in biomass because growth rates have slowed and incremental gains from growth are offset by losses from natural mortality or pruning. After this period, perennial woody crops are replaced by new ones and carbon stored in biomass is released to the atmosphere through burning (on-site of off-site) or decomposition. These crops constitute therefore a significant carbon pool, but when management practices or crop type do not change, it is assumed that removals from biomass increment are balanced by emissions from harvest, and thus in a long term, they are neither a sink nor a source of carbon.

Changes in carbon stocks in living biomass were only estimated when new plantations of such perennial woody crops, i.e. tree crops and vineyards for the case of Greece, were established or eradicated (changed to a different crop type).

$$\Delta C_{CC_{LB}} = \Delta C_{CC_G} - \Delta C_{CC_L}$$

where, $\Delta C_{CC_{LB}}$ is the annual change in carbon stocks in living biomass in cropland remaining cropland and changes crop type, t C yr^{-1}, ΔC_{CC_G} is the annual increase in carbon stocks due to biomass growth in new plantations, t C yr^{-1} and ΔC_{CC_L} is the annual decrease in carbon stocks due to biomass loss in eradicated crops, t C yr^{-1}.

Consistent with GPG LULUCF it was assumed that these plantations accumulate biomass linearly until they reach maturity, assumed to be at half the replacement cycle (***Figure 7.6***). During maturity biomass increases are offset by losses from pruning - in order the tree to be retained to the desired form - and natural mortality, and hence changes in living biomass are assumed to be zero. The annual growth rate (G_W), during the growth period, is derived thus by dividing biomass stock at maturity (B_M) by the time from crop establishment to maturity reach ($\lambda/2$). The annual increase in carbon stocks due to biomass growth in new plantations was calculated as:

$$\Delta C_{CC_G} = \sum_i \sum_{j=k-(\lambda i/2)-1}^{k} \frac{1}{\lambda_i / 2} \cdot A_{planted_{ij}} \cdot G_{W_i} \cdot CF, \; G_{W,i} = {B_{M,i}}/{(\lambda_i / 2)}$$

where, $A_{planted_{ij}}$ is the area where new plantations were established, by crop type (i = 17), ha yr^{-1}, G_{W_i} is the growth rate in new plantations, by crop type, t d.m. ha^{-1} yr^{-1}, CF is the carbon fraction of dry matter, t C (t d.m.)$^{-1}$, k is the inventory year, B_{M_i} is the average biomass stock at maturity, by crop type, d.m. ha^{-1} and λ_i is the average replacement cycle, by crop type, yr.

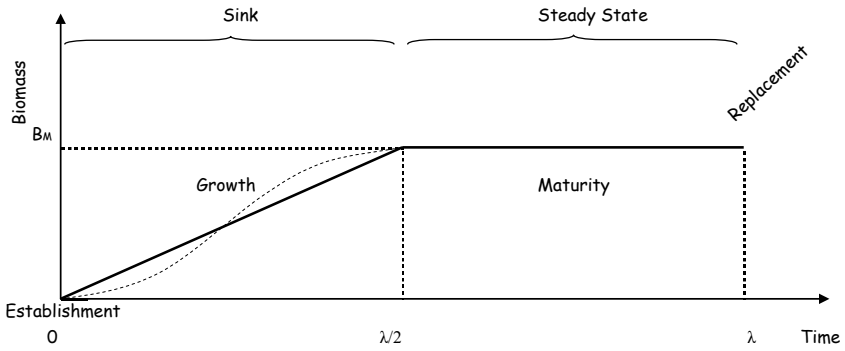


Figure 7.6 Assumed biomass accumulation in new plantations

The default annual loss rate is equal to biomass stocks at replacement (B_M), which are assumed removed entirely in the year of removal (GPG LULUCF). The annual decrease in carbon stocks due to biomass loss from eradication (ΔC_{CC_L}) was estimate as:

$$\Delta C_{CC_L} = \sum_i A_{eradicated_i} \bullet B_{M\,i}$$

where, $A_{eradicated_i}$ is the area of crop eradicated, by crop type (i = 17), ha yr^{-1} and B_{M_i} is the average biomass stock at maturity / replacement, by crop type, t d.m. ha^{-1}.

Data on areas planted and eradicated since 1963 were obtained by the 'Agricultural Statistics of Greece' of the Hellenic Statistical Authority, disaggregated by 17 crop types (16 tree crops and vineyards). Data on the factors B_M and λ for these crops were obtained from the Ministry of Rural Development and Food (Ministry of Agriculture, 1981) and expert judgment and are presented in ***Table 7.9***.

Change in carbon stocks in soils

A Tier 1 methodology was used for the estimation of carbon stock changes in soil, with country specific data for areas and IPCC default coefficients. The annual change in carbon stocks in soils in cropland remaining cropland ($\Delta C_{CC_{Soils}}$, tonnes C yr^{-1}) was estimated as the difference in the annual emissions from cultivated organic soils ($\Delta C_{CC_{Organic}}$, tonnes C yr^{-1}) from the annual change in organic carbon stocks in mineral soils ($\Delta C_{CC_{Mineral}}$, tonnes C yr^{-1}).

$$\Delta C_{CC_{Soils}} = \Delta C_{CC_{Mineral}} - \Delta C_{CC_{Organic}}$$

According to GPG LULUCF changes in dead organic matter and inorganic carbon were assumed to be zero. Liming of soils is applied to some extent in croplands, mainly in west of the country, that face more soil acidification problems. However, oxide (CaO) and hydroxide ($Ca(OH)_2$) of lime are used for this purpose - rather than carbonate containing lime -, that do not result in emissions of CO_2 when applied to soil. These materials are proved to be more efficient, since limestone ($CaCO_3$) has large diameter that result in small / slow dissolubility under the Greek dry conditions.

CO_2 is produced in the production of lime and hydrated lime, but these emissions are estimated and reported under the Industrial Processes Sector (Chapter 4).

Table 7.9 Average biomass stock at maturity and replacement cycle for different crop types

Crop Type	B_M (tonnes d.m. ha^{-1})	λ (yr)
Vineyards	12	26
Citrus trees (orange. lemon. mandarin. biter orange. citron. bergamot trees)	54	30
Apple trees	54	26
Pear trees	48	26
Peach trees	48	26
Apricot trees	60	30
Cherry trees	60	40
Sour cherry trees	54	30
Fig trees for fresh figs	42	30
Fig trees for dried figs	42	30
Almond trees	60	40
Walnut trees	60	50
Chestnut trees	90	50
Carob trees	54	50
Hazelnut trees	54	50
Pistachio trees	42	30
Olive trees[17]	71.5	50

Mineral soils

The default IPCC methodology that a certain concentration of carbon stock is associated with one crop type and management practice under a specific climate and soil type, and thus changes in soil carbon stocks occur when crop type or management practices are altered, was followed. The annual change in carbon stocks in mineral soils was estimated using a Tier1 method based on equation 3.3.4 of GPG LULUCF:

$$\Delta C_{CC_{Mineral}} = [\ \sum_i (SOC_0 \cdot A)_i - \sum_i (SOC_{(0\text{-}T)} \cdot A)_i\ ] / T$$

$$SOC = SOC_{REF} \cdot F_{LU} \cdot F_{MG} \cdot F_I$$

where, SOC_0 is the soil organic carbon stock in the inventory year, t C yr^{-1}, $SOC_{(0\text{-}T)}$ is the soil organic carbon stock T years prior to the inventory year, t C yr^{-1}, T is the inventory time period, yr, A is the land area of each parcel, ha, *i* represents the set of cropland types or crop type categories,

[17] Olive groves constitute the majority of new plantations (approximately 90%) during 1990-2009. They are not subject of regular replacement since they retain their productivity for many decades, but a replacement cycle was assigned for inventory estimation purposes.

(i = 13), SOC_{REF} is the reference soil organic carbon stock, t C ha^{-1}, F_{LU} is the stock change factor for land-use or land-use change type, F_{MG} is the stock change factor for management regime and F_I is the stock change factor for input of organic matter.

The IPCC default inventory time period was used (T = 20). The high majority of agricultural soils in Greece are high activity clays (Yassoglou, 2004), and thus only one soil type was considered. According to the climatic classification (by Thornwaite) of Greece, about 80% of croplands are found on dry warm temperate climate and the rest 20% on moist warm temperate (Carras, 1973). However, since land area data disaggregated by climatic type were not available, a weighted average value for reference soil organic carbon stock was selected for the whole of the country (SOC_{REF} = 0.8 • 38 + 0.2 •88 = 48 tonnes C ha^{-1}, Table 3.3.3 of GPG LULUCF). Similarly, one weighted average land use factor, management factor and input factor was assumed for each crop type, selected from table 3.3.4 of GPG LULUCF. The stock change factors used are presented in ***Table 7.10.***

Table 7.10 Stock change factors used for different crop types

Crop Type	F_{LU}	F_{MG}	F_I
Cereals for grain	0.80	1.00	0.92
Edible pulse	0.80	1.00	1.08
Fodder seeds	0.80	1.00	1.08
Industrial plants	0.80	1.00	0.92
Aromatic plants	0.80	1.04	0.92
Fodder plants	0.80	1.04	0.92
Melons. watermelons & potatoes	0.80	1.00	1.35
Vegetables & other garden crops	0.80	1.00	1.35
Vines (grapes & raisins)	0.80	1.00	0.92
Citrus trees	0.80	1.08	0.92
Fruit trees	0.80	1.04	0.92
Nut & dried fruit trees	0.80	1.11	0.92
Olive & other trees	0.80	1.04	0.92

Carbon stocks in mineral soils were estimated to increase over the period 1990 – 2007 with an average annual rate of 61 kt C yr^{-1}. However, this value represents annual change in carbon stocks in minerals soils not only in Cropland remaining Cropland, but also in Cropland converted to Grassland and Cropland converted to Forest Land. This is because the methodology used to represent land areas is following Approach 1 (GPG LULUCF, Chapter 2), i.e. gives areas of crop types at two points in time, that do not allow determining the initial crop type of the area abandoned or afforested, and thus allow to report separately carbon stock changes in Cropland remaining Cropland and Cropland converted to Grassland or Forest land. It was assumed that soil organic carbon in the cropland abandoned or afforested recovered to the reference carbon stock SOC_{REF}. This is the Tier 1 assumption for both Land converted to grassland (F_{LU}, F_{MG}, F_I.= 1)

and Land converted to Forest land ($SOC_{Ext\ Forest} = SOC_{Int\ Forest} = SOC_{REF}$). The aggregate area of cropland abandoned and cropland afforested was calculated as the difference between the total area of cropland in the inventory year and 20 years ago.

Organic Soils

Unlikely the situation with mineral soils, where carbon fluxes were estimated from changes in soil carbon stocks followed changes in crop type/management, emissions from organic soils are estimated as net annual flux caused by cultivation and continuous exhaustion of organic matter. The annual loss of carbon from organic soils was estimated using a Tier1 method and equation 3.3.5 of GPG LULUCF.

$$\Delta C_{CC_{Organic}} = A_{Organic} \cdot EF$$

where, $\Delta C_{CC_{Organic}}$ represents CO_2 emissions from cultivated organic soils in cropland remaining cropland,, t C yr^{-1}, $A_{Organic}$ is the land area of cultivated organic soils, ha and EF is the emission factor for cultivated organic soils, t C $ha^{-1}yr^{-1}$.

All cultivated organic soils are found under warm temperate climate, hence one climate type was considered when choosing the emission factor (EF = 10 tonnes C $ha^{-1}yr^{-1}$, Table 3.3.5, GPG LULUCF). Area of cultivated organic soils was obtained from a study of the Soil Science Institute of Athens (SSIA, 2001).

7.4 Grassland (CRF Source Category 5C)

7.4.1 Category description

Grassland includes rangeland and pasture with vegetation that falls below the threshold of forest definition and are not expected to exceed without human intervention. Pastures that have been fertilised or sown are considered as cropland.

Under this category are reported CO_2 emissions from lands converted to Grassland and non-CO_2 emissions from wildfires (***Table 7.11***). Changes in soil carbon stock in Cropland converted to Grassland are estimated and reported in the Cropland remaining Cropland category.

Table 7.11 Emissions / removals of greenhouse gases (in kt) from Grassland for the period 1990 - 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO_2	0.01	0.21	NO	NO	0.49	3.00	NO	0.08	NO	0.31	NO
CH_4	0.67	0.57	1.71	1.20	1.25	0.53	0.57	0.86	1.69	0.19	2.64
N_2O	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.02
Total (in kt CO_2 eq)	15.47	13.30	39.63	27.78	29.45	15.27	13.21	19.96	39.06	4.72	61.12

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2	NO	0.02	2.03	0.37	NO	0.04	0.06	0.05	0.00
CH_4	0.53	0.10	0.13	0.33	0.17	0.27	5.47	0.58	0.60
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00
Total (in kt CO_2 eq)	12.30	2.32	5.11	8.02	3.93	6.28	126.48	13.37	13.39

IE: Included Elsewhere

7.4.2 Methodology

7.4.2.1 Grassland remaining Grassland

The living biomass pool in grassland includes above- and belowground carbon stocks in woody and herbaceous (grasses and forbs) vegetation. Grasslands in Greece are extensively managed without significant management improvements (e.g. species changes, irrigation, fertilisation) and management practices applied are generally static. Hence, the Tier 1 assumption that is no change in biomass stocks was followed and aboveground grass biomass was only considered for estimating emissions from wildfires.

The methods used to estimate emissions from wildfires in grasslands are these described in Forest land section, with the difference that all carbon in the aboveground biomass is assumed to be released to the atmosphere upon disturbance (no transfer to dead organic pool is considered, f_{BL} = 0). However, CO_2 released is assumed to be removed by photosynthesis of vegetation regrowing during the subsequent year and therefore only emissions of non-CO_2 gases are reported. For these estimations two grassland types were considered; one with herbaceous vegetation and average biomass stock of 2.2 tonnes d.m. ha^{-1} and one with woody vegetation (shrubland) and average biomass stock of 8 t dm . ha^{-1} (Kokkinidis, 1989). Data on area of grasslands burnt were obtained from the statistics of the Ministry of Environment, Energy and Climate Change (GDPDFNE, annual statistics).

According to GPG LULUCF, changes in dead organic matter and inorganic carbon stocks were assumed to be zero. Concerning the carbon pool in mineral soils, all area was characterised as nominal managed both in the inventory year and 20 years ago, and hence according to equation 3.4.8 of GPG LULUCF, $F_{MG} = F_I = 1$ and $\Delta C_{CC_{Mineral}} = 0$, i.e. the annual change in carbon stocks in mineral soils was zero. Changes in carbon stocks of organic soils are associated with drainage and other management perturbations of these soils. In Greece, areas of organic soils under the grassland classification are negligible, remain in a natural state and therefore greenhouse gas emissions/removals have not been considered. CO_2 emissions from liming of grasslands were not considered since liming is not applied on these lands. Non-CO_2 emissions from other sources (e.g. CH_4 emissions from grazing livestock on grassland) were estimated and reported in the *Agriculture* sector (Chapter 6).

7.4.2.2 Land converted to Grassland

Changes in biomass and soil C stocks associated with Forest land and Cropland conversion to Grassland are addressed in this category.

Since Greek law allow the land use change of Forest land only in cases of national interest, there is only a very small area where such deforestation occur (e.g. construction of high-tension lines). The carbon emissions and removals in land use conversion to grassland result from the removal of existing and replacement with different vegetation. The methodology used to estimate C stock changes on these lands follows the GPG LULUCF approach, where the carbon stock change is equal to the carbon stock change due to removal of biomass from the initial land use (i.e. carbon in biomass immediately after conversion minus the carbon in biomass prior to conversion), plus carbon stocks from biomass growth following conversion. As a result of conversion, it is assumed that the dominant vegetation is removed entirely, after which the area is taken over by grassland.

$$\Delta C_{LG_{LB}} = A_{Conversion} \bullet (L_{Conversion} + \Delta C_{Growth})$$

$$L_{Conversion} = C_{After} - C_{Before}$$

where, $\Delta C_{LG_{LB}}$ is the annual change in carbon stocks in living biomass in land converted to grassland, tonnes C yr^{-1}, $A_{Conversion}$ is the annual area of land converted to grassland from some initial use, ha yr^{-1}, $L_{Conversion}$ is the carbon stock change per area for that type of conversion when land is converted to grassland, tonnes C ha^{-1}, ΔC_{Growth} is the carbon stocks from one year of growth of grassland vegetation after conversion, tonnes C ha^{-1}, C_{After} is the carbon stocks in biomass immediately after conversion to grassland, tonnes C ha^{-1}, C_{Before} is the carbon stocks in biomass immediately before conversion to grassland, tonnes C ha^{-1}.

For the area of forest land converted to grassland, direct estimates of spatially disaggregated areas converted annually for each initial forest type and each final grassland type, were used. These data were provided by the local Forest Service for each land unit converted.

The average carbon stock in biomass immediately before conversion C_{Before} was obtained from the average biomass stock Bw of each forest type, as calculated in the category Forest land remaining Forest land. Carbon stocks in biomass immediately after conversion are assumed to be zero (C_{After} = 0). According to the GPG LULUCF, changes in biomass carbon stocks for grassland established following land use conversion ΔC_{Growth} are accounted for in the year of the conversion. For these estimations two grassland types were considered; one with herbaceous vegetation and average biomass stock of 2.2 tonnes d.m. ha^{-1} and one with woody vegetation (shrubland) and average aboveground biomass stock of 8 t dm . ha^{-1} (Kokkinidis, 1989). Belowground biomass stocks were approximated using the default root-shoot ratio suggested by the GPG LULUCF (table 3A.1.8).

According to Tier 1 approach, soil C stocks in both forest land and grassland (unmanaged land) are assumed equal to the reference level (i.e. land use, management and input factors equal 1), and hence C stock changes in soil is zero. Croplands that have been abandoned and taken over by grassland were also considered in this section. It was assumed that biomass stocks do not change after conversion, and hence carbon stock changes in living biomass were zero. Carbon stock

changes in soil were estimated and reported under the category Cropland remaining Cropland. All relevant information and methods used are presented in Section 7.3.2. No croplands on organic soils have been abandoned. Non-CO_2 emissions from wildfires on Lands converted to Grassland are reported under the category Grassland remaining Grassland.

7.5 Wetlands (CRF Source Category 5D)

Wetlands include land that is covered or saturated by water for all or the greatest part of the year (e.g. lakes, reservoirs, marshes), as well as river bed (including torrent beds) and that does not fall into the forest land, cropland, grassland or settlements categories. In this category, carbon stock changes, as well as N_2O and CH_4 emissions associated with organic soils managed for peat extraction and flooded lands in the category Land converted to Wetlands have to be reported[18]. The first activity is not considered since it does not occur in the country. Flooded lands are defined as water bodies regulated by human activities for energy production, irrigation, recreation, etc., and where substantial changes in water area due to water level regulation occur. Carbon stock changes in lands converted to flooded lands are caused by biomass decomposition in these areas. This loss has not been estimated due to lack of sufficient data, but it is expected to be relative small since area flooded after 1990 is small.

7.6 Settlements (CRF Source Category 5E)

Settlements include all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other land-use categories. Parties have to estimate and report carbon stock changes in living biomass in Land converted to Settlements[19].

The amount of C stock change in living biomass in land that is cleared for expanding settlements is estimated by multiplying the forest area converted annually to settlements by the difference in carbon stocks between biomass in the land prior to conversion (C_{Before}) and that in the settlements after conversion (C_{After}). The equation used to estimate annual changes in carbon stocks in living biomass in land converted to settlements is:

$$\Delta C_{LS_{LB}} = A \bullet (C_{After} - C_{Before})$$

where, $\Delta C_{LS_{LB}}$ is the annual change in carbon stocks in living biomass in land converted to settlement, tonnes C yr^{-1}, A is the area of land converted annually to settlement from some initial use, ha yr^{-1}, C_{After} is the carbon stocks in living biomass immediately after conversion to

[18] Parties do not have to prepare estimates of emissions and removals from Wetlands remaining Wetlands, although they may do so if they wish.

[19] Parties do not have to prepare estimates of emissions and removals from Settlements remaining Settlements, although they may do so if they wish.

settlement, tonnes C ha^{-1}, C_{Before} is the carbon stocks in living biomass immediately before conversion to settlement, tonnes C ha^{-1}.

The default assumptions of GPG LULUCF, that all living biomass present before conversion to settlements is lost in the same year as the conversion takes place, and that carbon stocks in living biomass following conversion (CAfter) are equal to zero, have been followed.

Actual areas converted annually have been used for each unit of land converted to settlements. These data were provided by the local Forest Service disaggregated by initial land use and vegetation type.

Three types of land use changes to settlements have been indentified:

- Forest land converted to Settlements
- Grassland converted to Settlements, and
- Other land converted to Settlements

The average carbon stock in biomass in forest land and grassland immediately before conversion C_{Before} was obtained from the average biomass stock Bw of each vegetation type, as reported in the categories Forest land and Grassland respectively. Belowground biomass stocks were approximated using the default root-shoot ratio suggested by the GPG LULUCF (table 3A.1.8).

For the category other land, it is assumed that carbon stocks in living biomass are equal to zero, and hence changes in carbon stocks in living biomass in other land converted to settlements are zero.

7.7 Other land (CRF Source Category 5F)

The category of 'Other land' includes all land areas that do not fall into any of other land-use categories (e.g. rocky areas, bare soil, mine and quarry land). In accordance with GPG LULUCF, changes in carbon stocks and non-CO_2 emissions were not assessed for the category 'Other Land remaining Other Land' assuming that it is typically unmanaged. However, changes in carbon stocks associated with the conversion of forest land and grassland to other land (mainly mines and quarries) have been calculated and reported, since the act of conversion releases the carbon previously held on these lands.

The difference between initial and final living biomass carbon pools is used to calculate change in carbon stocks due to land-use conversion. The equation used to estimate annual changes in carbon stocks in living biomass in land converted to other land is:

$$\Delta C_{LO_{LB}} = A \bullet (C_{After} - C_{Before})$$

where, $\Delta C_{LS_{LB}}$ is the annual change in carbon stocks in living biomass in land converted to other land, tonnes C yr^{-1}, A is the area of land converted annually to other land from some initial use, ha yr^{-1}, C_{After} is the carbon stocks in living biomass immediately after conversion to other land, tonnes C ha^{-1}, C_{Before} is the carbon stocks in living biomass immediately before conversion to other land, tonnes C ha^{-1}.

The average carbon stock in biomass in forest land and grassland immediately before conversion C_{Before} was obtained from the average biomass stock B_W of each vegetation type, as reported in the categories Forest land and Grassland respectively. Belowground biomass stocks were approximated using the default root-shoot ratio suggested by the GPG LULUCF (table 3A.1.8). It is assumed that the dominant vegetation is removed entirely, resulting in no carbon remaining in living biomass after conversion. ($C_{After} = 0$).

Actual areas converted annually have been used for each unit of land converted to 'Other Land'. These data were provided by the local Forest Service disaggregated by initial land use and vegetation type.

8. Waste (CRF sector 6)

8.1 Overview

In this chapter the emissions of greenhouse gases from the sector *Waste* are presented and the relative methodologies of emissions calculation per source are described.

According to the IPCC Directives, the following source categories are included in this sector:

- Solid waste disposal on land
- Wastewater handling
- Waste incineration

The remainder of this chapter is organized as follows, Paragraph 8.1 continues with the presentation of emissions trends from the waste sector, a brief description of the methodology applied for the calculation of GHG emissions and the assessment of the completeness of the GHG inventory for the waste sector. Then (Paragraphs 8.2 – 8.4) detailed information on the methodologies applied (including references on the activity data and the emission factors used) for the calculation of GHG emissions per source of emissions is presented.

8.1.1 Emissions trends

In 2009 GHG emissions from *Waste* decreased by 26.5% compared to 1990 levels (***Figure 8.1***). while the average annual rate of decrease of emissions for the period 1990 – 2009 is estimated at 1.4%.

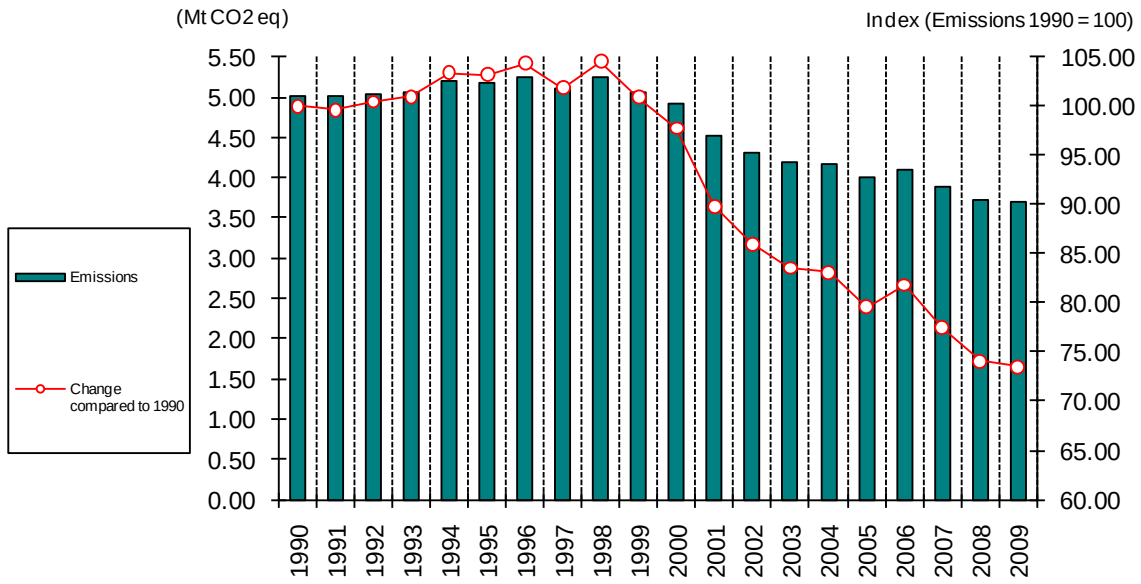


Figure 8.1 Total GHG emissions (in kt CO_2 eq) from Waste for the period 1990 – 2009

The sector *Waste* is responsible for carbon dioxide, methane and nitrous oxide emissions. GHG emissions from *Waste* per gas are presented in ***Table 8.1***.

Table 8.1 GHG emissions (in kt CO_2 eq) from Waste per gas for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO_2	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
CH_4	4693.7	4669.1	4702.9	4728.6	4837.5	4826.0	4883.2	4751.0	4883.8	4693.0	4538.1
N_2O	328.2	334.3	341.4	340.6	354.4	357.3	356.3	363.6	364.9	373.2	371.5
Total	5022.1	5003.6	5044.4	5069.3	5192.1	5183.4	5239.6	5114.8	5248.8	5066.3	4909.7
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
CO_2	0.15	0.41	0.79	0.98	1.87	2.26	3.06	3.61	3.53		
CH_4	4140.2	3947.5	3823.8	3800.4	3617.4	3726.8	3507.0	3332.9	3303.1		
N_2O	369.0	369.1	370.0	371.3	377.1	379.1	380.8	381.8	383.3		
Total	4509.4	4317.1	4194.6	4172.7	3996.4	4108.1	3890.9	3718.3	3690.0		

Methane represents the major greenhouse gas from *Waste*, with a contribution which, however, decreased from 93% in 1990 to 90% in 2009. Overall, CH_4 emissions in 2009 decreased by 29.6% compared to 1990 levels, with an average annual rate of -1.6%.

Greenhouse gases emissions from solid waste disposal on land present an increasing trend, while, on the contrary, emissions from wastewater handling are gradually decreasing. The decrease is mostly noticeable since 1999 because of the constant increase of wastewater volume treated under aerobic conditions, while since 2002 the rate of increase is slowing down.

As a result, the major source category from *Waste* (***Figure 8.2***) since 1997 is solid waste disposal on land with a contribution increasing from 37.0% in 1990 to 67.0% in 2009. On the contrary, GHG emissions from wastewater handling present a declining trend, with an average annual rate of -3.2% for the period 1990 – 2009. Emissions from the incineration of clinical waste present a remarkable increase during the period 1990 – 2009; though the contribution of this source to total GHG emissions of the sector is negligible.

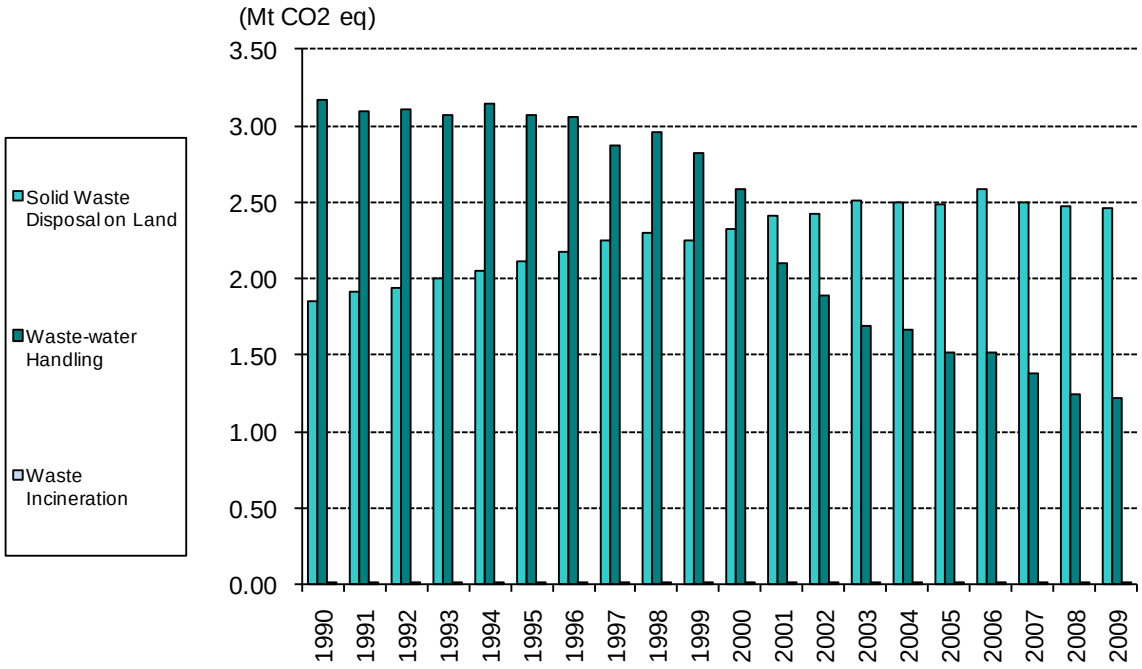


Figure 8.2 Greenhouse gases emissions (in kt CO_2 eq) from Waste per source category for the period 1990 – 2009

The emissions from the waste sector decrease for the period 1999-2009 while a small increase is observed for 2006. In gereral, as it it is shown in Figure 8.2, GHG emissions from solid waste disposal on land increase, on the contrary to GHG emissions from wastewater handling which decrease or remain almost constant. Thus their sum presents small fluctuations.

8.1.2 Methodology

The calculation of GHG emissions from *Waste* is based on the methodologies and emission factors suggested by the IPCC Guidelines and the IPCC Good Practice Guidance.

- Data on quantities of waste generated and sent to managed or unmanaged landfills is provided by the Waste management sector of the Ministry of Environment, Energy and Climate Change (MEECC).
- Data on population used in the calculations are provided by the Hellenic Statistical Authority. In the present inventory the annual permanent population is calculated as the average of the population in the end of the current (examined) year and the previous one, contrary to the previous inventories in which the annual population used was the existed one at the end of each year.

- The main sources of information for the necessary data and parameters are the Ministry of Environment, Energy and Climate Change (MEECC), the Association of Communities and Municipalities in the Attica Region (ACMAR), the Athens Water Supply and Sewerage Company (EYDAP) as well as various research studies and international databases.

The methodology applied for the calculation of emissions per source category is briefly presented in ***Table 8.2***, while a detailed description is given in Paragraphs 8.2 – 8.4.

Table 8.2 Methodology for the estimation of emissions from waste

	CO_2		CH_4		N_2O	
	Methodology	Emission Factor	Methodology	Emission Factor	Methodology	Emission Factor
Solid waste disposal on land			T2	D, CS		
Wastewater handling			D	D, CS	D	D, CS
Waste Incineration	D	D	D	CS	D	CS

T2: Tier 2 IPCC methodology
D: Default IPCC methodology / emission factor
CS: Country Specific

Key categories

The following key categories are included in the sector *Waste* (***Table 8.3*** - see Paragraph 1.5 for a complete presentation of the results of the key categories analysis and Annex I for the presentation of the relevant calculations).

Table 8.3 Key categories from the Waste sector

Source category	Gas	Level assessment	Trend assessment
Solid waste disposal on land	CH_4	☒	☒
Wastewater handling	CH_4	☒	☒

8.1.3 Completeness

Table 8.4 gives an overview of the IPCC source categories included in this chapter and presents the status of emissions estimates from all sub-sources in the waste sector.

N_2O emissions from industrial wastewater are estimated for first time in the current submission using country specific emission factors.

Table 8.4 Completeness of the GHG inventory for the waste sector

	CO_2	CH_4	N_2O
A. Solid waste disposal on land			
1. Managed waste disposal on land	NO	☒	
2. Unmanaged waste disposal on land	NO	☒	
3. Disposal of sewage sludge	NO	☒	
B. Wastewater treatment			
1. Industrial wastewater		☒	☒
2. Domestic and commercial wastewater		☒	☒
C Waste incineration	☒	☒	☒

NO: Not Occurring

8.2 Solid waste disposal on land (CRF Source Category 6A)

8.2.1 Description

Solid waste disposal on land is responsible for methane emissions. Methane is emitted during the anaerobic decomposition of organic waste disposed of in various solid waste disposal sites (SWDS). The main characteristic of this process is that organic waste decomposes at a diminishing rate over time and takes many years to decompose completely. Moreover, other factors such as the type of waste disposed, the characteristics of the disposal sites and the climate conditions, affect the decomposition rate. Methane emissions were calculated using the First Order Decay (FOD) method (Tier 2).

Carbon dioxide emissions occur during the flaring of biogas released from the decomposition of waste. However, these emissions should not be included in the total GHG emissions of the sector as they are of biogenic origin. Recovery and flaring of biogas constitute a waste management practice in the major managed SWDS of Greece since 1992. The amounts of biogas flared were estimated taking into account detailed data for biogas recovery in the largest SWDS of the country, in Athens, in which the waste landfilled in 2009 represent the 50% of the total waste disposed in managed sites.

Moreover, methane emissions from sewage sludge (generated during municipal wastewater handling) landfilled are estimated. Data related to the annual sludge generated in the wastewater treatment facilities and the amounts landfilled in the SWDS, derive from Waste management sector of the Ministry of Environment, Energy and Climate Change (MEECC), EYDAP and ACMAR. In the current submission updated data have been used for the whole period of 1990-2009.

The application of the FOD method requires historical data of several decades related to the waste generated, their composition over the years, the waste management practices applied and the specific conditions at the sites (e.g. organic matter, humidity, temperature). In Greece, there is a lack of an integrated national system for the collection of these data, especially for historical data, while additional difficulties are created by the existence of a significant number of unmanaged waste disposal sites still operating. Therefore, the application of the FOD method was based on assumptions and estimations of certain parameters that were impossible to be calculated analytically for each waste disposal site.

For the period 2001-2009 the official data provided by Ministry of Environment, Energy and Climate Change was used. Concerning the data for the period 1960-2000 total quantities of generated waste were estimated according to studies by the Waste management sector of the Ministry of Environment, Energy and Climate Change (MEECC).

CH_4 emissions from solid waste disposal on land in 2009 accounted for 67% of total GHG emissions from Waste and for 2.0% of total national emissions (without LULUCF). The average annual rate of increase of emissions from solid waste disposal on land, for the period 1990 – 2009 is estimated at 1.7% (32.6 % total increase between 1990 and 2009). CH4 emissions from managed and unmanaged solid waste disposal sites are presented in ***Table 8.5***.

CH_4 emissions from managed SWDS in 2009 increased by 997% compared to 1990 levels, while emissions from unmanaged SWDS decrease by 11.6%. This difference is due to the reduction of the number of the unmanaged SWDS in operation. Emissions from sewage sludge disposal in 2009 are 19 times higher compared to 1990.

Table 8.5 CH_4 emissions (in kt) from managed and unmanaged solid waste disposal

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Managed SWDS	2.78	5.52	6.71	8.92	11.28	13.54	15.82	18.20	19.67	16.65	19.72
Unmanaged SWDS	85.10	84.44	84.06	83.91	83.86	83.96	84.21	84.49	84.76	84.93	85.08
Sludge treatment	0.62	1.19	1.72	2.21	2.66	3.20	3.70	4.29	4.82	5.32	5.87
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Managed SWDS	23.26	23.52	26.62	26.31	25.16	29.83	27.45	27.81	30.49		
Unmanaged SWDS	84.96	84.93	85.06	84.48	83.68	82.82	81.00	78.94	75.21		
Sludge treatment	6.40	7.03	7.64	8.26	9.31	10.37	10.66	10.89	11.63		

8.2.2 Methodology

The estimation of methane emissions from solid waste disposal on land is based on the application of the FOD method. The method was applied separately for the managed and unmanaged waste disposal, taking account of the different conditions in those sites and the detailed information available regarding the opening and closure years of the operation of the managed sites. Calculations were based on the following main assumptions:

- Unmanaged wastes are considered to be landfilled in sites of similar characteristics concerning their composition and management (depth of sites), while the starting year of disposal and degradation of total unmanaged waste is assumed to be 1960.
- Managed SWDS started operating in 1990, according to the decision of 1986, Joint Ministerial Decision 4951 / 1424/1986, which was prepared for the implementation of the provisions of the European Directive 75/442/EU. The operation of the managed SWDS was reinforced in 1997 through the release of Joint Ministerial Decision 114218/1997 in which official provisions concerning the administrative procedures for the operation of the sites were issued.

The equations used for the estimation of CH_4 emissions are the following:

CH_4 generated at year t: $$P_t = \sum_{x=x_0}^{t} \left(A \cdot k \cdot MSW_T(x) \cdot MSW_F(x) \cdot Lo(x)\right) \cdot e^{-k\cdot(t-x)}$$

CH_4 emissions at year t: $E_t = (P_t - R_t) \cdot (1 - OX)$

$$Lo(x) = MCF \cdot DOC \cdot DOC_F \cdot F \cdot {}^{16}\!/_{12}$$

Where, P_t is methane generation in the year *t*, E_t is methane emissions in the year *t*, *A* is the normalization factor which corrects the summation, *k* is the methane generation rate constant, MSW_T is the total municipal solid waste (MSW) generated, MSW_F is the fraction of MSW disposed at solid waste disposal sites, *Lo(x)* is the methane generation potential, *R* is the recovered CH_4, *OX* is the oxidation factor, *MCF* is the methane correction factor, *DOC* is the degradable organic carbon, DOC_F is the fraction DOC dissimilated and *F* the fraction by volume of CH_4 in landfill gas.

Methane emissions from sewage sludge are also calculated separately using the FOD method, considering the specific characteristics related to the *DOC*, DOC_F and *k* parameters. The sludge content of the municipal waste disposed in the SWDS is not included in the waste composition used for the calculations of methane from municipal solid waste disposal on land.

The basic steps followed for the calculation of methane emissions are presented hereafter.

Generated quantities of municipal solid waste

At national level, there is a lack of confirmed official time-series of data regarding the composition and quantity of municipal solid waste (MSW) generated. Only a limited number of recent measurements on solid waste composition exist, while the acquisition of data from disposal sites on *weighted* solid waste quantities is extremely difficult. Furthermore, prefectural authorities often face problems in hiring adequate and skilled personnel, a fact which results to significant shortages concerning maintenance and processing of related databases. Additional difficulties arise from the fact that for the majority of the previous years, a large number of unmanaged SWDS existed. According to the Ministry of Environment, Energy and Climate Change (MEECC), 2182 unmanaged SWDS were still operating in 2000 (MEECC 2001). Following the National and Regional Planning of Solid Waste Management (compiled in the end of 2003), the process of closure and rehabilitation of unmanaged sites is already in progress and is expected to be completed in the following years, along with the construction of managed SWDS, following to the standards set by the EU directives, in order to cover the needs of the country. Nowdays, there is a small number of Unmanaged waste disposal sites which is planned to be eliminated until the end of 2011.

Estimates on solid waste quantities generated are included in various reports from research programmes and studies, but refer to specific points in time rather than to a whole period, while different assumptions have been applied in each case for the estimation of quantities generated. Therefore, data for some years are either missing or are unreliable. The quantities of municipal solid wastes for the period 1960-2000 was estimated on the basis of population figures and coherent assumptions regarding generation rates per capita and day, in order to derive complete

time series for waste quantities generated. For the rest of the period 2001-2009 more accurate data for the quantities of municipal solid wastes was used as they were provided by the waste management sector of the Ministry of Environment, Energy and Climate Change (MEECC).

In order to meet the recommendation of 2010 centralized ERT review for improvement of transparency in relation to Activity Data used for the estimations, the following are presented:

- Data concerning the period 1960-2000 were obtained from the report entitled "Quantification of objectives of directive 31/99 E.C. on landfill of wastes, 2001 (p. 195 of the National Inventory Report -Waste Sector)" which was composed by the General Directorate for the Environment, Environmental Planning Division, Solid waste management division of the Ministry of Environment, Energy and Climate Change. The data provided in this report were based on studies that were performed in various managed waste disposal sites of Greece. E.g. the respective study for the biggest managed disposal site of Greece located in Attica region was carried out by the National Technical University of Athens. The amount of waste disposed on managed disposal sites was estimated through sample weighting of the tracks that enter the disposal sites and it was correlated to the estimated population of the people served by these sites.
- The data concerning the period 2001-2008 were obtained by the report entitled "Report for the national strategy on the biodegradable waste management" which was composed by the same division of the MEECC. According to this report, the generation rate of solid waste quantities was considered to show an increase of 35 % for the period 2000 – 2020. This assumption was justified with data obtained from recent respective studies. Moreover, it has already been explained by the Solid waste management division of MEECC that the National Strategy for municipal wastes will be updated soon in the framework of the 2008/98/EC Dir.

In ***Table 8.6*** the estimated data on population served for the whole period 1960-2009 is presented.

For the estimation of the quantities of municipal solid wastes the method was used in previous submission were based on the assumption that MSW generation rates was in the order of 0.8 – 1.1 kg/ capita and day, depending on the type of region (rural, semi-urban, urban, large urban regions) in 1997. According to the Ministry of Environment, Energy and Climate Change (MEECC) the MSW generation rate was assumed to change annually by 0.028 kg/ capita and day, while a higher figure (annual increase by 0.035 kg/capita and day) was assumed for the regions of Athens, Central Macedonia, Crete and the islands of South Aegean. A higher figure for MSW generation rate (2.1 kg/ capita and day) was considered for foreign visitors. For the period 1960 – 1990 the rates of annual per capita waste increase are lower (0.8% - 1.5% depending on the region). The average values of daily waste generation rates estimated, are presented In ***Table 8.7***.

Table 8.6 Total population served (in thousands)

Year	Permanent population	Tourists (in equivalent permanent)	Total population served
1960	8350.54	79.73	8.430.27
1965	8540.59	81.75	8.622.34
1970	8730.63	83.83	8.814.46
1975	9157.35	85.96	9.243.31
1980	9643.24	88.14	9.731.38
1985	9948.21	97.24	10.045.45
1990	10156.90	99.45	10.256.35
1991	10256.29	83.62	10.339.91
1992	10369.87	101.09	10.470.96
1993	10465.53	101.67	10.567.19
1994	10553.04	113.49	10.666.53
1995	10634.39	106.22	10.740.61
1996	10709.17	97.25	10.806.43
1997	10776.50	108.80	10.885.30
1998	10834.88	115.53	10.950.41
1999	10882.58	124.61	11.007.19
2000	10917.48	127.18	11.044.66
2001	10949.96	119.05	11.069.01
2002	10987.54	110.55	11.098.09
2003	11019.04	110.71	11.129.74
2004	11050.62	111.97	11.162.60
2005	11103.92	111.60	11.215.53
2006	11148.46	117.96	11.266.42
2007	11192.85	131.73	11.324.58
2008	11237.07	131.44	11.368.50
2009	11282.75	127.88	11.410.63

On the basis of the above, the following MSW quantities for the years 1990 – 2009 were estimated (***Table 8.8***). For the period 2001-2009, confirmed data was obtained from the Waste management sector of the Ministry of Environment, Energy and Climate Change (MEECC) as it is mentioned above. These data is presented in ***Table 8.8***.

Table 8.7 Waste generation rates (kg/cap/day) of permanent population and tourists

Year	Permanent population	Tourists	Total population
1960	0.566	1.400	0.573
1965	0.611	1.530	0.620
1970	0.656	1.659	0.666
1975	0.697	1.789	0.707
1980	0.735	1.919	0.746
1985	0.772	2.048	0.785
1990	0.809	2.100	0.821
1991	0.816	2.100	0.827
1992	0.844	2.100	0.856
1993	0.872	2.100	0.884
1994	0.901	2.100	0.913
1995	0.929	2.100	0.940
1996	0.957	2.100	0.967
1997	0.985	2.100	0.996
1998	1.017	2.100	1.029
1999	1.050	2.100	1.062
2000	1.082	2.100	1.094
2001	1.118	2.100	1.128
2002	1.136	2.100	1.145
2003	1.150	2.100	1.159
2004	1.164	2.100	1.174
2005	1.176	2.100	1.186
2006	1.189	2.100	1.198
2007	1.200	2.100	1.210
2008	1.213	2.100	1.224
2009	1.228	2.100	1.237

Table 8.8 Quantities of MSW generated by year (in Mt)

Year	1960	1965	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998
Generated MSW	1.765	1.951	2.142	2.384	2.651	2.877	3.075	3.119	3.273	3.41	3.556	3.686	3.815	3.958	4.112
Year	1999	2000	2001†	2002†	2003†	2004†	2005†	2006†	2007†	2008†	2009†				
Generated MSW	4.266	4.411	4.559	4.64	4.71	4.781	4.854	4.927	5.002	5.077	5.154				

†official data

Composition of generated municipal solid waste

As mentioned before, accurate data on the composition of municipal solid waste generated at national level are not available, as a comprehensive analysis at national scale covering a complete time period (so as to take into account seasonal variations because of tourist activity) has not been accomplished yet. However, measurements in some regions have been carried out, although they refer to different time periods (e.g. ULAPA 1996, MEECC 1999). Recent estimates of the composition of MSW at national level exist only for 1997 (MEECC 1998).

Additional an analysis obtained by ACMAR was used. This analysis was performed at the Attica region during 2007. The estimated values were confirmed with the data used by other parties to be similar.

In order to estimate the composition of MSW generated on an annual basis the following assumptions were made (MEECC 2001a) considering the estimation for 1997 (national level) as base:

- The share of putrescibles is assumed to decrease by 0.3% annually, while metals and glass are assumed to decrease annually by 0.1% and 0.02% respectively.
- The share of paper and plastics is assumed to increase by 0.2% annually.
- The share of wood and textiles is assumed to be constant because for both the value was low, 1% and 3.25% respectively.

The fraction of solid waste that is garden (yard) waste, park waste and other non-food organic putrescibles were included in the category of putrescibles, although a more detailed and accurate breakdown of solid waste is inquired. The 2010 centralized ERT review recommended the use of appropriate DOC values for these kinds of waste, i.e. garden (yard) waste, waste park and other non-food putrescibles, however it is not yet possible to achieve this, due to lack of available accurate data regarding the composition of solid waste in this type of waste. The use of this more detailed characterization of waste will be included in the estimations when any type of new information is available. For example, the findings of works performed in the framework of the preparation of the National Strategy for municipal wastes which is expected to be updated soon, will be examined for the identification of useful information.

For the period 1960 – 1990 an annual increase (backwards) of 0.2% was assumed for putrescibles, metals and glass are also assumed to increase (backwards) by 0.1% and 0.02% respectively, while paper and plastics are assumed to decrease annually (backwards) by 0.1% and 0.2% respectively.

The estimated composition of generated MSW on an annual basis is presented in ***Table 8.9***.

Table 8.9 Estimated composition (%) of MSW generated for the period 1990 - 2008

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Putrescibles	44.85	44.55	44.25	43.95	43.65	43.35	43.05	42.75	42.45	42.15	41.85
Textiles	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25
Wood	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Paper	18.60	18.80	19.00	19.20	19.40	19.60	19.80	20.00	20.20	20.40	20.60
Plastics	7.10	7.30	7.50	7.70	7.90	8.10	8.30	8.50	8.70	8.90	9.10
Metals	5.20	5.10	5.00	4.90	4.80	4.70	4.60	4.50	4.40	4.30	4.20
Glass	4.64	4.62	4.60	4.58	4.56	4.54	4.52	4.50	4.48	4.46	4.44
Rest	15.36	15.38	15.40	15.42	15.44	15.46	15.48	15.50	15.52	15.54	15.56

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Putrescibles	41.55	41.25	40.95	40.65	40.35	40.05	39.75	39.45	39.15
Textiles	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25
Wood	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Paper	20.80	21.00	21.20	21.40	21.60	21.80	22.00	22.20	22.40
Plastics	9.30	9.50	9.70	9.90	10.10	10.30	10.50	10.70	10.90
Metals	4.10	4.00	3.90	3.80	3.70	3.60	3.50	3.40	3.30
Glass	4.42	4.40	4.38	4.36	4.34	4.32	4.30	4.28	4.26
Rest	15.58	15.60	15.62	15.64	15.66	15.68	15.70	15.72	15.74

In order to meet the recommendation of 2010 centralized ERT review for improvement of transparency in relation to composition of municipal solid waste data generated in Greece, the following are presented:

- Estimates of the composition of MSW at a national level from a study of MEECC concerning the year 1997 (MEECC 1998).
- Studies that have been carried out in various regions of the country (e.g. Union of Local Authorities in the Prefecture of Attica 1996, MEECC 1999). In these studies, waste composition analysis was performed on a representative sample of typical garbage bins of various regions of Greece, in order to identify the fraction of each component (Putrescibles, Textiles, Wood, Paper, Plastics, Metals, Glass and Rest) on the total MSW quantity produced.
- Recently, an analysis by the Association of Communities and Municipalities in the Attica Region was performed in cooperation with National and Kapodistrian University of Athens in Attica region, following the same methodology.

Quantities and composition of MSW at disposal sites

In order to estimate the quantities of MSW that end up at disposal sites (managed or unmanaged), data on the recycling of paper, aluminium, metals, plastics and glass in different regions were

collected. Recycled quantities estimated, include also the part of putrescibles used for compost production. For 2009, the percentage of MSW recycled is estimated at 19 %, significantly higher than this of 2000, which was about 8%, due to the recycle projects that are promoted in Athens. It was assumed that after the subtraction of recycled materials, the remaining quantities of municipal solid waste end up to various disposal sites (managed or unmanaged).

The estimated composition of the disposed municipal solid wastes in the two categories of SWDS (managed and unmanaged) is presented in ***Table 8.10***.

According to the most recent data by the Ministry of Environment, Energy and Climate Change (MEECC) (10/2004), out of the various existing disposal sites, 71 fulfil the criteria set by the IPCC guidelines so as to be considered as managed. For each one of those sites, the start year of operation was taken into account, together with data and estimations on the quantities and composition of MSW generated in the areas served by those sites, as well as data on the quantities of recycled materials.

The remaining part of MSW (after the subtraction of the corresponding quantities of the recycled materials in the remaining regions) is disposed at unmanaged disposal sites (***Table 8.11***).

The amount of dry sewage sludge disposed in the managed site of Athens is also presented in ***Table 8.11***. The the degradable organic carbon and the fraction of DOC dissimilated are both estimated at 40%. The fraction of methane in the landfill gas released from sludge is 60%.

Table 8.10 Estimated composition (%) of MSW disposed for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Putrescibles	49.52	49.12	48.61	48.11	47.60	47.14	46.68	45.84	45.42	44.99	44.58
Textiles	3.59	3.58	3.57	3.56	3.54	3.53	3.52	3.55	3.54	3.53	3.52
Wood	1.10	1.10	1.10	1.09	1.09	1.09	1.08	1.09	1.09	1.09	1.08
Paper	11.56	11.89	12.47	12.97	13.46	13.89	14.31	14.87	15.29	15.71	16.09
Plastics	7.84	8.04	8.24	8.42	8.61	8.80	9.00	9.12	9.28	9.45	9.63
Metals	5.74	5.62	5.39	5.24	5.10	4.98	4.85	4.78	4.65	4.52	4.39
Glass	3.69	3.68	3.71	3.73	3.75	3.76	3.76	3.81	3.82	3.83	3.83
Rest	16.96	16.96	16.92	16.88	16.84	16.81	16.79	16.93	16.91	16.88	16.86
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Putrescibles	45.57	45.22	44.56	45.17	45.25	44.06	47.52	45.76	47.70		
Textiles	3.56	3.56	3.54	3.62	3.67	3.73	4.06	3.95	4.01		
Wood	0.86	0.86	0.86	0.88	0.90	0.91	1.00	0.98	1.00		
Paper	14.88	15.17	16.00	15.36	15.33	16.16	5.71	9.04	6.58		
Plastics	10.01	10.21	10.35	10.67	10.96	11.30	13.13	13.00	13.46		
Metals	4.25	4.12	3.97	3.77	3.57	3.45	4.36	4.12	4.06		
Glass	3.79	3.76	3.73	3.14	2.62	2.40	4.58	4.07	3.75		
Rest	17.09	17.10	17.00	17.40	17.70	17.99	19.63	19.09	19.44		

Table 8.11 Estimated quantities of MSW and sludge disposed (in kt) and Degradable Organic Carbon (DOC) per category (in kt)

Year	Managed SWDS	DOC – managed SWDS	Unmanaged SWDS	DOC – unmanaged SWDS	Sludge (dry)	DOC - sludge
1960			1764.55	272.93		
1965			1900.67	282.70		
1970			2073.38	306.04		
1975			2290.65	334.87		
1980			2522.02	363.87		
1985			2726.94	392.06		
1990	1160.08	160.31	1624.67	224.52	43.40	17.36
1991	1198.41	166.44	1630.78	226.49	43.40	17.36
1992	1246.11	174.92	1733.21	243.29	43.40	17.36
1993	1295.02	183.30	1820.73	257.71	43.40	17.36
1994	1406.12	200.64	1854.26	264.59	43.40	17.36
1995	1477.90	212.31	1911.78	274.64	51.62	20.65
1996	1544.44	223.33	1973.34	285.36	51.62	20.65
1997	1639.62	238.94	1983.06	288.99	61.00	24.40
1998	1799.82	264.08	896.79	131.58	59.32	23.73
1999	2005.12	296.17	1921.72	283.86	60.14	24.05
2000	2160.65	321.05	1909.25	283.69	66.34	26.53
2001	2336.78	338.13	1820.22	263.38	67.76	27.10
2002	2379.56	345.80	1853.55	269.36	77.65	31.06
2003	2423.82	357.68	1904.43	281.04	79.76	31.90
2004	2705.28	395.98	1592.98	233.17	83.37	33.35
2005	2824.04	413.96	1470.51	215.55	116.77	46.71
2006	2875.51	426.68	1419.55	210.64	123.20	49.28
2007	2805.07	318.00	1194.25	135.39	73.95	29.58
2008	3227.59	398.64	952.81	117.68	71.63	28.65
2009	4147.06	484.84	26.60	3.11	109.21	43.69

Methane generation rate constant

The methane generation rate constant *k* is related to the time taken for the degradable organic carbon in waste to decay to half its initial mass:

$$k = \ln 2 / t_{1/2}$$

where $t_{1/2}$ is the time taken for the DOC in waste to decay to half its initial mass("half life") of waste during degradation process.

The estimation of *k* is determined by the conditions in the disposal sites (e.g. moisture content, temperature, soil type) and by the composition of waste land filled. Considering the fact that climate in Greece is dry temperate (the ratio of mean annual precipitation to potential evaportranspiration (MAP/PET) is around 0.5), "half life" was estimated at 17 years for paper and textiles, 35 for wood, 12 years for food waste and 9 years for sewage sludge disposed on land.

Biogas flaring

According to data from the Ministry of Environment, Energy and Climate Change (MEECC), recovery and flaring of biogas constitute management practices in the 4 major managed SWDS of Greece (in the cities of Athens, Patra, Thessalonica and Larissa). For 3 of these sites (in Patra, Thessalonica and Larissa) the collection of data on the amount of biogas flared has not been possible yet. The estimation of biogas recovered in these sites was based on the assumption that for technical reasons, 60% of biogas released is finally recovered and flared.

Detailed measurements data have been collected only for the SWDS of Athens, in which almost 50% of total waste going to managed sites is disposed. In ***Table 8.12***, quantities of waste disposed in the 3 sites for which the CH_4 recovery is based on assumptions, the volume of biogas flared in the SWDS of Athens and methane that is totally recovered, are presented.

Table 8.12 CH_4 recovery from biogas flaring in managed SWDS

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Waste landfilled in the SWDS of Patra. Thessalonica and Larissa (kt)	241.0	247.0	260.7	274.4	288.2	365.8	382.7	401.8	421.9	497.0	520.4
Biogas flared in the SWDS of Athens (10^6 m^3)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.60	21.90	21.90
Total CH_4 recovery (kt)	0.00	0.00	1.72	2.31	2.90	3.66	4.42	5.20	7.29	14.77	15.74
Year	2001	2002	2003	2004	2005	2006	2007	2008	2008		
Waste landfilled in the SWDS of Patra. Thessalonica and Larissa (kt)	538.8	563.9	590.2	618.0	652.6	681.8	695.5	660.7	693.7		
Biogas flared in the SWDS of Athens (10^6 m^3)	21.00	30.00	30.00	42.05	56.90	53.42	67.61	76.83	83.45		
Total CH_4 recovery (kt)	16.36	20.54	21.54	26.85	33.21	33.04	38.78	42.75	45.75		

In the current submission the figures of biogas recovered appear lower than these of the previous submission for the period 1990-2008. This is the result of the improvement of the methodology for

estimation of biogas flared, from Tier 1 to Tier 2 (FOD), and of the revision of DOC_F value. The assumption that biogas flared in managed SWDS where there is not measurable data, is the 60% of biogas released, has been taken into account. Data for managed SWDS of Athens are the same with these presented in the previous submission, because it is measurable data.

For the estimation of methane recovered in the SWDS of Athens, the fraction of methane in landfill gas (*F*) was calculated at 0.5 and methane density at 0.7 kg CH_4/m^3, based on the data collected.

Only biogas recovered in SWDS of Athens is used to generate energy. The CH_4 emissions from this process are accounted in energy sector.

Other parameters

- Methane Correction Factor (*MCF*): 1 for managed SWDS, 0.8 for unmanaged SWDS. The figure for unmanaged SWDS has been revised in the current submission following the recommendations of 2010 centralized ERT review. Although the breaking down the unmanaged sites into the different IPCC categories is not easy, the high majority of them are characterized as '*deep*' thus the figure of 0.8 is selected as the most appropriate figure.
- Degradable organic carbon (*DOC*): 0.4 for paper and textiles (default value), 0.3 for wood (default value), 0.15 for food waste (default value) and 0.4 for sewage sludge.
- Fraction of DOC dissimilated (DOC_F) for solid waste. The default value of 0.6 was used after the recommendations of 2010 centralized ERT review for applying figure in the range suggested in the IPCC good practice guidance.
- Fraction of DOC dissimilated (DOC_F) for sewage sludge 0.4 was used. Since 2002 due to a number of issues raised concerning the transfer and disposal of sludge in the managed waste disposal site of Athens most of the sewage sludge remains in the wastewater treatment facility of Athens stored under aerobic conditions with negligible methane production. Therefore a lower than the default value was applied as DOC_f for sludge.
- Fraction of methane in landfill gas (*F*): 50% (default value) for solid waste, 0.6 for sewage sludge.
- Oxidation factor (*OX*): 0.1 for managed SWDS, 0.0 for unmanaged SWDS (default values).

8.2.3 Uncertainties and time-series consistency

The combined uncertainty of CH_4 emissions from unmanaged SWDS and managed SWDS as % of total emissions are estimated by 1.0% and 0.2%, respectively. The uncertainty associated with activity data is 20% according to Good Practice Guidance for poor quality data. On the other hand, the uncertainty associated with emission factors of CH_4 emissions from unmanaged SWDS and managed SWDS are 72 % and 40 %, respectively, as it is estimated according to Good Practice Guidance.

The combined uncertainty of CH_4 emissions from municipal sludge disposal on land as % of total emissions is estimated by 0.1%. The uncertainty associated with activity data is 20% according to Good Practice Guidance for poor quality data while the uncertainty associated with emission factors is 40 %.

The results of uncertainty analysis are presented in Table 1.9. The detailed calculations of uncertainty are presented in Annex IV (Tables IV.1 – IV.3).

The time-series consistency of emissions is controlled by applying consistent methodologies and verified activity data inline with IPCC guidelines. In case of changes or refinements in methodologies and EFs based on country-specific data, time-series consistency is ensured by performing recalculations according to the IPCC good practice guidance.

8.2.4 Source-specific QA/QC and verification

Source-specific quality control is carried out based on the principles of inventory Quality Assurance / Quality Control (QA/QC) plan (National Systems under Article 5 Paragraph 1 of the Protocol as described in Decision 20/CP.7). The special procedures are followed in the waste sector are:

1. Cross checking information regarding waste quantities, composition and sewage sludge by waste management sector of MEECC and by Association of Communities and Municipalities in the Attica Region (ACMAR).

2. Cross checking information provided by the waste management sector of Ministry of Environment, Energy and Climate Change (MEECC) and by the Ministry of Development, regarding the biogas recovered in MSW disposal sites which is used for energy generation.

3. Comparison of information regarding waste quantities, composition and sewage sludge with this for other countries.

4. Estimations were checked with several calculations tools with checking of emissions trends and sums deviations.

8.2.5 Recalculations

The estimated CH_4 emissions from solid waste disposal on land and CH_4 biogas flared have been recalculated for the period 1990-2008 due to the recommendations of 2010 centralized ERT. The figure of DOC_F has been revised as well as the figure of MCF for unmanaged SWDS. Moreover, updated data was used for the years 2007 and 2008 as far as the recycling waste quantities was concerned. Finally, the figures of biogas flared in managed SWDS where there is not measurable data have been recalculated due to use of Tier 2 (FOD) approach. The deviation of the emissions estimated in the current submission compared to the emissions estimated in the previous

submission and the impact on total emissions (excl LULUCF) of recalculations are presented in ***Table 8.13.***

Table 8.13 Recalculations of CH4 emissions from solid waste disposal on land (%)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Difference	3.328	2.777	9.446	8.673	8.017	9.496	8.745	8.310	7.954	9.830	9.058
Impact on total emissions (excl LULUCF)	0.057	0.050	0.159	0.153	0.142	0.168	0.156	0.147	0.138	0.164	0.153

Year	2001	2002	2003	2004	2005	2006	2007	2008
Difference	8.190	7.755	7.237	6.957	7.388	7.478	7.935	9.455
Impact on total emissions (excl LULUCF)	0.143	0.137	0.129	0.124	0.127	0.137	0.138	0.166

8.2.6 Planned improvements

Futher investigation regarding composition of disposed wastes is planed. The development of a central database which will include most of the above data has already been scheduled by the Ministry of Environment, Energy and Climate Change (MEECC) and is expected to provide valuable information in the near future. Furthermore, the National and Regional Planning for the Solid Waste Management is expected to provide data regarding the process of unmanaged sites rehabilitation and the construction of new managed sites.

8.3 Wastewater handling (CRF Source Category 6B)

8.3.1 Description

Domestic and industrial wastewater handling under anaerobic conditions produces CH_4. In Greece, domestic wastewater handling in aerobic treatment facilities shows a substantial increase since 1999, while in the industrial sector only a few units exist where wastewater is handled under anaerobic conditions. CH_4 emissions from wastewater handling in 2009 accounted for 0.68% of total GHG emissions and for 22.8% of GHG emissions from *Waste*.

N_2O emissions from industrial wastewater handling and from human consumption of food and their subsequent treatment through wastewater handling systems (indirect emissions) are also included in the wastewater handling source category. N_2O emissions from industrial wastewater have been estimated for first time in this submission. N_2O emissions from this source in 2009 account for 0.31% of total greenhouse gases emissions and 10.4% of greenhouse gases emissions from *Waste*.

Wastewater handling is a key category of CH_4 emissions, which have a substantial contribution in emissions trends (trend assessment). In ***Table 8.14*** CH_4 and N_2O emissions from wastewater handling for the period 1990 – 2009 are presented.

Table 8.14 CH_4 and N_2O emissions (in kt) from wastewater handling

Year		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Domestic and commercial wastewater	CH_4	102.98	101.47	99.33	95.26	94.09	92.16	90.06	86.44	82.77	78.18	60.53
Human sewage	N_2O	1.05	1.07	1.09	1.09	1.13	1.14	1.14	1.16	1.16	1.19	1.19
Industrial wastewater	CH_4	32.04	29.73	32.13	34.87	38.46	36.95	38.74	32.82	40.53	38.40	44.91
Industrial wastewater	N_2O	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Year		2001	2002	2003	2004	2005	2006	2007	2008	2009
Domestic and commercial wastewater	CH_4	34.71	29.49	24.13	18.39	15.00	12.69	11.13	10.89	10.40
Human sewage	N_2O	1.18	1.18	1.18	1.19	1.20	1.21	1.22	1.22	1.23
Industrial wastewater	CH_4	47.82	43.01	38.64	43.53	39.11	41.76	36.76	30.18	29.56
Industrial wastewater	N_2O	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

CH_4 emissions from domestic wastewater handling and industrial wastewater handling in 2009 decreased by 90% and 7.7%, respectively compared to 1990 levels. The reduction of emissions from domestic wastewater handling is mainly due to the increased number of wastewater handling facilities under aerobic conditions. According to estimates provided by the Ministry of Environment, Energy and Climate Change (MEECC) the penetration of such facilities increased from 32% (of total population served) in 1999 and to 90.8% in 2009. N_2O emissions from human consumption of food and their subsequent treatment through wastewater handling systems (indirect emissions) increased by 16.8% compared to 1990 levels. N_2O emissions from industrial wastewater handling increased by 7.1% compared to 1990 levels.

Considering the fact that there are not sufficient data regarding all the wastewater handling facilities of the country and as a result methane emissions are calculated based on the total population serve. Emissions from domestic wastewater treatment and the sewage sludge removed from wastewater are not considered separately. However, as it is already mentioned in Paragraph 8.2, methane emissions from sewage sludge disposed in managed sites have been estimated. Therefore, in order to avoid double counting of emissions from sludge treatment, the organic load (in biochemical oxygen demand) of sludge that is actually disposed on land was subtracted by the organic load of wastewater treated.

8.3.2 Methodology

CH_4 and N_2O emissions from wastewater handling were estimated according to the default methodologies suggested by IPCC. The possibility of the use of a higher tier method for the calculation of CH_4 emissions from wastewater handling was examined, focusing on the collection of the required activity data. However, this has not yet been realized due to lack of data regarding the treatment systems of domestic and industrial wastewater in Greece.

CH_4 emissions from domestic and commercial wastewater handling

Methane emissions from domestic and commercial wastewater handling are calculated using the following equations:

$$CH_4 \text{ emissions} = TOW \times EF - MR$$

$$TOW = P \times D_{dom}$$

$$EF = Bo \times MCFs$$

The parameters used are presented hereafter:

- **Total organic waste, *TOW***. The calculation of total organic waste is based on population data (*P*), as presented in ***Table 8.6***, and the degradable organic component D_{dom}, that is set equal to 0.05 kg BOD/person/day (suggested value for Europe).
- **Emission factor, *EF***. The emission factor is estimated considering the maximum methane production potential ***Bo*** and the weighted average of the methane conversion factors (***MCFs)***, for

the different wastewater treatment systems used in the country. The value of 0.6 kg CH_4/kg BOD was used for the domestic wastewater handling while the value of 0.25 kg CH_4/kg COD was used for the industrial wastewater handling, as suggested by the IPCC Good Practice Guidance. The MCF indicates the extent to which the methane producing potential (Bo) is realised in each type of treatment method. The default values for these factors are 0 for aerobic conditions and 1 for anaerobic conditions (and these values were applied in the calculations).

- **Methane recovery *MR*** is considered to be equal to zero.

In ***Table 8.15*** the degradable organic waste (as kt BOD) for the period 1990 – 2009, is presented.

The calculation of BOD from sludge removed and disposed on land (***Table 8.15***) is based on the amounts of sludge transferred in the managed SWDS of Athens (Table 8.11) and the following parameters:

- Volume of biogas per unit of dry matter: 200 m^3/ tn dry matter. The factor results from the data provided by EYDAP.
- Methane density: 0.7 kg CH_4/ m3
- Fraction of methane in sludge biogas (F): 0.6

Table 8.15 BOD (in kt) from domestic and commercial wastewater, sludge and total for the period 1990 – 2009

Year	Wastewater	Sludge	Total
1990	180.66	6.51	187.18
1991	182.19	6.51	188.70
1992	184.58	6.51	191.09
1993	186.34	6.51	192.85
1994	188.15	6.51	194.66
1995	189.04	6.98	196.02
1996	190.24	6.98	197.22
1997	190.41	8.24	198.66
1998	191.83	8.02	199.85
1999	192.75	8.13	200.88
2000	192.60	8.96	201.57
2001	192.85	9.16	202.01
2002	192.05	10.49	202.54
2003	192.34	10.78	203.12
2004	192.45	11.27	203.72
2005	188.90	15.78	204.68
2006	188.59	17.02	205.61
2007	188.57	18.10	206.67
2008	189.08	18.39	207.48

2009	187.77	20.47	208.24

Biochemical oxygen demand (BOD) for sludge is finally subtracted from total BOD and methane emissions are calculated based on the fraction of BOD that degrades anaerobically. The relevant data are included in the reports of the Ministry of Environment, Energy and Climate Change (MEECC) on the implementation of EU Directive 91/71 regarding the collection, treatment and disposal of municipal wastewater.

N_2O emissions from domestic wastewater handling

N_2O emissions from domestic wastewater handling are estimated as the indirect nitrous oxide emissions from human consumption of food and their subsequent treatment through wastewater handling systems are estimated by the following equation:

$$N_2O \text{ emissions} = \text{Protein} \times P \times \text{Frac}_{NPR} \times EF\ (N_2O\text{-}N/N)$$

Data on protein consumption (*Protein*) are provided by FAO. The population (*P*) used, is the one presented in Table 8.6, while the values of the parameters regarding the fraction of protein that is nitrogen ($Frac_{NPR}$) and the conversion of nitrogen to nitrous oxide [*EF* (N_2O-N/N)] are those suggested by the IPCC Guidelines.

In ***Table 8.16*** the consumption of protein (kg/person/year) for the period 1990 – 2009, is presented.

Table 8.16 Annual protein consumption (in kg/person) for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Protein (kg/capita)	40.66	41.10	41.43	40.95	42.19	42.27	41.87	42.49	42.30	43.11	42.71
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Protein (kg/capita)	42.30	42.23	42.23	42.23	42.71	42.71	42.71	42.71	42.71		

CH_4 emissions from industrial wastewater handling

The methodology for calculating methane emissions from industrial wastewater is similar to the one used for domestic wastewater. In order to estimate the total organic waste produced through anaerobic treatment, the following basic steps were followed:

- Collection of data (from the ELSTAT) regarding industrial production of approximately 25 industrial sectors / sub-sectors for the period 1990 – 2009.
- Calculation of wastewater generated, by using the default factors per industrial sector (m^3 of wastewater/t product) suggested by the IPCC Good Practice Guidance.
- Calculation of degradable organic fraction of waste, by using the default factors (kg COD/m^3 wastewater) suggested by the IPCC Good Practice Guidance for each sector / sub-sector.

↳ The distribution between aerobic and anaerobic treatment of industrial wastewater for each industrial sector was estimated on the basis of data derived from a project financed by the Ministry of Environment, Energy and Climate Change (MEECC) (2001b). The maximum methane production potential factors Bo and the methane conversion factors for aerobic and anaerobic treatment, which were used for the final estimation of methane emissions, are similar to those used for domestic wastewater handling.

In ***Table 8.17*** the degradable organic waste (as COD) for the period 1990 – 2009, is presented.

Table 8.17 Total COD (in kt) from industrial wastewater for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
COD (kt)	20.48	17.17	19.01	21.52	22.10	19.48	20.30	18.19	22.52	18.09	23.22
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
COD (kt)	24.64	22.36	19.85	21.66	19.33	21.44	16.72	13.37	12.75		

CH_4 emissions from sludge generated industrial wastewater handling

For the estimation of CH_4 emissions from sludge generated industrial wastewater handling is being used a methodology similar to the one used for the estimation of CH_4 emissions from industrial wastewater handling. Having estimated the degradable organic component from industrial wastewater handling treated anaerobically as described in the previous paragraph, the remaining part is considered as this treated aerobically. The fraction of it removed as sludge is estimated based either on published data for some major Greek companies (see Vlyssides et al., 2004; Vlyssides et al., 2006; Vlyssides et al., 2007; Vlyssides et al., 2008) or on assumptions for the industrial sectors that there are not sufficient data. In general, it is considered the aerobically systems is composed of a primary treatment of wastewater (mainly a primary clarifier) and a secondary treatment, which is consisted of an aeration tank and a final clarifier. The fraction of total degradable organic component removed through the primary clarifier is considered equal to 30% for the industrial sectors for which there are no available data while the other 35% is removed through the secondary clarifier.

The maximum methane production potential (Bo) is equal to 0.25 kg CH4/kg COD, as suggested by the IPCC Good Practice Guidance while the methane recovery is considered to be equal to zero.

The degradable organic waste of industrial sludge (as COD) for the whole time series period 1990 – 2008 is presented in ***Table 8.18***.

Table 8.18 TOW (in COD kt) removed as sludge from industrial wastewater handling for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
COD (kt)	107.67	101.73	109.49	117.97	131.75	128.31	134.65	113.08	139.61	135.51	156.42

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
COD (kt)	166.66	149.70	134.70	152.45	137.12	145.59	130.33	107.35	105.48

N_2O emissions from industrial wastewater handling

N_2O emissions from industrial wastewater have been estimated for the first time in the current submission on the basis of the emission factors equal to 0.25 g N_2O/m^3 of wastewater production (EMEP/CORINAIR, 2007). The waste water production is resulting from the model for the estimation of methane emissions from industrial waste water. The waste water production for the whole time series period 1990 – 2009 is presented in ***Table 8.19***.

Table 8.19 Waste water production from the industrial sector (1000000m^3) for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Waste water	40.54	39.30	41.93	42.69	47.11	43.97	47.24	40.33	48.89	43.13	49.63
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Waste water	52.45	49.30	47.25	49.54	48.06	51.91	48.69	41.63	43.41		

8.3.3 Uncertainties and time-series consistency

The combined uncertainty of CH_4 emissions of wastewater handling sector as % of total emissions is estimated by 0.7%. The uncertainty associated with activity data is 30% while the uncertainty associated with emission factor is 100% according to Good Practice Guidance.

The combined uncertainty of N_2O emissions of wastewater handling sector as % of total emissions is estimated by 0.03%. The uncertainty associated with activity data is 5% while the uncertainty associated with emission factor is 10% according to Good Practice Guidance.

The results of uncertainty analysis are presented in Table 1.9. The detailed calculations of uncertainty are presented in Annex IV (Tables IV.1 – IV.3).

The time-series consistency of emissions is controlled by applying consistent methodologies and verified activity data inline with IPCC guidelines. In case of changes or refinements in methodologies and EFs based on country-specific data, time-series consistency is ensured by performing recalculations according to the IPCC good practice guidance.

8.3.4 Recalculations

CH_4 emissions from domestic wastewater handling have been recalculated because of the availability of updated activity for the period 1990-2008. Moreover, CH_4 emissions from sludge generated industrial wastewater have been recalculated because of the availability of updated activity concerning the fraction of degradable organic component removed as sludge for some

industrial sectors for the period 1990-2008. Finally, N_2O emissions from industrial wastewater have been estimated for first time in the current submission. The deviation of the emissions estimated in the current submission compared to the emissions estimated in the previous submission and the impact on total emissions (excl LULUCF) of recalculations are presented in ***Table 8.20***.

Table 8.20 Recalculations of CH_4 and N_2O emissions from domestic and commercial wastewater handling (%)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
					CH_4						
Difference	-8.056	-7.684	-7.966	-7.888	-9.576	-9.191	-9.223	-8.570	-9.616	-10.212	-11.678
Impact on total emissions (excl LULUCF)	-0.238	-0.221	-0.227	-0.224	-0.275	-0.252	-0.245	-0.201	-0.225	-0.228	-0.232
					N_2O						
Difference	0.967	0.920	0.961	0.981	1.041	0.963	1.038	0.867	1.049	0.904	1.046
Impact on total emissions (excl LULUCF)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003

Year	2001	2002	2003	2004	2005	2006	2007	2008
				CH_4				
Difference	-13.366	-13.950	-14.845	-15.965	-16.941	-17.958	-19.029	-30.857
Impact on total emissions (excl LULUCF)	-0.210	-0.194	-0.176	-0.188	-0.173	-0.191	-0.177	-0.299
				N_2O				
Difference	1.114	1.046	1.000	1.045	0.998	1.073	1.001	0.991
Impact on total emissions (excl LULUCF)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003

8.3.5 Planned improvements

The treatment conditions of the industrial wastewater and the distribution of different wastewater treatment systems are examined in order to use a more detailed methodology on the estimation of the emissions from industrial wastewater.

8.4 Waste incineration (CRF Source Category 6C)

8.4.1 Description

Carbon dioxide, Methane and Nitrous oxide emissions from the incineration of clinical waste produced have been estimated. For the incineration of clinical waste, a central plant covers the total daily needs of hospitals in Athens. According to Waste management department of MEECC there there is no other plant for incineration of any other waste type in Greece.

8.4.2 Methodology

For the estimation of CO_2 emissions, the default method suggested by the IPCC Good Practice Guidance was used. CH_4 and N_2O emissions were estimated using default methodology and country specific emission factors.

Data related to the amount of clinical waste incinerated derive from the ACMAR, which is operating the incinerator. The relevant parameters and emission factor used are the ones suggested in the IPCC Good Practice Guidance. Carbon Dioxide emissions were calculated based on the following equation:

$$CO_2 \text{ emissions} = CW \times CCW \times FCF \times EF \times 44/12$$

where, *CW* is the amount of clinical waste, *CCW* is the fraction of carbon content in the waste (60%), *FCF* is the fraction of fossil carbon (40%) and *EF* is the burn out efficiency of combustion of the incinerator (95%).

Methane and Nitrous oxide emissions were calculated based on the following equation:

$$CH_4 \text{ emissions} = CW \times EF_{CH_4} \text{ and}$$

$$N_2O \text{ emissions} = CW \times EF_{N_2O}$$

while the emissions factors' values were 0.06 kg CH_4 / tn waste and 0.1 kg N_2O / tn waste for the CH_4 and for the N_2O, respectively.

In ***Table 8.21*** the amount of clinical waste incinerated and emissions released for the period 1990 – 2009 are presented.

8.4.3 Uncertainties and time-series consistency

The combined uncertainty of CO_2 emissions of waste incineration sector as % of total emissions is estimated by 0.003%. The combined uncertainty of CH_4 emissions of waste incineration sector as % of total emissions is estimated by 0.000004%. The combined uncertainty of N_2O emissions of waste incineration sector as % of total emissions is estimated by 0.001%.

The uncertainty associated with activity data is 5% while the uncertainty associated with emission factors for all gases is 100% according to Good Practice Guidance.

The results of uncertainty analysis are presented in Table 1.9. The detailed calculations of uncertainty are presented in Annex IV (Tables IV.1 – IV.3).

The time-series consistency of emissions is controlled by applying consistent methodologies and verified activity data inline with IPCC guidelines. In case of changes or refinements in methodologies and EFs based on country-specific data, time-series consistency is ensured by performing recalculations according to the IPCC good practice guidance.

Table 8.21 Clinical waste (in kt) and emissions (in tn) for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Clinical waste	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
CO_2	150	150	150	150	150	150	150	150	150	150	150
CH_4	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
N_2O	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Clinical waste	0.18	0.49	0.94	1.17	2.23	2.70	3.67	4.32	4.22		
CO_2	150	411	785	978	1865	2257	3065	3614	3529		
CH_4	0.011	0.030	0.056	0.070	0.134	0.162	0.220	0.259	0.253		
N_2O	0.018	0.049	0.094	0.117	0.223	0.270	0.367	0.432	0.422		

8.4.4 Recalculations

No recalculations were performed.

9. Recalculations and improvements

9.1 Explanations and justifications for recalculations

The recalculations made are driven by the results of the various review processes, QC checks and internal audits and the ERT reviews of the annual submissions of Greece by the nominated experts from the UNFCCC (mainly the recent centralized review held from 13 to 18 September 2010).

The reasons for recalculations made, can be classified as follows:

- ***Changes or refinements in methods***. A methodological change occurs when an inventory agency uses a different tier to estimate emissions from a source category (e.g. for key source categories) or when it moves from a tier described in the IPCC Guidelines to a national method. Methodological changes are often driven by the development of new and different data sets. A methodological refinement occurs when an inventory agency uses the same tier to estimate emissions but applies it using a different data source or a different level of aggregation.
- ***Inclusion of new sources***. A new source is defined as a source for which estimates (all or some gases) did not exist in previous inventories either due to lack of data or because it has just been identified.
- ***Allocation***. Changes in allocation of emissions to different sectors or sources/sub-sources.
- ***Correction of errors***. This case concerns errors during calculating emissions (e.g. transcript errors) or while filling in the required information in the CRF tables. Inconsistencies resolving is also included in this category.
- ***Updated activity data***.

9.1.1 Recalculations of GHG inventory

The justification of the recalculations made in the present submission as far as the preparation of GHG inventory is concerned has been presented in details in Chapters 3 – 8. ***Table 9.1*** provides an overview of the recalculations made with regards to the previous submission according to the classification presented above.

Table 9.1 Overview of recalculations on preparation of GHG inventory

IPCC source	Sink categories	Gas	Explanation	
1.AA.2.E	Food Processing, Beverages and Tobacco \ Solid Fuels	CO_2 / CH_4 / N_2O	AD	Updated AD.
1.AA.2.F	Other (please specify) \ Other non-specified \ Solid Fuels	CO_2 / CH_4 / N_2O	A	Alternative fuels (tires, etc) used in cement plants were reallocated to other fuels
1.AA.2.F	Other (please specify) \ Other non-specified \ Other Fuels	CO_2 / CH_4 / N_2O	A	Alternative fuels (tires, etc) used in cement plants were reallocated to other fuels
1.AA.3.A	Civil Aviation \ Liquid Fuels \ Aviation Gasoline	CO_2 / CH_4 / N_2O	AD	Updated AD
1.AA.3.A	Civil Aviation \ Liquid Fuels \ Jet Kerosene	CO_2 / CH_4 / N_2O	AD	updated AD
1.AA.3.B	Road Transportation \ Liquid Fuels \ Gasoline	CH_4 / N_2O	EF	Updated emission factor
1.AA.3.B	Road Transportation \ Liquid Fuels \ Diesel Oil	CH_4 / N_2O	EF	Updated emission factor
1.AA.3.B	Road Transportation \ Liquid Fuels \ LPG	CH_4 / N_2O	EF	Updated emission factor
1.AA.3.C	Railways \ Liquid Fuels	CO_2	AD	updated AD
1.AA.3.D	Navigation \ Liquid Fuels \ Other Liquid Fuels (please specify) \ Lubricants	CH_4 / N_2O	EF	Updated emission factor
1.AA.5.B	Mobile (please specify) \ Other non-specified \ Liquid Fuels	CO_2 / CH_4 / N_2O		Correction of Notation Key
1.B.2.B.3	Transmission	CO_2 / CH_4	AD	Updated AD
1.B.2.B.4	Distribution	CH_4	AD	Updated AD
1.B.2.C.1.2	Gas	CO_2 / CH_4	AD	Updated AD
1.C1.A	Aviation \ Jet Kerosene	CO_2 / CH_4 / N_2O	E	Error in CRF compilation
1.C1.B	Marine \ Residual Fuel Oil	CH_4	EF	Updated emission factor
1.C1.B	Marine \ Lubricants	CH_4 / N_2O		Estimated for first time
2.A.2	Lime production	CO2	E	Error in the working files (2006)
2.B.2	Nitric Acid Production	N_2O	E	Error in the plant's reporting (2008).
2.C.1.1	Steel	CH_4	AD	Finalized data for 2008 from Hellenic Statistical Authority.
2.C.3	Aluminium Production	CF4 / C2F6 / C2F6	M	The plant is using the anode effect performance methodology (Overvoltage method) for years 2005-2008. For time series consistency the same methodology has been used for the whole time series.
2.IIA.F.1.1	Domestic Refrigeration	HFC-134a / HFC-134a	AD	Updated data due to recently published sectoral survey
2.F.3	Fire Extinguishers	HFC-227ea	AD	Update of the working files
2.IIA.F.4.1	Metered Dose Inhalers	HFC-134a	AD	Updated data from the National Organization for Medicines.
2.F.5	Solvents	HFCs / PFCs	E	Since actual emissions are reported as NO, NA, this should be the case for potential emissions.
2.F.8	Electrical Equipment	SF6	E	Reported in the right way and not as an aggregated total in 2.F.8.

4.A	Enteric Fermentation \ Cattle \ Option A \ Dairy Cattle	CH_4	M / AD	Improvement of the calculation method (T2) Updated activity data
4.A	Enteric Fermentation \ Cattle \ Option A \ Non-Dairy Cattle	CH_4	M / AD	Improvement of the calculation method (T2) Updated activity data
4.A	Enteric Fermentation \ Sheep	CH_4	AD	Updated activity data for the population of milked sheep
4.A	Enteric Fermentation \ Poultry	CH_4	NS	Estimation based on the experience of the other Annex I parties
4.B	Manure Management \ Dairy Cattle	CH_4	M / AD	Improvement of the calculation method (T2), Updated activity data
4.B	Manure Management \ Non-Dairy Cattle	CH_4	M / AD	Improvement of the calculation method (T2), Updated activity data
4.B	Manure Management \ Sheep \	CH_4	M	Improvement of the calculation method (T2)
4.B	Manure Management \ Solid storage and dry lot	N_2O	EF	Use of adjustment factors on the estimation of N excretion rates for young animals (Non-Dairy Cattle) / Updated of Nex for cattle.
4.B	Manure Management \ Other AWMS	N_2O	EF	Use of adjustment factors on the estimation of N excretion rates for young animals (Non-Dairy Cattle) / Updated of Nex for cattle.
4.D.1.2	Animal Manure Applied to Soils	N_2O	EF	Use of adjustment factors on the estimation of N excretion rates for young animals (Sheep and Non-Dairy Cattle) and Updated activity data for the population of cattle
4.D.1.6	Other direct emissions (please specify) \ Other non-specified	N_2O	AD	Updated activity data for the sewage sludge used in Agriculture
4.D.2	Pasture, Range and Paddock Manure	N_2O	EF / AD	Use of adjustment factors on the estimation of N excretion rates for young animals (Sheep and Non-Dairy Cattle) and Updated activity data for the population of cattle
4.D.3.1	Atmospheric Deposition	N_2O	EF / AD	Use of adjustment factors on the estimation of N excretion rates for young animals (Sheep and Non-Dairy Cattle) and Updated activity data for the population of cattle and for the sewage sludge used in Agriculture
4.D.3.2	Nitrogen Leaching and Run-off	N_2O	EF / AD	Use of adjustment factors on the estimation of N excretion rates for young animals (Sheep and Non-Dairy Cattle) and Updated activity data for the population of cattle and for the sewage sludge used in Agriculture
5.A.1	Forest Land remaining Forest Land \ Carbon stock change	Carbon stock change in living biomass/Carbon/ Gains	M	Updated method
6.A.1	Managed Waste Disposal on Land	CH_4	AD / M	Updated activity data for the composition of MSW disposed / Modification of fraction of DOC dissimilated (DOC_F) for solid waste.
6.A.1	Managed Waste Disposal on Land / Recovery/CH4	CH_4	M	Use FOD methodology on the estimation of flared biogas. Revision of DOC_F.
6.A.2	Unmanaged Waste Disposal Sites	CH_4	AD / M	Updated activity data for the composition of MSW disposed / Modification of methane correction factor and fraction of DOC dissimilated (DOC_F) for solid waste.

6.A.3	Other (please specify) \ Municipal Sludge Disposal on Land	CH_4	AD / M	Updated activity data for the amount of sewage sludge / Modification of fraction of DOC dissimilated (DOCF) for sewage sludge.
6.B.1	Industrial Wastewater \ Wastewater	CH_4	AD	Updated activity data
6.B.1	Industrial Wastewater \ Wastewater and Sludge	N_2O	NS	CS method was used
6.B.1	Industrial Wastewater \ Sludge	CH_4	AD	Updated data for the fractions of industrial degradable organic component removed as sludge
6.B.2.1	Domestic and Commercial (w/o human sewage) \ Wastewater	CH_4	AD	Updated activity data for the amount of sewage sludge
6.B.2.2	Human sewage	N_2O	AD	Updated activity data for the population of Greece

E: Correction of errors. M: Change or refinement of methodology. NS: new sources. A: allocation to different sectors, AD: Update of Activity Data

9.1.2 KP-LULUCF inventory

No recalculations were performed.

9.2 Implications for emissions levels

9.2.1 GHG inventory

The difference of emissions estimates in the present inventory, compared to the previous one, per gas (carbon dioxide, methane, nitrous oxide and F-gases respectively) is presented in ***Tables 9.2 – 9.6.***

Table 9.2a Recalculation of CO_2 emissions (differences compared to previous submission, in kt)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy								0.07		1.50	1.50
Fuel Combustion Activities								0.07		1.50	1.50
Energy Industries											
Man. Ind. and Con.								0.07			
Transport										1.50	1.50
Fug. Emis. from Fuels											
Oil and Natural Gas											
Industrial processes											
Mineral Products											
LULUCF	-18.95	-18.95	-18.95	-18.95	-18.95	-18.86	124.76	124.76	124.76	207.43	197.90
Forest Land	-18.95	-18.95	-18.95	-18.95	-18.95	-18.86	124.76	124.76	124.76	207.43	197.90
TOTAL	-18.95	-18.95	-18.95	-18.95	-18.95	-18.86	124.76	124.83	124.76	208.93	199.39

Table 9.2a Recalculation of CO_2 emissions (differences compared to previous submission, in kt)

Year	2001	2002	2003	2004	2005	2006	2007	2008
Energy	1.50	1.50	1.50	1.50	1.50	473.13	0.48	44.49
Fuel Combustion Activities	1.50	1.50	1.50	1.50	1.50	473.13	0.47	44.48
Energy Industries						471.63		
Man. Ind. and Con.								8.64
Transport	1.50	1.50	1.50	1.50	1.50	1.50	0.47	35.84
Fug. Emis. from Fuels						0.00	0.00	0.01
Oil and Natural Gas						0.00	0.00	0.01
Industrial processes						-0.15		
Mineral Products						-0.15		
LULUCF	101.89	98.34	91.05	92.28	97.47	93.74	93.29	96.91
Forest Land	101.89	98.34	91.05	92.28	97.47	93.74	93.29	96.91
TOTAL	103.38	99.83	92.54	93.77	98.97	566.72	93.76	141.40

Table 9.3a Recalculation of CH_4 emissions (differences compared to previous submission. in kt CO_2 eq)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy	-19.56	-25.45	-34.46	-38.03	-41.49	-46.29	-54.26	-55.90	-59.02	-58.05	-54.92
Fuel Combustion Activities	-19.56	-25.45	-34.46	-38.03	-41.49	-46.29	-54.26	-55.90	-59.02	-58.05	-54.92
Energy Industries											
Man. Ind. and Con.								0.01			
Transport	-19.56	-25.45	-34.46	-38.03	-41.49	-46.29	-54.26	-55.90	-59.02	-58.05	-54.92
Fug. Emis. from Fuels											
Oil and Natural Gas											
Industrial processes											
Metal Production											
Agriculture	209.55	223.71	211.71	165.26	156.40	154.03	179.09	174.98	183.44	166.61	132.35
Enteric Fermentation	368.85	376.95	360.33	313.19	304.22	302.20	326.08	322.54	332.72	319.23	288.63
Manure Management	-159.30	-153.24	-148.62	-147.93	-147.82	-148.17	-146.99	-147.56	-149.28	-152.61	-156.28
Waste	-188.56	-177.58	-71.33	-74.71	-142.33	-91.02	-99.62	-62.38	-106.44	-77.53	-99.73
Solid Waste Disposal on Land	59.86	51.73	167.63	159.29	152.45	183.40	175.19	172.37	169.05	200.91	193.03
Waste-water Handling	-248.42	-229.31	-238.95	-234.00	-294.78	-274.42	-274.81	-234.75	-275.49	-278.44	-292.75
TOTAL	1.43	20.68	105.92	52.53	-27.42	16.73	25.21	56.70	17.97	31.03	-22.30

Table 9.3b Recalculation of CH_4 emissions (differences compared to previous submission. in kt CO_2 eq)

Year	2001	2002	2003	2004	2005	2006	2007	2008
Energy	-43.88	-34.41	-28.38	-15.07	-8.61	0.04	-6.22	0.05
Fuel Combustion Activities	-43.88	-34.41	-28.38	-12.73	-3.92	-0.96	-8.07	-11.54
Energy Industries						0.18		
Man. Ind. and Con.					0.09	0.17		0.00
Transport	-43.88	-34.41	-28.38	-12.73	-4.01	-1.31	-8.07	-11.54
Fug. Emis. from Fuels				-2.35	-4.69	1.00	1.85	11.59
Oil and Natural Gas				-2.35	-4.69	1.00	1.85	11.59
Industrial processes								0.06
Metal Production								0.06
Agriculture	109.31	133.79	171.00	207.13	226.50	208.16	193.92	185.26
Enteric Fermentation	268.20	292.68	327.87	361.46	379.76	363.61	350.64	341.18
Manure Management	-158.89	-158.89	-156.87	-154.32	-153.27	-155.44	-156.72	-155.92
Waste	-85.20	-72.32	-60.67	-84.38	-61.07	-70.53	-52.47	-171.52
Solid Waste Disposal on Land	182.21	174.51	169.10	162.62	170.70	179.74	183.88	213.40
Waste-water Handling	-267.41	-246.83	-229.77	-247.00	-231.77	-250.27	-236.35	-384.92
TOTAL	-19.78	27.06	81.94	107.68	156.81	137.67	135.23	13.84

Table 9.4a Recalculation of N_2O emissions (differences compared to previous submission, in kt CO_2 eq)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy	-0.45	1.51	21.26	49.31	76.92	83.22	72.92	75.46	71.44	78.96	-64.91
Fuel Combustion Activities	-0.45	1.51	21.26	49.31	76.92	83.22	72.92	75.46	71.44	78.96	-64.91
Energy Industries											
Manufacturing Industries and Construction								0.05			
Transport	-0.45	1.51	21.26	49.31	76.92	83.22	72.92	75.41	71.44	78.96	-64.91
Other Sectors								0.00		0.00	
Industrial processes											
Chemical Industry											
Agriculture	-74.98	-67.55	-70.57	-117.87	-132.78	-145.81	-124.40	-128.75	-130.71	-145.74	-164.71
Manure Management	40.32	42.90	43.10	23.77	18.51	12.16	21.31	18.75	16.18	10.85	4.74
Agricultural Soils	-115.29	-110.46	-113.67	-141.64	-151.29	-157.97	-145.71	-147.50	-146.90	-156.60	-169.44
Waste	3.14	3.05	3.25	3.31	3.65	3.41	3.66	3.13	3.79	3.34	3.85
Waste-water Handling	3.14	3.05	3.25	3.31	3.65	3.41	3.66	3.13	3.79	3.34	3.85
TOTAL	-72.29	-63.00	-46.06	-65.25	-52.21	-59.18	-47.82	-50.16	-55.48	-63.44	-225.77

Table 9.4b Recalculation of N_2O emissions (differences compared to previous submission, in kt CO_2 eq)

Year	2001	2002	2003	2004	2005	2006	2007	2008
Energy	-97.04	-66.16	-44.38	-6.47	-1.01	26.16	30.66	47.91
Fuel Combustion Activities	-97.04	-66.16	-44.38	-6.47	-1.01	26.16	30.66	47.91
Energy Industries						0.27		
Manufacturing Industries and Construction					0.05	0.39		0.04
Transport	-97.04	-66.16	-44.38	-6.47	-1.06	25.51	30.66	47.87
Other Sectors								
Industrial processes								54.88
Chemical Industry								54.88
Agriculture	-180.31	-168.15	-142.68	-123.97	-113.17	-117.24	-124.58	-128.79
Manure Management	-0.91	1.13	8.56	15.28	19.13	18.14	14.67	13.61
Agricultural Soils	-179.39	-169.28	-151.25	-139.24	-132.31	-135.38	-139.25	-142.41
Waste	4.06	3.82	3.66	3.84	3.73	4.02	3.77	3.74
Waste-water Handling	4.06	3.82	3.66	3.84	3.73	4.02	3.77	3.74
TOTAL	-273.28	-230.49	-183.40	-126.59	-110.46	-87.05	-90.15	-22.26

Table 9.5 Recalculation of F-gases emissions (differences compared to previous submission, in kt CO_2 eq)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
HFC											
PFC	5.76	6.71	6.06	3.97	2.44	2.81	1.87	4.31	4.78	3.77	3.32
TOTAL	5.76	6.71	6.06	3.97	2.44	2.81	1.87	4.31	4.78	3.77	3.32
Year	2001	2002	2003	2004	2005	2006	2007	2008			
HFC			0.17	0.15	-0.17	-3.62	-11.87	-7.88			
PFC	2.04	2.33	2.71	1.84	1.74	-8.73	1.53	1.91			
TOTAL	2.04	2.33	2.88	1.99	1.58	-12.35	-10.34	-5.97			

In ***Table 9.6*** the effect of the recalculations made on the total GHG emissions in Greece excluding LULUCF on a per gas basis is presented.

Table 9.6 Comparison of the 2010 inventory with the present inventory (in Mt CO_2 eq)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO_2 emissions											
2010 submission	80.77	80.40	81.80	80.80	83.45	83.58	85.97	90.75	95.35	94.51	100.06
2011 submission	80.75	80.38	81.78	80.78	83.43	83.56	86.09	90.88	95.47	94.72	100.26
Change (%)	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	0.15	0.14	0.13	0.22	0.20
CH_4 emissions											
2010 submission	9.79	9.73	9.74	9.76	9.99	9.96	10.15	9.98	10.26	10.01	10.05
2011 submission	9.79	9.75	9.84	9.82	9.97	9.98	10.17	10.04	10.28	10.04	10.03
Change (%)	0.01	0.21	1.09	0.54	-0.27	0.17	0.25	0.57	0.18	0.31	-0.22
N_2O emissions											
2010 submission	10.20	9.88	9.72	8.86	8.67	8.96	9.19	8.98	8.88	8.81	8.67
2011 submission	10.13	9.82	9.67	8.79	8.62	8.90	9.15	8.93	8.82	8.75	8.44
Change (%)	-0.71	-0.64	-0.47	-0.74	-0.60	-0.66	-0.52	-0.56	-0.62	-0.72	-2.60
F-gases emissions											
2010 submission	1.20	1.37	1.16	1.76	2.24	3.35	3.85	4.21	4.74	5.48	4.43
2011 submission	1.20	1.37	1.17	1.77	2.24	3.35	3.85	4.21	4.74	5.48	4.43
Change (%)	0.48	0.49	0.52	0.23	0.11	0.08	0.05	0.10	0.10	0.07	0.07
Total emissions											
2010 submission	104.43	103.95	105.26	104.38	107.18	109.02	112.07	116.88	122.46	122.34	126.25
2011 submission	104.37	103.91	105.33	104.37	107.11	108.98	112.05	116.89	122.43	122.31	126.00
Change (%)	-0.06	-0.03	0.06	-0.01	-0.07	-0.04	-0.02	0.01	-0.03	-0.02	-0.19

Year	2001	2002	2003	2004	2005	2006	2007	2008
CO_2 emissions								
2010 submission	102.33	101.88	106.34	106.45	110.21	108.19	111.24	106.87
2011 submission	102.43	101.98	106.43	106.54	110.31	108.76	111.34	107.01
Change (%)	0.10	0.10	0.09	0.09	0.09	0.52	0.08	0.13
CH_4 emissions								
2010 submission	9.63	9.48	9.26	9.28	9.02	9.05	9.02	8.80
2011 submission	9.61	9.50	9.35	9.38	9.18	9.19	9.15	8.82
Change (%)	-0.21	0.29	0.88	1.16	1.74	1.52	1.50	0.16
N_2O emissions								
2010 submission	8.50	8.38	8.26	8.21	7.89	7.64	7.89	7.10
2011 submission	8.23	8.15	8.08	8.09	7.78	7.55	7.80	7.08
Change (%)	-3.22	-2.75	-2.22	-1.54	-1.40	-1.14	-1.14	-0.31
F-gases emissions								
2010 submission	4.07	4.30	4.12	4.30	4.04	2.12	2.18	2.57
2011 submission	4.08	4.31	4.12	4.30	4.04	2.10	2.17	2.57
Change (%)	0.05	0.05	0.07	0.05	0.04	-0.58	-0.47	-0.23
Total emissions								
2010 submission	127.73	127.36	130.97	131.40	134.31	130.23	133.36	128.52
2011 submission	127.44	127.16	130.88	131.38	134.36	130.75	133.39	128.55
Change (%)	-0.23	-0.16	-0.07	-0.01	0.04	0.39	0.03	0.02

9.2.2 KP-LULUCF inventory

No recalculations were performed.

9.3 Implications for emissions trends

9.3.1 GHG inventory

Total GHG emissions of years 1990-2008 (without LULUCF) in the current submission are at similar level to the emissions reported in the 2010 submission. The emission trends in Greece for the period 1990 – 2008 (without LULUCF) according to the inventories submitted in 2010 & 2011 are shown in ***Figure 9.1***. The most significant deviation takes place for the emissions of 2006 due to an error that it was identified through the comparison of Sectoral .vs. Reference approach (its impact on total emissions was less than 0.4%). Emission trends have not been affected significantly by the recalculations because in most cases the recalculations concerned the whole period.

The average annual rate of emissions increase for the period 1990 – 2008 in the present inventory is calculated to be similar compared to the one that had been calculated in the previous inventory (1.282% and 1.287%, respectively).

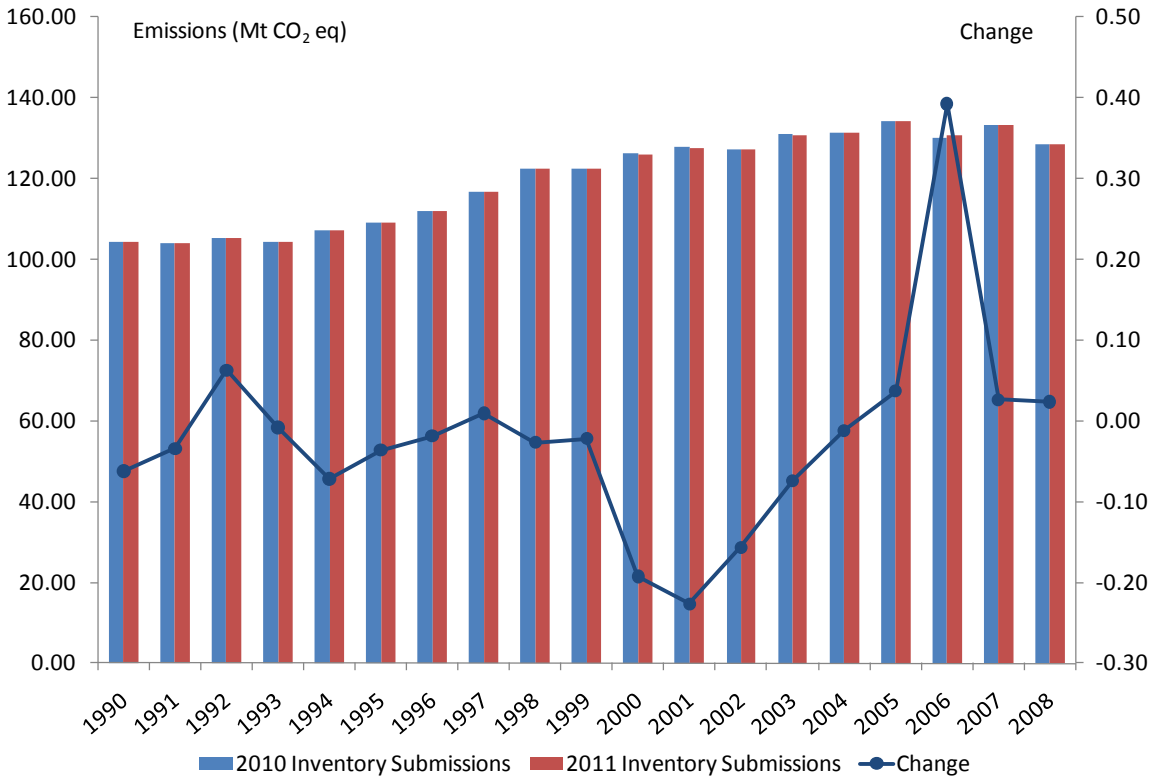


Figure 9.1 ***GHG emissions trends in Greece for the period 1990 – 2008 (without LULUCF) according to the inventories submitted in 2010 &2011***

9.3.2 KP-LULUCF inventory

No recalculations were performed.

9.4 Recalculations, including in response to the review process, and planned improvements

9.4.1 GHG inventory

An inventory improvement procedure is in place, which utilizes:

a) the recommendations from ERT reports,

b) the findings of independent audits carried out by local experts at the end of each year,

c) the findings of annual internal audits taken place by MEECC personnel between September and November of each year,

d) the output of key category analysis, uncertainty analysis and QA/QC procedures,

as a basis to prioritize, plan and materialize future improvements and recalculations. As mentioned above, details on the resulted recalculations and improvements planned per source/sink category have been presented in the respective chapters (Chapters 3 – 8), along with Table 9.1.

The emissions from categories that were reported as NE in the previous submission and for which methods exist in the Revised 1996 IPCC guidelines and/or the IPCC good practice guidance have been calculated and reported in this submission for the whole time-series 1990-2009. Additionally, the improvement of the completeness of the GHG emissions inventory is being further investigated through the inclusion in the next submissions of emissions of categories where IPCC methods and emission factors do not exist.

Finally, it should be mentioned that the results and the proposals that will arise from the review of the present inventory, within the technical review process defined in relevant decisions of the Conference of the Parties, will be integrated in the plan for the improvement of the GHG emissions inventory.

In ***Table 9.7*** information regarding major changes in methodological descriptions performed in current NIR compared to previous year NIR is provided. Finally, in ***Table 9.8*** an overview of the responses to the outcomes of the 2010 review of Greek GHG inventory is presented. Since at the time of the writing of this report the 2010 ERT review report was not finalized (draft), the numbering of the ERT suggestions and the text may change. For the same reason the recommendations concerning LULUCF were not included in the table.

Table 9.7 Documentation of major changes in methodological descriptions compared to previous year NIR

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please tick where the latest NIR includes major changes in methododological descriptions compared to the previous year NIR	Please tick where this is also reflected in recalculations compared to the previous year CRF	If ticked please provide some more detailed information for example related to sub-category, gas, reference to pages in the NIR, etc
Total (Net Emissions)			
1. Energy			
A. Fuel Combustion (Sectoral Approach)			
1. Energy Industries			
2. Manufacturing Industries and Construction			
3. Transport	√	√	A recalculation of the whole timeseries of road transport was carried out with more accurate and up-to-date input data and with the same methodological approach (COPERT IV). The whole emissions database is now coherent and credible in terms of input data used and calculation method applied
4. Other Sectors			
5. Other			
B. Fugitive Emissions from Fuels			
1. Solid Fuels			
2. Oil and Natural Gas			
2. Industrial Processes			
A. Mineral Products			
B. Chemical Industry			
C. Metal Production	√	√	The plant is using the anode effect performance methodology (Overvoltage method) for years 2005-2008. For time series consistency the same methodology has been used for the whole time series.
D. Other Production			
E. Production of Halocarbons and SF6			
F. Consumption of Halocarbons and SF6			
G. Other			
3. Solvent and Other Product Use			
4. Agriculture			
A. Enteric Fermentation	√	√	Improvement of calculation method (T2) for Dairy Cattle and other Cattle
B. Manure Management	√	√	Improvement of calculation method (T2) for Dairy Cattle, other Cattle and sheep Modification N excretion rates for Cattle and Buffalo
C. Rice Cultivation			
D. Agricultural Soils	√	√	Modification N excretion rates for Cattle, Buffalo and sheep
E. Prescribed Burning of Savannas			
F. Field Burning of Agricultural Residues			
G. Other			
5. Land Use, Land-Use Change and Forestry			
A. Forest Land			
B. Cropland			
C. Grassland			
D. Wetlands			
E. Settlements			
F. Other Land			
G. Other			
6. Waste			
A. Solid Waste Disposal on Land	√	√	Replacement of DOC_F parameter for managed and unmanaged SWDS Use FOD method for the estimation of Biogas flared in managed SWDS which there is not measurable data Replacement of MCF parameter for unmanaged SWDS
B. Waste-water Handling	√	√	Estimation of CH_4 emissions for sludge removed by industrial wastewater Estimation of N_2O emissions for industrial wastewater
C. Waste Incineration			
D. Other			
7. Other (as specified in Summary 1.A)			
Memo Items:			
International Bunkers			
Aviation			
Marine			
Multilateral Operations			
CO2 Emissions from Biomass			

9.4.2 KP-LULUCF inventory

No recalculations were performed.

Table 9.8 Reporting on the outcomes of the 2010 review of Greek GHG inventory

Category	Review	Response by Greece
General (Completeness)	10. The ERT encourages Greece to report, in its next annual submission, estimates for categories not yet addressed, in order to further improve the completeness and accuracy of its inventory.	Greece has provided estimates in categories for which the IPCC Revised 1996 Guidelines and the IPCC GPG include estimation Methodologies, namely direct and indirect N2O emissions from the application of sludge to agricultural soils, PFC emissions from fire extinguishers, HFC and PFC emissions from solvents, CO2 emissions from limestone and dolomite use for magnesia production, or CH4 emissions from industrial wastewater (sludge). These estimates where provided in a resubmission of 2010 files in September 2010 and are also being included in the current submission. Additionally, the improvement of the completeness of the GHG emissions inventory is being further investigated through the inclusion in the next submissions of emissions of categories where IPCC methods and emission factors do not exist (paragraph 10.4.1 of NIR).
General (Key Categories)	14. The ERT encourages Greece to use a finer disaggregation of categories in its next annual submission and also to consider using a qualitative approach to identifying key categories so as to address those categories that have very high uncertainties (e.g. solvent and other product use).	The disaggregation of the categories has been performed. See also Annex I of current NIR.
Energy	32. The inventory for the sector is generally complete. CO2, CH4 and N2O emissions from geothermal energy production and CH4 and N2O emissions from lubricants in marine bunkers, for which there are no default IPCC methodologies, are reported as not estimated ("NE"). Greece documented the not-estimated categories in CRF table 9, but only geothermal energy production is documented in the NIR. The ERT noted that other mobile combustion was reported as NO although, in accordance with the Revised 1996 IPCC Guidelines, military fuel use should be reported under this category. In response to a question raised by the ERT, Greece stated that, for confidentiality reasons, military fuel use is not reported separately but included under the relevant categories in the energy sector. The ERT recommends that Greece report other mobile combustion as included elsewhere, providing the relevant explanation, in its next annual submission.	Done
Energy	33. Greece uses IPCC methodologies to estimate emissions from stationary combustion and the COPERT IV model to estimate CH4 and N2O emissions from road transportation. The EFs used are a mixture of default, country-specific and plant-specific EFs for stationary combustion and core inventory of air emissions (CORINAIR) EFs for road transportation. The ERT noted that Greece uses mainly EU ETS data for plant-specific energy consumption, EFs and net calorific values (NCVs) for stationary combustion in the energy industries and manufacturing industries and construction categories. The ERT further noted that corrections were made to AD provided in the national energy balance for many categories in the energy sector because of the use of EU ETS data, plant-specific data, and assumptions for the correlation of data from different information sources (e.g. the AD on landing and take-off (LTOs) and civil aviation fuel used, and on consumption of lubricants for road transportation). The present ERT agrees with the conclusion of the previous ERT that the Party has not provided sufficient information in its NIR to confirm whether the EU ETS data have been prepared and incorporated in the inventory submission in line with the IPCC good practice guidance. The ERT recommends that Greece provide detailed information (e.g. in an annex to the NIR) on the EU ETS data used, including analysis of completeness and consistency with the IPCC methodology, and on the verification procedure applied to ensure conservation of the fuel mass balance and completeness of the data, and report on the progress made with regard to this issue in its next NIR.	2011 NIR section 3.2.4.7.

Category	Review	Response by Greece
Energy	34. The reporting on the energy sector is generally transparent and Greece provides detailed information on the methodologies used, descriptions of assumptions, the rationale for recalculations and details of planned improvements in the sector. However, the ERT noted that the Party could further enhance transparency by providing in the NIR more background documentation on country-specific and plant-specific EFs (e.g. the CO2 EFs for lignite and natural gas), AD (e.g. on aviation gasoline used for civil aviation) and disaggregated AD (e.g. vehicle population by class and rate of fuel consumption, lignite used in energy industries and manufacturing industries, and the mixture of solid fuels used in energy industries and chemical production) and the ERT recommends that Greece do so in its next NIR. The ERT commends Greece for its efforts to follow the recommendation of the previous ERT with regard to ensuring time-series consistency when using EU ETS data in the energy sector, and recommends that the Party include the relevant detailedinformation provided during the review in its next NIR, in order to improve transparency.	2011 NIR section 3.2.4.2, 3.2.5.2, figures 3.7 – 3.10
Energy	36. For 2008, the estimates of apparent consumption and CO2 emissions derived from the reference approach were 1.0 per cent lower and 0.2 per cent higher, respectively, than those derived from the sectoral approach. Greece attributes this to statistical differences in fuel consumption, losses and the use of different EFs for the two approaches. The ERT noted that the difference between the estimates derived from the two approaches, especially for gaseous fuels, could also be caused by the incorrect consideration of gas works gas as a secondary gaseous fuel, which is reported in the sectoral approach but not in the reference approach. The ERT recommends that Greece allocate gas work gas to the secondary solid fuels in its next annual submission.	Done, 2011 NIR section 3.2.1
Energy	37. Apparent consumption in the reference approach corresponds closely to the data provided to the International Energy Agency (IEA). However, the ERT found discrepancies with the IEA data, especially with regard to the stock change for liquid and gaseous fuels. This may have been caused by the incorrect consideration of non-energy use of fuels in the reference approach. The ERT noted that, according to the Revised 1996 IPCC Guidelines, in the reference approach the amount of fuel reallocated to the industrial processes sector should be indicated in CRF table 1.A(d) and not extracted from the stock change, as was done by Greece. The ERT recommends that Greece follow the IPCC approach for its next annual submission.	Done, 2011 NIR section 3.2.1
Energy	38. During the review, the ERT noted that the consumption of fuel for international aviation reported in the CRF tables is systematically higher than the IEA data. The ERT also noted that jet kerosene used for international aviation has not been reported in CRF table 1.A(b) for the period 2006–2008 and that for the other years of the time series the data in CRF tables 1.A(b) and 1.C do not correlate. In response to a question raised by the ERT on this matter, Greece stated that "total inland consumption" from the energy balance includes both domestic and bunker fuels and that this amount is further disaggregated on the basis of the LTOs data. However, to ensure consistency with the national energy balance, the fuel used for international aviation has not been reported in the reference approach. This is not in line with the Revised 1996 IPCC Guidelines. The ERT recommends that Greece cross-check data on jet kerosene, correct them in CRF tables 1.A(b) and 1.C and ensure time-series consistency in its next annual submission.	Done, 2011 NIR section 3.2.1
Energy	39. Greece reports CH4 and N2O emissions from lubricants from marine bunkers as "NE", owing to a lack of appropriate EFs. However, since the Party reports emissions of these gases from lubricants used for national navigation, the ERT recommends that Greece provide estimates for the non-estimated gases using the EFs for navigation in its next annual submission.	Done

Category	Review	Response by Greece
Energy	40. Following the recommendation of the previous ERT, Greece allocated a part of natural gas, petroleum coke and solid fuels used as a feedstock in manufacturing industries to the industrial process sector. However, the ERT identified a discrepancy in the figures for natural gas consumption reported for ammonia production in the NIR and in CRF table 1.A(d). In response, Greece explained that table 3.9 of the NIR and CRF table 1.A(d) include only the quantities of the fuels used as feedstock and allocated to the energy sector and do not include the amounts of the fuels used as feedstock and allocated to the industrial processes sector. This is not in line with the Revised 1996 IPCC Guidelines. The ERT recommends that Greece report properly in CRF tables 1.A(b) and 1.A(d) all feedstocks and non-energy use of fuels (as identified in the national energy balance), the associated CO2 emissions and the category/sector under which they are allocated in the inventory.	Done
Energy	41. The ERT found that a part of the natural gas used as feedstock (non-energy use) is still accounted for in the energy sector under chemical industry, and that this leads to large inter-annual variation and low implied emission factors (IEFs) for CO2, CH4 and N2O emissions from gaseous fuels. A similar problem was identified by the ERT in relation to the lubricants included in liquid fuels for iron and steel which are used for non-energy purposes. During the review, Greece recalculated and resubmitted all emission estimates related to the non-energy use of natural gas, reallocating natural gas used as feedstock to ammonia production (industrial processes sector) and leaving only the energy use of natural gas in the subcategory chemical industry (energy sector). Greece also used revised AD to estimate emissions from the non-energy use of natural gas in hydrogen production and reported these emissions under petroleum refining. The ERT noted that there are still inconsistencies between the amount of natural gas used as feedstock for ammonia production and/or for hydrogen production in refineries and the updated data on natural gas reported in CRF table 1.A(d), and recommends that Greece check the consistency of these figures and correct them as necessary.	Done
Energy	42. The ERT noted that the NCVs and carbon EFs for lignite are significantly different for energy industries and for manufacturing industries and construction. In response to a question raised by the ERT during the review, Greece provided detailed information explaining and justifying this difference, including that the lignite is distributed from different mining fields. The ERT recommends that Greece include this information in its next NIR.	Done, 2011 NIR section 3.2.4.2.
Energy	43. The ERT noted that the estimates of emissions of CO2, CH4 and N2O from combustion of gaseous and liquid fuels in petroleum refining were recalculated for the years 2005–2007, on the basis of the plant-specific data of refineries on the amounts of natural gas and naphtha used for hydrogen production. However, it was only during the review that Greece provided detailed explanations of the recalculations made for the entire time series and the assumptions made. The ERT recommends that Greece report relevant information, including on recalculations of AD and EFs for the entire time series, as provided to the ERT during the review in its next annual submission.	Done, 2011 NIR section 3.2.4.2.
Energy	44. The ERT found significant changes in the EFs for domestic and imported natural gas presented in the Party's 2010 NIR compared with those reported in the previous NIR. In response to a question raised by the ERT, Greece indicated that the CO2 EF for natural gas was calculated for each year of the time series using country-specific data on the chemical composition of natural gas, and that for public electricity and heat production for the years 2005–2008 the EFs were based on plant-specific data (from the EU ETS reports). The ERT commends Greece's efforts to use country-specific and plant-specific EFs for key categories, and recommends that the Party include information on the data on chemical composition used to calculate the CO2 EFs for natural gas and the background data used for the calculation of plant-specific EFs in its next annual submission.	Done, 2011 NIR section 3.2.4.2.

Category	Review	Response by Greece
Energy	Civil aviation: liquid fuels CO2 45. The ERT noted that the data on jet kerosene in the CRF tables are high compared with the IEA data. Also, the Party's inventory includes the consumption of aviation gasoline for civil aviation, while no such consumption is included in the IEA data. Greece explained that, since there is a discrepancy between the number of LTOs and the corresponding fuel consumption from the national energy balance, the adjustment applied to the estimate for the base year5 is continuously applied in the estimation of CO2 emissions from civil aviation. The ERT recommends that Greece continue its efforts to estimate the country-specific share of LTOs and the corresponding fuel consumption, and report any progress on this matter in its next annual submission.	2011 NIR 2011 section 3.2.5.2, 3.2.5.5-6
Energy	Road transportation: liquid fuels CO2 46. The ERT noted that Greece continues to apply the method used by the ERT in the initial review for calculating the consumption of lubricants for road transportation, which is based on the average lubricant consumption/fuel consumption ratio for the cluster of countries for the whole time series rather than on the data from the national energy statistics. The present ERT reiterates the recommendation of previous ERTs that Greece verify the data on lubricants used for road transportation and report thereon in its next annual submission.	2011 NIR section 3.2.5.2, figures 3.7 – 3.10
Energy	47. The ERT also noted that inadequate information is provided in the NIR on the methodology used to split the AD for road transportation into the different calculation categories. The ERT recommends that Greece provide more detailed information on and justification for the AD on vehicle fleet population by class, fuel consumption rate, distance travelled and fuel use.	2011 NIR section 3.2.5.2
Energy	49. The changes in the IEFs for gaseous fuels in the subcategories food processing, beverages and tobacco, commercial/institutional and residential within the time series are large (e.g. the N2O IEF changes from 2.5 kg/TJ for the period 1990–1995 to 1 kg/TJ for the period 1998–2008). Greece attributes these changes to the introduction of the use of natural gas after 1995, which was used in addition to or instead of the gas works gas previously used. The ERT noted that, in accordance with the Revised 1996 IPCC Guidelines, gas works gas is considered a secondary solid fuel and should not be reported under gaseous fuels. The ERT recommends that Greece reallocate gas works gas to the appropriate fuel group in its next annual submission.	Done, 2011 NIR section 3.2.4.8
Energy	50. The ERT noted unusual trends in the CH4 IEF for solid fuels in manufacturing industries and construction: after a constant IEF (1 kg/TJ) for the period 1993–2004, in the following years of the time series the IEF shows inter-annual changes of 5–20 per cent. Greece explained that these changes were due to the introduction of alternative fuels, such as scrap tyres and other waste, in cement plants since 2005. The ERT recommends that Greece report scrap tyres and other waste used in cement production as other fuels, separately from solid fuels, in its next annual submission.	Done, 2011 NIR section 3.2.4.8
Industrial Processes	53. However, the ERT recommends that the Party further enhance transparency by providing specific information in the NIR on the tier of methodology used for each (sub)category, such as that provided for cement production during the review.	Done, all available information is provided in sections 4.2-4.14 of the NIR 2011.

Category	Review	Response by Greece
Industrial Processes	55. The ERT considers that the Party should enhance transparency by providing information on the actual sources (not data providers) of AD for HFC emissions from substitutes for ozone-depleting substances, and recommends that Greece provide this information in its next annual submission.	Done, all the available data are reported in Section 4.13.2 of the NIR 2011.
Industrial Processes	56. The ERT commends Greece for its clear and transparent description of this category, except for the determination of the EF for the period 1990–2004, on which the ERT recommends that Greece include more information in the NIR, such as that provided during the review week.	Done, the respective information has been Included in Section 4.2 of NIR 2011
Industrial Processes	57. The ERT noted some inconsistencies in the reported values for 2008 (see para.41) and recommends that Greece recheck the values for non-energy use of natural gas reported in table 1.A(d) and for ammonia and/or hydrogen production and include the relevant background information in the NIR of its next annual submission.	Done. The consistency with the energy sector has been re-checked. Inconsistent values have been corrected in the reported emissions of the energy sector of the 2011 submission
Industrial Processes	58. During the review, the Party provided relevant information regarding the data sources used for the verification of plant-specific AD used to estimate these emissions. The ERT recommends that Greece include this information in its next annual submission, in order to improve transparency.	Done. Included in paragraph 4.7.4 of NIR 2011.
Industrial Processes	59. The ERT observed a discrepancy between the PLF value for transport refrigeration reported in the NIR (12.5 per cent) and that provided in the CRF tables (10 per cent). The ERT recommends that Greece correct this error in its next annual submission.	Done. The PLF value reported in NIR 2011 is the correct one.
Industrial Processes	62. The ERT recommends that Greece complete its reporting of these emissions in the CRF table 2(II)Fin order to improve transparency.	Done. Emissions have been correctly reported. An improvement plan has been in put in force in order to collect data for the estimation of SF6 emissions from GIS installation with PPC. See also paragraphSection 4.14.6 of NIR 2011..
Agriculture	66. The inventory is generally transparent in terms of the description of the AD, methods and EFs applied. However, the ERT noted that the characterization of the sheep population is not transparently described in the NIR and that the assumptions used by experts for the allocation of animals to the different animal waste management systems (AMWS) are not provided. The ERT recommends that Greece improve the transparency of the NIR in relation to these issues in its next annual submission.	Done (paragraph 6.2.2 of NIR).
Agriculture	69. For the estimation of emissions from enteric fermentation, Greece applied the IPCC tier 2 method using country-specific information for sheep and the tier 1 method with default EFs for other animals. As the emissions from cattle are significant (accounting for 41.5 per cent of the emissions from enteric fermentation), that animal category should be considered a key category, and the ERT recommends that Greece use the tier 2 method for estimating these emissions from cattle. The ERT also recommends that the Party disaggregate the emissions from enteric fermentation by the significant animal types when undertaking the key category analysis, consistent with the approach outlined in the IPCC good practice guidance.	Tier 2 method was used for estimating of emissions from cattle (paragraph 6.2.2 of NIR). Emissions from enteric fermentation were disaggregated by the significant animal types (paragraph 1.5.1 of NIR and Annex I).
Agriculture	70. The ERT noted the following issues with the outlined approach: energy for growth was estimated only for lambs and not for all growing sheep; energy for wool growth was estimated only for sheep grown for wool production rather than for all sheep; the number of milking ewes used to estimate energy for maintenance is lower than the number of animals by milking type used to estimate the energy requirements for lactation; and all births are assumed to be singles, while the number of female sheep over one year old (mature sheep) and the number of milking ewes is less than the number of births each year. The ERT recommends that Greece apply the enhanced characterization outlined in the IPCC good practice guidance, in which the population is broken down by age and sex classes and for each of these classes the number/proportion in each grazing/housing condition, milking and wool production type is identified. To ensure the accuracy of the results, the ERT also recommends that the Party undertake category-specific QC checks, such as those outlined in the IPCC good practice guidance.	Done (paragraph 6.2.2 of NIR).
Agriculture	72. The NIR does not provide a clear description of the way in which the country-specific data were developed or chosen. The present ERT reiterates the recommendation of the previous ERT that Greece improve the documentation and justification of country-specific data and provide the basic information supporting the experts opinions used for	Done (paragraph 6.3.2 of NIR).

Category	Review	Response by Greece
	defining the EF in its next annual submission.	
Agriculture	73. The two previous ERTs noted that Greece had used the default nitrogen excretion (Nex) values for cattle (70 kg/head/year for dairy and 50 kg/head/year for non-dairy) for the Mediterranean, while the dairy milk production has increased to levels similar to those of Western Europe. The previous ERT recommended that the Party either provide a justification for this choice or use the defaults for Western Europe. The previous ERT also recommended that Greece investigate the possibility of developing country-specific Nex values. The present ERT reiterates those recommendations.	Done (paragraph 6.3.2 of NIR).
Agriculture	74. The ERT identified that Greece did not estimate the direct and indirect N2O emissions associated with the use of sewage sludge on agricultural soils. Data to estimate emissions from this category are available from data collected under the EU sewage sludge directive (86/278/EEC). During the review, the Party submitted estimates of emissions from this category for the period 2004–2008 and provided the ERT with information on the data used and the method applied. The ERT concluded that the estimates are acceptable and transparently documented. The ERT recommends that Greece include the relevant methodological information and justifications in the NIR of its next annual submission.	Done (paragraph 6.5 of NIR).
Agriculture	75. Greece used the enhanced characterization of the sheep population for estimating CH4 emissions from enteric fermentation for sheep. However, this level of characterization is not maintained when estimating CH4 and N2O emissions from manure management for sheep, as recommended in the IPCC good practice guidance. The ERT recommends that Greece use a single characterization for sheep for estimating emissions for all relevant categories under the agriculture sector in its next annual submission.	Done (paragraph 6.3.2 of NIR).
Waste	92. The inventory for the waste sector is generally complete. CH4 emissions from the treatment of industrial sludge were reported as "NE", but, during the review, Greece provided emission estimates for this subcategory (see para. 101 below). Greece also reported as "NE" N2O emissions from industrial, domestic and commercial wastewater and sludge, for which there are no IPCC methods available to estimate emissions.	CH4 emissions from the treatment of industrial sludge are reported in paragraph 1.3.1 and methodology details in paragraph 1.3.2 of NIR N2O emissions from industrial wastewater and sludge are reported in paragraph 1.3.1 and methodology details in paragraph 1.3.2 of NIR N2O emissions from domestic and commercial wastewater and sludge are reported in paragraph 1.3.1 and methodology details in paragraph 1.3.2 of NIR
Waste	93. The transparency of the NIR has been improved, in response to recommendations of previous ERTs. Information is now provided on implemented category-specific tier 2 QC procedures. However, the ERT noted that there are still issues of transparency in relation to the explanation and justification of underlying assumptions used for estimations of AD, particularly related to information provided by different research studies and programmes.	Information has been included in paragraphs 8.2.1 and 8.2.2 of NIR.
Waste	95. There are recommendations of the previous ERT that have not been addressed by the Party, such as the unchanged uncertainty values from the 2008 submission, which are reiterated in the relevant category chapters below.	Done (paragraph 1.7 and Annex IV of NIR).
Waste	97. Accurate data on the composition of municipal solid waste are not available at the national level. For example, garden and park waste as well as other non-food putrescibles have been included in the general putrescibles category. As the DOC value of these waste types differs, their allocation to the same category is not in line with the Revised 1996 IPCC Guidelines. The ERT reiterates the recommendation made in the previous review report that Greece estimate these waste types separately using appropriate DOC values.	The use of appropriate DOC values for waste types like garden (yard) waste and park waste is not possible yet, due to lack of available accurate data. However, the possibility of use of a more detailed composition data of waste landfilled is a continuously target for Greece. It must be noticed that the National Strategy for municipal wastes will be updated soon and any type of new information provided by it will be used.
Waste	99. As the methane correction factor (MCF) and other parameters used for estimating emissions differ between unmanaged and uncategorized SWDS, Greece's allocation of all unmanaged SWDS to uncategorized is not in line with the IPCC good practice guidance. The ERT reiterates the recommendation made in the previous review report that Greece break down the unmanaged sites into the different IPCC categories, apply the appropriate CH4 correction factors and recalculate the corresponding time series. The previous ERT also recommended that the DOCf value be	Done (paragraph 8.2.2 of NIR).

Category	Review	Response by Greece
	revised; however, in the 2010 submission the DOCf remains at 0.77, which is higher than the default of 0.5 recommended in the IPCC good practice guidance. The value used by Greece is not adequately explained or justified in the NIR, which is not in accordance with the IPCC good practice guidance. The NIR states that Greece will change this value once a country-specific value has been estimated. The ERT recommends that, in the meantime, Greece recalculate its emission estimates applying the default DOCf value suggested in the IPCC good practice guidance.	
Waste	101. CH4 emissions from the treatment of industrial sludge were reported as "NE". During the review, Greece provided emission estimates for this category for the entire time series (916.60 Gg CO2 eq in 2008) based on expert judgement. The ERT commends the Party for this improvement and recommends that Greece include the relevant methodological explanations in its next annual submission. The ERT reiterates the recommendation made in the previous review report that Greece provide additional information regarding the country's wastewater and sludge treatment systems (aerobic, anaerobic, treated and untreated).	Done (paragraph 8.3 of NIR).
Waste	102. CO2, CH4 and N2O emissions from incineration of hospital waste in the Attica region were estimated for the first time for the Party's 2010 submission. The IPCC default method and country-specific EFs were applied. The ERT commends Greece for this improvement in the completeness of its inventory and encourages the Party to collect data on the amounts of waste incinerated in other medical institutions as well as to provide information on whether the incineration of other waste of fossil origin without energy recovery occurs in Greece.	Information is provided in paragraph 8.4 of NIR

PART II: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

10. KP-LULUCF

10.1 General Information

10.1.1 Definition of forest

For reporting purposes under the Kyoto Protocol, forest land is defined as land with a tree crown cover of more than 25 per cent, an area larger than 0.3 hectares and a minimum tree height of 2 metres - or the potential to achieve it. The same definition of forest land is used in the UNFCCC inventory. Greece uses different single minimum values compared to those of FAO in order to ensure consistency with national legislation.

10.1.2 Elected activities under Article 3, paragraph 4 of the Kyoto Protocol

Greece has chosen to elect Forest Management activity under Article 3.4 of the Kyoto Protocol. In accordance with the Annex to Decision 16/CMP.1, credits from Forest Management are capped for Greece in the first commitment period to 330 kt CO_2 per year, or 1650 kt CO_2 for the whole commitment period.

10.1.3 Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time

There is a clear correspondence between the UNFCCC categories and the Kyoto Protocol Activities. Definitions are consistent with those used in the UNFCCC inventory. Units of land subject to Article 3.3 Afforestation and Reforestation are reported jointly and are defined as units of land that did not comply with the forest definition in 1st January 1990, but do so some time before 31st December 2012. Afforestation / Reforestation category is equivalent to 5.A.2 UNFCCC category (Land converted to Forest land). Forest Management activity under Art. 3.4 is equivalent with 5.A.1 UNFCCC category (Forest land remaining Forest land). Units of land subject to Article 3.3 Deforestation are defined as units of land that did comply with the forest definition on or after 1st January 1990 but ceased to comply later on. Deforestation encompasses the UNFCCC subcategories 5.B.2.1, 5.C.2.1, 5.D.2.1, 5.E.2.1 and 5.F.2.1 (Forest land converted to other land uses).

10.1.4 Precedence conditions and hierarchy among Art. 3.4 activities

Not applicable, as only Forest Management has been elected under Article 3.4.

10.2 Land-related information

10.2.1 Methodology used to develop the land transition matrix

The data sources on land areas used for the UNFCCC inventory are used for the Kyoto Protocol reporting. Afforestation / Reforestation data are obtained from the afforestation registry of the Ministry of Environment, Energy and Climate Change (GDPDFNE). This registry contains afforestation activities on croplands under the EEC Regulations 2080/92 and 1257/99 since the beginning of the programmes, in 1994. Afforestation of land occurred by natural regeneration is not yet estimated due to lack of activity data. Deforestation data are obtained from the Land Use Change Database recently developed by the Ministry of Environment, Energy and Climate Change. This dataset includes, among others, the land use changes from forest land to grassland, wetlands, settlements and other land. Information for the units of lands under Forest Management is provided by the Forest Management Plans Database maintained by the Ministry of Environment, Energy and Climate Change.

The ARD and FM datasets contain direct estimates of spatially disaggregated areas converted or managed each year since 1990. These data are provided by the Forest Service Service (from the local to the central Forest Agency), and are consistent with the definition of forest and the activities described above.

Table 10.1 NIR 2. Land transition matrix

Areas and changes in areas between the previous and the current inventory year [(1), (2), (3)]

From previous inventory year \ To current inventory year		Article 3.3 activities		Article 3.4 activities				Other [(5)]	Total area at the beginning of the current inventory year[(6)]
		Afforestation and Reforestation	Deforestation	Forest Management (if elected)	Cropland Management (if elected)	Grazing Land Management (if elected)	Revegetation (if elected)		
		(kha)							
Article 3.3 activities	Afforestation and Reforestation	33.25	0.00						33.25
	Deforestation		3.15						3.15
Article 3.4 activities	Forest Management (if elected)		0.00	1,167.12					1,167.12
	Cropland Management[(4)] (if elected)	NA	NA		NA	NA	NA		NA
	Grazing Land Management[(4)] (if elected)	NA	NA		NA	NA	NA		NA
	Revegetation[(4)] (if elected)	NA			NA	NA	NA		NA
Other [(5)]		0.00	0.00	16.13	0.00	0.00	0.00	11,976.09	11,992.22
Total area at the end of the current inventory year		33.25	3.15	1,183.25	0.00	0.00	0.00	11,976.09	13,195.74

(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 previous year and the current inventory year. For example, the total area of land subject to Forest Management in the year preceding the inventory year, and which was deforested in the inventory year, should be reported in the cell in column of Deforestation and in the row of Forest Management.

(2) Some of the transitions in the matrix are not possible and the cells concerned have been shaded.

(3) In accordance with section 4.2.3.2 of the IPCC good practice guidance for LULUCF, the value of the reported area subject to the various activities under Article 3.3 and 3.4 for the inventory year should be that on 31 December of that year.

(4) Lands subject to Cropland Management, Grazing Land Management or Revegetation which, after 2008, 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 or Revegetation, respectively.

(5) "Other" includes the total area of the country that has not been reported under an Article 3.3 or an elected Article 3.4 activity.

(6) 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 and is constant for all years.

10.2.2 Maps and database to identify the geographical locations, and the system of identification codes for the geographical locations

The reporting method 2 of the GPG LULUCF has been used to report activities under art. 3.3 and 3.4. The geographical units that have been used for this purpose are the 51 prefectures of Greece. ***Figure 10.1*** present the map and the identification codes of these geographical locations.

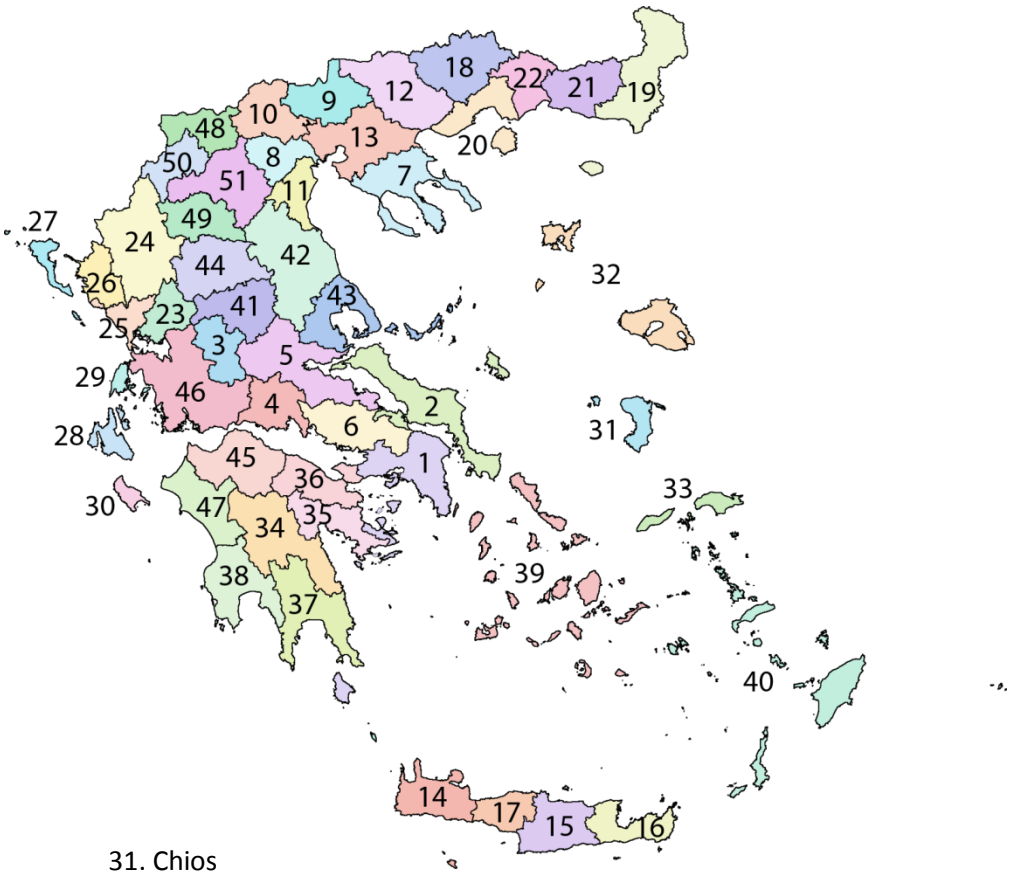


Figure 10.1 Map and identification codes for the geographical locations

10.3 Activity-specific information

10.3.1 Methods for carbon stock change and GHG emission and removal estimates

Methodologies for estimating carbon stock changes and GHG emissions for Article 3.3 Afforestation/Reforestation and Deforestation and Article 3.4 Forest Management are the same as those used for the UNFCCC greenhouse gas inventory. Description of methods, assumptions, activity data and emission factors are presented in the relevant section of chapter 7. As reported in table NIR 1, carbon stock changes from the dead organic matter and from soils have not been assessed yet. This is planned for the next submission.

Table 10.2 NIR 1. Activity coverage

Activity coverage and other information relating to activities under Article 3.3 and elected activities under Article 3.4

Activity		Change in carbon pool reported[1]					Greenhouse gas sources reported[2]					
		Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil	Fertilization[3]	Drainage of soils under forest management	Disturbance associated with land-use conversion to croplands	Liming	Biomass burn	
							N_2O	N_2O	N_2O	CO_2	CO_2	CH_4
Article 3.3 activities	Afforestation and Reforestation	R	R	NR	NR	NR	NO			NO	R	R
	Deforestation	R	R	NR	NR	NR			NO	NO	R	R
Article 3.4 activities	Forest Management	R	R	NR	NR	NR	NO	NO		NO	R	R
	Cropland Management	NA	NA	NA	NA	NA			NA	NA	NA	NA
	Grazing Land Management	NA	NA	NA	NA	NA				NA	NA	NA
	Revegetation	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 or elected activity under Article 3.4. If changes carbon pool are not reported, it must be demonstrated in the NIR that this pool is not a net source of greenhouse gases. Indicate NA (not applicable) for each activity that is not elected u Article 3.4. Explanation about the use of notation keys should be provided in the text.

(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 or elected a 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 text.

(3) N_2O emissions from fertilization for Cropland Management, Grazing Land Management and Revegetation should be reported in the Agriculture sector. If a Party is not able to sepa fertilizer applied to Forest Land from Agriculture, it may report all N_2O emissions from fertilization in the Agriculture sector.

(4) If CO_2 emissions from biomass burning are not already included under changes in carbon stocks, they should be reported under biomass burning; this also includes the carbon comp CH_4. Parties that include CO_2 emissions from biomass burning in their carbon stock change estimates should report IE (included elsewhere).

Table NIR 1.1 Additional information
Selection of parameters for defining "Forest"under the Kyoto Protocol

Parameter	Range	Selected value
Minimum land area	0.05 - 1 ha	0.30
Minimum crown cover	10 - 30 %	25.00
Minimum height	2 - 5 m	2.00

Since there is a clear correspondence between the Kyoto Protocol activities ‘Afforestation / Reforestation’ and ‘Forest Management’, and the UNFCCC categories ‘Conversion to Forest land’ and ‘Forest land remaining Forest land’, uncertainty levels of the net emissions/removals are the same for both inventories. The uncertainty of emissions from units of land under ‘Deforestation’ is estimated to be 51%.

Table 10.3 Uncertainty analysis for the KP-LULUCF activities

Art. 3.3 & 3.4 Activities	Gas	Uncertainty (%)
Afforestation / Reforestation	CO_2	112.8
Deforestation	CO_2	51.0
Forest Management	CO_2	34.0
Forest Management	CH_4	70.9
Forest Management	N_2O	70.9

10.4 Article 3.3

10.4.1 Information that demonstrates that activities began on or after 1 January 1990 and before 31 December 2012 and are directly human-induced

Estimates of carbon stock changes and GHG emissions have been made only for afforestation activities on croplands under the EEC Regulations 2080/92 and 1257/99. Planting of these lands started in 1994. Deforestation data are obtained from the recently developed Land Use Change Database. This database contains annual statistical data on areas under land use change since 1990 collected from the local Forest Services.

10.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

From the land use change database only legal deforestations are drawn to be included in the art. 3.3 Deforestation activity. Lands that have illegally lost their forest cover are not classified as deforested, but as areas that temporary lost their vegetation. These areas are reforested either naturally or after the human intervention. Harvested or disturbed forest areas are not included in the land use change database.

10.4.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

Areas that have lost forest cover (through illegal harvest or burning or wildfire) are recorded at the relevant registry in the local Forest Service. Information on the size and geographical location of these areas is collected but is not readily available for use under the scope of the KP inventory. Greece is currently planning a mechanism to keep these areas under surveillance.

10.5 Article 3.4

10.5.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

In Article 3.4 Forest Management activity, only the forests that have a forest management plan started in 1990 or later have been included. These forests cover about the 35% of the total forest land of Greece (high forest).

10.5.2 Information relating to Cropland Management, Grazing Land Management and Revegetation, if elected, for the base year

These activities were not elected by Greece.

10.6 Other information

10.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

In accordance with the GPG LULUCF, the assessment of key categories under article 3.3 and 3.4 of Kyoto Protocol was based on the assessment made for the UNFCCC inventory. In the cases where there is a clear correspondence between the UNFCCC categories and the Kyoto Protocol Activities (i.e. Afforestation/ Reforestation and Forest Management), a Kyoto Protocol activity was considered as key when the associated category was identified as key in the UNFCCC inventory.

The Kyoto Protocol activity of Deforestation encompasses the UNFCCC subcategories 5.B.2.1, 5.C.2.1, 5.D.2.1, 5.E.2.1 and 5.F.2.1 (Forest land converted to other land uses). The sum of these subcategories is much smaller than the smallest UNFCCC key category. Moreover, none of the categories 5.B.2, 5.C.2, 5.D.2, 5.E.2 and 5.F.2 has been identified as key, and hence Deforestation is not identified as a key category.

Table 10.4 (NIR 3) Key categories under Kyoto Protocol art. 3.3 and 3.4

Key category	Gas	Criteria	Associated key category in UNFCCC inventory
KP-LULUCF			
Afforestation / Reforestation	CO_2	Trend	Land converted to Forest Land
Forest Management	CO_2	Level, Trend	Forest Land remaining Forest Land

10.7 Information relating to Article 6

Not applicable to Greece.

11. Information on accounting of Kyoto units

11.1 Summary of information reported in the SEF tables

For the information about the national registry on the issue, acquisition, holding, transfer, cancellation, withdrawal and carryover of assigned amount units, removal units, emission reduction units and certified emission reductions during the year 2010 (X-1) the respective software application has been used, which is included in this reporting submission) SEF_GR_2011_1_2-3-43 30-1-2011.

11.2 Discrepancies and notifications

No discrepancies identified by the transaction log, was found concerning the completion or termination of the relevant transactions. GR registry has not received any notification (for lCER or tCER) from the Executive Board of the Clean development mechanism (CDM), according to paragraphs 49, 50 and 56 of the annex to decision 5/CMP.1. There are no quantities of ERUs, CERs, tCERs, lCERs, AAUs and RMUs, held in the national registry at the end of that year, that are not valid for use towards compliance with commitments under Article 3, paragraph 1, pursuant to paragraph 43(b) of the annex to decision 13/CMP.1. Moreover, no problems had occurred that caused a discrepancy.

11.3 Publicly accessible information

Account information is provided in the registry interface through the corresponding Web site of CITL:

http://www.ghg.greekregistry.eu/, http://ec.europa.eu/environment/ets/

https://registry.ekpaa.gr/crrepekpaaproduction/en/index.htm

The information is provided through the Web site of UNFCCC:

http://www.ghg.greekregistry.eu/,
http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/4771.php

The Information does not include current holdings of ERUs, CERs, AAUs and RMUs in each account because this is confidential according to EU Registry Regulation No 994/2008/EC.

11.4 Calculation of the commitment period reserve (CPR)

The commitment period reserve for Greece has not changed since the initial report review (FCCC/IRR/2007/GRC, 28.12.2007) and amounts to 601,802,826 t CO_2 eq.

12. Information on changes in national system

The legal framework defining the roles-responsibilities and the co-operation between the main entities of the national system was formalized by circular 918/21-4-08 released by the former Ministry for the Environment, Physical Planning and Public Works, entitled "Structure and operation of the National Greenhouse Gases Inventory System- Roles and Responsibilities". The above-mentioned circular includes a description of each entity's responsibilities, concerning the inventory preparation, data providing or other relative information.

The Presidential Decree No 189 dated 5th November 2009, defines the responsibilities of the new Ministries established in October 2009. The new Ministry of Environment, Energy and Climate change retains the responsibilities regarding the Environment, and Physical Planning of the former Ministry for the Environment, Physical Planning and Public Works and incorporates the General Directorate of Energy and Natural Resources, previously belonging to the Ministry of Development as well as the General Directorate of Forest Development and Protection and Natural Resources, previously belonging to the Ministry of Rural Development and Food. On the other hand, the Public Works General Secretariat of the former Ministry for the Environment, Physical Planning and Public Works was transferred to the new Ministry of Infrastructure, Transport and Networks.

Accordingly, while the appointed focal persons remain with the same responsibilities, there is a restructuring of the national system concerning the names and the roles of the ministries involved.

Detailed information on the present national system is provided in section 1.2. of this submission.

As the UNFCCC secretariat has been informed, the UNFCCC Focal point of Greece was changed from Ms Elpida Politi to Ms Afroditi Kotidou (Address: Villa Kazouli, Kifisias 241, 14561, Athens, Greece, e-mail: A.Kotidou@ekpaa.minenv.gr, tel.: +30210 8089275, fax: +30210 8089239). Ms Elpida Politi retired.

13. Information on changes in national registry

There are no changes in the national registry system since the last year's submission.

The registry software was upgraded by smart technologies GmbH (version 1.1.11.4).

The national registry system is operated by the National Center of Environment and Sustainable development which is supervised by the Ministry of Environment, Energy and Climate Change (MEECC).

14. Minimization of adverse impacts in accordance with Article 3, paragraph 14

14.1 Information on how Greece is striving, under Article 3, paragraph 14, of the Kyoto Protocol, to implement the commitments mentioned in Article 3, paragraph 1, of the Kyoto Protocol 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, of the Convention

In this section Greece provides information on how it is implementing its commitment under Article 3, paragraph 14 of the Kyoto Protocol, i.e. how it is striving to implement its commitment under Article 3, paragraph 1 of the Kyoto Protocol in such a way as to minimize potential adverse social, environmental and economic impacts on developing countries. In order to strive for such a minimization, an assessment of potential positive and negative impacts – both of direct and indirect nature - is necessary with a double objective to maximize positive impacts and to minimize adverse impacts.

Impacts on third countries are mostly indirect and frequently cannot be directly attributed to a specific policy. Therefore, an estimation of potential adverse social, environmental and economic impacts usually comes out as a result from complex assessments of indirect influences.

The majority of Greek policies is directly related to the implementation of EU policies on a national level. An impact assessment is carried out for every new policy initiative at an EU level, and is taking into account during the adoption process of the relative legislation. Greece, as a EU Member State, is participating in the development and adoption process of EU policies.

Two major EU policies, Directive 2009/28/EC on the promotion of the use of renewable energy and Directive 2008/101/EC concerning the extension of the EU emissions trading scheme (ETS) to the aviation sector, have been identified as having potential impacts on third countries. Both directives will be implemented in Greece and will be analyzed in the rest of the paragraph.

Directive on the promotion of the use of renewable energy - Promotion of biomass and biofuels

The Directive on renewable energy (Directive 2009/28/EC), a part of the EU's climate and energy package, sets ambitious targets for all Member States, such that the 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 – 18% for Greece) and a 10% share of renewable energy specifically in the transport sector, which includes biofuels, biogas, hydrogen and electricity from renewable energy

sources. Biomass is one of the renewable energy sources promoted by this Directive and the use of biofuels is important for the achievement of the renewable target in the transport sector.

The impact assessments related to enhanced biofuel and biomass use at a EU level showed that the cultivation of energy crops could have both positive and negative impacts. Positive impacts derive from the fact that the increase of domestic demand for bioenergy generates new export revenues and employment opportunities for developing countries and boosts rural economies. Thus, there could be clear economic and social benefits. At the same time, the new EU energy crop demand could increase the impact on biodiversity, soil and water resources and can have positive as well as negative effects on air pollutants. The extent of carbon reduction and other environmental effects from the promotion of biofuels can vary according to the feedstock employed, the way the feedstock and the biofuels are produced, how they are transported and how far. Growing future demand for biomass feedstock combined with growing global food consumption could add to the agricultural sector's pressure on land use and result in adverse land use changes.

To address the risk of such adverse impacts, Article 17 of the EU's Directive on renewable energy sources creates pioneering "sustainability criteria", applicable to all biofuels (biomass used in the transport sector) and bioliquids. The sustainability criteria adopted are:

- establish a threshold for GHG emission reductions that have to be achieved from the use of biofuels;
- exclude the use of biofuels from land with high biodiversity value (primary forest and wooded land, protected areas or highly biodiverse grasslands),
- exclude the use of biofuels from land with high C stocks, such as wetlands, peatlands or continuously forested areas.

Greece is in the process of transposing the Directive into national law, and under this process the implementation of the sustainability criteria will be defined. The issue of the sustainability criteria is of high importance to Greece, since it will define the market and use of solid and gaseous biomass energy sources.

In this context, Greece will adopt national measures in order to respect the sustainability criteria and assess the impact of the production of biofuels on soil, water and biodiversity, for which it will report to the EU every two years, according to the Directive. Such data shall be used by the Commission in order to prepare a report informing the third countries and the Member States on the application of the above-mentioned criteria.

The reporting obligation refers also to the potential positive and negative land use change effect on EU and Third countries, including the estimation of the availability of foodstuffs at affordable prices, in particular for people living in developing countries, as well as other development issues.

Another action describing the country’s efforts to minimize adverse effects on third countries is the execution of research on second generation biomass technologies by its research centers and

universities (e.g. National Technical University – School of Chemical Engineering). The goal of second generation biofuel processes is to extend the amount of biofuel that can be produced sustainably by using biomass consisting of the residual non-food parts of current crops, such as stems, leaves and husks that are left behind once the food crop has been extracted, as well as other crops that are not used for food purposes (non food crops) and also industry waste such as woodchips, skins and pulp from fruit pressing. Second generation biofuels are expected to expand the biomass feedstock available for biofuel production.

The preparation for the implementation of Directive 2009/28/EC is supported by national legislation promoting the developmemt of RES.

Inclusion of aviation in the EU emission trading scheme

The inclusion of aviation activities to and from EU airports in the EU emissions trading scheme, is likely to have adverse effects on aircraft operators from developing countries. Greece, as a member of the EU ETS system, has been appointed as administering Member state for a number of operators coming from developing countries.

The impacts of the above mentioned measure include impacts on the aircraft operators from developing countries that operate on route covered by the scheme. The inclusion of international flights and third coutries' operators, avoid distortions of competition on specific routes and discrimination as to nationality. However, in order to reduce the aggregated costs for third country airlines especially from regions that include developing countries, airlines operating limited services are exempt from the Community scheme.

Indirect positive effects are to be expected by the inclusion of the aviation into the EU ETS, as it shall create additional demand for credits generating from JI and CDM projects, permitting therefore additional investments in clean technologies in developing countries. Similarly, additional finance for climate change mitigation and adaptation in developing countries should be raised through the auctioning of emissions allowances by the country. Proceeds of auctioning are to be contributed to the Global Energy Efficiency and Renewable Energy Fund, and measures to avoid deforestation and facilitate adaptation in developing countries.

14.2 Information on how Greece gives priority in implementing the commitments under Article 3. Paragraph 14 to specific actions

The current section addresses the subparagraphs (a) to (f) of paragraph 24 of the reporting requirements in Annex I to decision 15/CMP.1. In cases where the relation of specific actions to the minimization of adverse social, environmental and economic impacts resulting from policies and measures to mitigate GHG emissions is not clearly defined the respective subparagraphs have been ommitted. In any case, the main ways how Greece is striving to minimize adverse impacts have been already described in the previous section.

(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

The current paragraph includes information on the means used by the country in order to enhance the progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies that run counter to the objectives of the Convention and on the application of market instruments.

Greece, as a Member of the EU, supports and makes the necessary steps to implement the EU Common Agricultural Policy. In the specific policy environmental concerns have been gradually incorporated. Such examples are the including "decoupled" direct payments which have replaced price support; environmental cross compliance; a substantial increase in budget for rural development. As part of 2008 Common Agriculture Policy Health Check, additional part of direct aid has been shifted to climate change, renewable energy, water management, biodiversity, innovation; - transparency of agricultural subsidies has improved. It is important to note that in the other areas most subsidies are within the competence of the country.

The energy market liberisation (National Law 2773/1999) has been an important step to create a original internal energy market and can be considered as a mean to address market imperfections and to reflect externalities. The existence of a competitive internal energy market is a strategic instrument both in terms of giving local consumers a choice between different companies supplying gas and electricity at reasonable prices, but also in terms of making the market accessible for all suppliers, especially the smallest and those investing in renewable forms of energy.

In the same time, Greece participates in the EU Emissions Trading Scheme, which constitutes an important markert instrument to implement the objectives of the Convention and Article 3, paragraph 1 of the Kyoto Protocol which aims at creating the right incentives for forward looking low carbon investment decisions by reinforcing a clear, undistorted and long-term carbon price signal.

Finally, the taxation on energy products and electricity, as defined by the Directive 2003/96/EC, contribute to establishment of rules for the taxation of energy products used as motor or heating fuel, taxes on energy consumption, and common minimum levels of taxation. The Directive has been transposed into Greek legislation with Laws 3336/2005 and 3340/2005. In addition, the National Customs Code (Law 2960/2001), as applicable, makes use of the options provided for in such Directive to exonerate, totally or partially, the electricity generated by renewable energy sources, as well as natural gas or biofuel. Further information on the implementation of the respective laws has already been reported in the 5th National Communication of Greece (January 2010).

(b) 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

One of the main research priorities of EU is orientated to the development, diffusion and transfer of less-greenhouse-gas emitting fossil fuels technologies. Greece, as an EU Member State, supports financially the pilot projects on carbon capture and storage and the relative cooperation of EU and China.

Various bilateral and multilateral cooperations have been already mentioned in the 5th National Communication of Greece (January 2010). In the context of these cooperations a number of projects is implemented in order to facilitate and finance the transfer and access of developing countries to environmentally sound technologies.

It should be also noted that in the EU's 'Creation and Operation of an EU-GCC Clean Energy Network', created in December 2009, a special working group is oriented to CCS technologies. Greece is an official partner of the project (Institute of Communications and Computer Systems of the National Technical University of Athens).

(c) 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

In the oil and gas industry the upstream sector is a term commonly used to refer to the exploration, drilling, recovery and production of crude oil and natural gas. The downstream sector includes the activities of refining, distillation, cracking, reforming, blending storage, mixing and shipping and distribution.

The EU contributes to strengethening of the capacities of fossil fuel exporting countries in the areas of energy efficiency via the work of the Energy Expert Group of the Gulf Cooperation Council (GCC), in particular in the working sub-group on energy efficiency. As part of the EU's research programme, a project called "EUROGULF" was launched with the objective of to analyse EU-GCC relations with respect to oil and gas issues and propose new policy initiatives and approaches to enhance cooperation between the two regional groupings. In Greece, the Energy Policy Unit of the National Technical University of Athens (NTUA) has actively participated in the EUROGULF Project ('*EUROGULF: An EU-GCC Dialogue for Energy Stability and Sustainability'*), as well as in other similar projects.

The European e-network on clean energy technologies, currently under development as part of the EU's research and development, is also aiming at the objective: promote research and technical development of clean energy technologies in the GCC countries. The Commission has recently started a project with the specific objective to create and facilitate the operation of an EU-GCC Clean Energy Network during the next three years. The network is to be set up to act as a catalyst and element of coordination for development of cooperation on clean energy.

The project has started in December 2009 and is structured in 5 working groups. Greece officially participates in the Network (Institute of Communications and Computer Systems of the National Technical University of Athens). Further information can be found in the website http://eugcc.epu.ntua.gr/Home.aspx.

(d) Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies.

A number of activities aiming at the decrease of the dependence on the consumption of fossil fuels in developing countries have been supported and implemented by Greece. Most of the activities are oriented at the promotion of renewable energies and energy efficiency in those countries, contributing to the covering of rural electricity needs and the improvement of air quality. Such indicative projects have already been mentioned in the 7th chapter of the 5th national communication (January 2010), and include:

- Project "SYN-ENERGY" (Recipient countries: Albania, Bosnia-Herzegovina, Croatia, FYROM, Moldavia, Montenegro, Serbia, Georgia, Ukraine)
- Applications of Renewable Energy and Energy Savings Methods (Recipient country: Libanon)
- Renewable Energy Sources – Development and Implementation of Solar Energy (Recipient country: Armenia)
- Action Plan for Cooperation in the field of Renewable Energy Sources (Recipient country: Turkey)
- Installation of solar systems for household use in poor households in the region of Monaragala (Recipient country: Sri Lanka).

Greece, as an EU Member State, also supports and facilitates the EU Cooperation with Developping Countries. The programmes included in this respect are:

- Renewable energy cooperation with the Mediterranean and Gulf countries
- Africa, Caribbean and the Pacific (ACP-E) Energy Facility
- Euro-Solar Programme in Latin America
- Latin America Investment Facility (LAIF)
- Global Energy Efficiency and Renewable Energy Fund (GEEREF)

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ANNEXES

Annex I: Key categories

The IPCC Good Practice Guidance defines procedures (in the form of decision trees) for the choice of estimation methods within the context of the IPCC Guidelines. Decision trees formalize the choice of the estimation method most suited to national circumstances considering at the same time the need for accuracy and the available resources (both financial and human). Generally, inventory uncertainty is lower when emissions are estimated using the most rigorous methods, but due to finite resources, this may not be feasible for every source category. Therefore it is good practice to identify those source categories (key source categories) that have the greatest contribution to overall inventory uncertainty in order to make the most efficient use of available resources.

In that context, a "key source category" is one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of direct greenhouse gases in terms of the absolute level of emissions (level assessment) or/and to the trend of emissions (trend assessment).

As a result of the adoption of the LULUCF Good Practice Guidance (Decision 13/CP.9) the concept of key sources has been expanded in order to cover LULUCF emissions by sources and removals by sinks. Therefore the term key category is used in order to include both sources and sinks.

As far as possible, key source categories should receive special consideration in terms of two important inventory aspects.

5. The use of source category-specific good practice methods is preferable, unless resources are unavailable.
6. The key source categories should receive additional attention with respect to quality assurance (QA) and quality control (QC).

The determination of the key categories without *LULUCF* for the Greek inventory system is based on the application of the Tier 1 methodology described in the IPCC Good Practice Guidance (***Tables I.1, I.3*** and ***I.5***), adopting the categorization of sources that is presented in table 7.1 of the IPCC Good Practice Guidance. In the 2010 Centralised Review the ERT has encouraged Greece to explore the possibility of using a finer disaggregation of categories in the next submission, namely 2011 submission. In answer to that encouragement Greece has run the analysis using more disaggregated data in the Energy Sector and in the Agriculture Sector. Tier 1 methodology for the identification of key categories assesses the impacts of various categories on the level and the trend of the national emissions inventory. Key categories are those which, when summed together in descending order of magnitude, add up to over 95% of total emissions (level assessment) or the trend of the inventory in absolute terms. It should be noted that, according to the IPCC GPG the trend is estimated on the basis of the base year (1990). The methodology for the determination of key categories with *LULUCF* is in fact the same as for the one for key sources without LULUCF (***Tables I.2, I.4 and I.6***).

The key categories analysis analysis has been performed for the total of the time series (years 1990-2009) on both level and trend analysis basis. Any differences between the key categories in the time-series are due to the flunctuation of the trend in specific categories and refer to trend analysis. The results of the analysis for each year can be viewed in Table 7 of the corresponding CRF excel file.

Table I.1 Key categories analysis without LULUCF – Level assessment for 2009

IPCC source categories	GHG	Base year (Gg CO_2 eq)	Current year (Gg CO_2eq)	Level Assessment	Cumulative total of column E
Energy Industries: Solid fuels	CO2	35,207.38	41,184.64	33.61	33.61
Road Transportation	CO2	11,742.20	20,964.70	17.11	50.72
Oher Sectors: Liquid fuels	CO2	8,006.48	9,668.15	7.89	58.61
Energy Industries: Liquid fuels	CO2	7,683.34	9,043.01	7.38	65.99
Manufacturing Industries & Construction: Liquid fuels	CO2	5,637.96	5,984.75	4.88	70.87
Cement Production	CO2	5,640.90	4,581.72	3.74	74.61
Energy Industries: Gaseous fuels	CO2	102.03	4,392.05	3.58	78.19
Navigation	CO2	1,824.81	2,808.20	2.29	80.48
ODS substitutes	HFC	0.00	2,568.96	2.10	82.58
Solid waste disposal on land	CH4	1,858.37	2,464.00	2.01	84.59
Animal Production	N2O	1,821.24	1,779.65	1.45	86.04
Indirect N2O from nitrogen used in agr.	N2O	2,868.92	1,774.73	1.45	87.49
Enteric fermentation: Sheep	CH4	1,655.96	1,673.07	1.37	88.86
Civil Aviation	CO2	716.84	1,451.76	1.18	90.04
Coal Mining (surface)	CH4	1,095.27	1,369.57	1.12	91.16
Direct N2O from agr. soils	N2O	2,761.36	1,360.48	1.11	92.27
Manufacturing Industries & Construction: Gaseous fuels	CO2	0.00	1,065.30	0.87	93.14
Oher Sectors: Gaseous fuels	CO2	0.00	926.82	0.76	93.89
Wastewater handling	CH4	2,835.35	839.12	0.68	94.58
Enteric fermentation: Other	CH4	661.10	617.06	0.50	95.08
Enteric fermentation:Non Dairy Cattle	CH4	537.47	585.41	0.48	95.56
Limestone & Dolomite Use	CO2	582.80	431.03	0.35	95.91
Wastewater handling	N2O	328.19	383.17	0.31	96.23
Nitric Acid Production	N2O	1,109.04	367.42	0.30	96.52
Enteric fermentation:Dairy Cattle	CH4	391.75	359.93	0.29	96.82
Ferroalloys	CO2	622.23	356.46	0.29	97.11
Manufacturing Industries & Construction: Solid fuels	CO2	3,928.07	345.48	0.28	97.39
Manure management	CH4	337.46	326.67	0.27	97.66
Manure management	N2O	341.77	302.20	0.25	97.90
Lime Production	CO2	431.97	288.78	0.24	98.14
Road Transportation	N2O	122.45	218.13	0.18	98.32
Oher Sectors: Liquid fuels	N2O	349.81	214.36	0.17	98.49
Aluminium Production	CO2	231.96	194.66	0.16	98.65
Ammonia Production	CO2	240.28	187.61	0.15	98.81
Oil, Natural Gas and Other sources	CH4	91.59	171.98	0.14	98.95
Solvent and other product use	CO2	169.71	161.38	0.13	99.08
Energy Industries: Solid fuels	N2O	134.19	155.96	0.13	99.20
Solvent and other product use	N2O	138.63	154.23	0.13	99.33
Iron and Steel Production	CO2	92.70	137.04	0.11	99.44

IPCC source categories	GHG	Base year (Gg CO_2 eq)	Current year (Gg CO_2eq)	Level Assessment	Cumulative total of column E
Rice Production	CH4	69.10	117.60	0.10	99.54
Railways	CO2	202.69	97.45	0.08	99.62
Road Transportation	CH4	89.96	80.34	0.07	99.68
Oher Sectors: Biomass	CH4	76.59	67.63	0.06	99.74
Aluminium Production	PFCs	263.38	36.13	0.03	99.77
Field burning of agr.residues	CH4	27.06	31.08	0.03	99.79
Oher Sectors: Biomass	N2O	31.80	28.08	0.02	99.82
Energy Industries: Liquid fuels	N2O	19.40	23.13	0.02	99.83
Navigation	N2O	14.21	22.42	0.02	99.85
Manufacturing Industries & Construction: Liquid fuels	N2O	15.98	21.61	0.02	99.87
Manufacturing Industries & Construction: Other Fuels	CO2	0.00	16.41	0.01	99.88
Civil Aviation	N2O	7.71	15.55	0.01	99.90
Oher Sectors: Solid fuels	CO2	119.43	14.73	0.01	99.91
Other Mineral (Glass)	CO2	20.20	13.33	0.01	99.92
Manufacturing Industries & Construction: Biomass	N2O	9.91	12.58	0.01	99.93
Field burning of agr.residues	N2O	10.05	11.64	0.01	99.94
Railways	N2O	24.22	11.53	0.01	99.95
Oher Sectors: Liquid fuels	CH4	7.36	8.54	0.01	99.96
Energy Industries: Liquid fuels	CH4	6.57	7.83	0.01	99.96
Oil, Natural Gas and Other sources	CO2	70.23	7.52	0.01	99.97
Energy Industries: Solid fuels	CH4	6.06	7.04	0.01	99.97
Manufacturing Industries & Construction: Biomass	CH4	5.03	6.39	0.01	99.98
SF6 from electrical equipment	SF6	3.07	5.02	0.00	99.98
Manufacturing Industries & Construction: Gaseous fuels	N2O	0.00	3.97	0.00	99.99
Waste incineration	CO2	0.15	3.53	0.00	99.99
Energy Industries: Gaseous fuels	N2O	0.05	2.32	0.00	99.99
Manufacturing Industries & Construction: Liquid fuels	CH4	3.10	1.86	0.00	99.99
Manufacturing Industries & Construction: Solid fuels	N2O	17.74	1.67	0.00	99.99
Energy Industries: Gaseous fuels	CH4	0.04	1.57	0.00	100.00
Railways	CH4	2.38	1.13	0.00	100.00
Navigation	CH4	2.37	0.95	0.00	100.00
Oher Sectors: Gaseous fuels	N2O	0.00	0.52	0.00	100.00
Civil Aviation	CH4	0.26	0.51	0.00	100.00
Iron and Steel Production	CH4	0.21	0.42	0.00	100.00
Manufacturing Industries & Construction:Gaseous fuels	CH4	0.00	0.40	0.00	100.00
Oher Sectors:Gaseous fuels	CH4	0.00	0.35	0.00	100.00
Manufacturing Industries & Construction: Other Fuels	N2O	0.00	0.33	0.00	100.00
Manufacturing Industries & Construction: Other Fuels	CH4	0.00	0.15	0.00	100.00
Waste incineration	N2O	0.01	0.13	0.00	100.00
Manufacturing Industries & Construction: Solid fuels	CH4	0.82	0.08	0.00	100.00
Energy Industries: Biomass	N2O	0.00	0.07	0.00	100.00
Oher Sectors: Solid fuels	N2O	0.71	0.07	0.00	100.00
Energy Industries: Biomass	CH4	0.00	0.05	0.00	100.00
Oil, Natural Gas and Other sources	N2O	0.20	0.02	0.00	100.00

IPCC source categories	GHG	Base year (Gg CO_2 eq)	Current year (Gg CO_2eq)	Level Assessment	Cumulative total of column E
Waste incineration	CH4	0.00	0.01	0.00	100.00
Oher Sectors: Solid fuels	CH4	0.05	0.00	0.00	100.00
Other transportation	CO2	0.00	0.00	0.00	100.00
Other transportation	CH4	0.00	0.00	0.00	100.00
Other transportation	N2O	0.00	0.00	0.00	100.00
Other Chemicals	CH4	0.52	0.00	0.00	100.00
HFC-23 Emissions from HCFC-22 Manufacture	HFC	935.06	0.00	0.00	100.00
TOTAL		104,365.21	122,543.32	100.00	

Table I.2 Key categories analysis with LULUCF – Level assessment for 2009

IPCC source categories	GHG	Current year (Gg CO_2 eq) (absolute values)	Level Assessment with LULUCF	Cumulative total
Energy Industries: Solid fuels	CO2	41,184.64	32.79	32.79
Road Transportation	CO2	20,964.70	16.69	49.48
Oher Sectors: Liquid fuels	CO2	9,668.15	7.70	57.17
Energy Industries: Liquid fuels	CO2	9,043.01	7.20	64.37
Manufacturing Industries & Construction: Liquid fuels	CO2	5,984.75	4.76	69.14
Cement Production	CO2	4,581.72	3.65	72.79
Energy Industries: Gaseous fuels	CO2	4,392.05	3.50	76.28
Navigation	CO2	2,808.20	2.24	78.52
ODS substitutes	HFC	2,568.96	2.05	80.56
Solid waste disposal on land	CH4	2,464.00	1.96	82.52
Forest Land remaining Forest Land	CO2	1,955.56	1.56	84.08
Animal Production	N2O	1,779.65	1.42	85.50
Indirect N2O from nitrogen used in agr.	N2O	1,774.73	1.41	86.91
Enteric fermentation: Sheep	CH4	1,673.07	1.33	88.24
Civil Aviation	CO2	1,451.76	1.16	89.40
Coal Mining (surface)	CH4	1,369.57	1.09	90.49
Direct N2O from agr. soils	N2O	1,360.48	1.08	91.57
Manufacturing Industries & Construction: Gaseous fuels	CO2	1,065.30	0.85	92.42
Oher Sectors: Gaseous fuels	CO2	926.82	0.74	93.16
Wastewater handling	CH4	839.12	0.67	93.83
Cropland remaining Cropland	CO2	737.22	0.59	94.41
Enteric fermentation: Other	CH4	617.06	0.49	94.90
Enteric fermentation:Non Dairy Cattle	CH4	585.41	0.47	95.37
Limestone & Dolomite Use	CO2	431.03	0.34	95.71
Wastewater handling	N2O	383.17	0.31	96.02
Nitric Acid Production	N2O	367.42	0.29	96.31
Enteric fermentation:Dairy Cattle	CH4	359.93	0.29	96.60
Ferroalloys	CO2	356.46	0.28	96.88
Conversion to Forest Land	CO2	350.63	0.28	97.16
Manufacturing Industries & Construction: Solid fuels	CO2	345.48	0.28	97.44
Manure management	CH4	326.67	0.26	97.70
Manure management	N2O	302.20	0.24	97.94
Lime Production	CO2	288.78	0.23	98.17
Road Transportation	N2O	218.13	0.17	98.34
Oher Sectors: Liquid fuels	N2O	214.36	0.17	98.51
Aluminium Production	CO2	194.66	0.15	98.67
Ammonia Production	CO2	187.61	0.15	98.81
Oil, Natural Gas and Other sources	CH4	171.98	0.14	98.95
Solvent and other product use	CO2	161.38	0.13	99.08
Energy Industries: Solid fuels	N2O	155.96	0.12	99.20
Solvent and other product use	N2O	154.23	0.12	99.33
Iron and Steel Production	CO2	137.04	0.11	99.44
Rice Production	CH4	117.60	0.09	99.53
Railways	CO2	97.45	0.08	99.61
Road Transportation	CH4	80.34	0.06	99.67
Oher Sectors: Biomass	CH4	67.63	0.05	99.72
Aluminium Production	PFCs	36.13	0.03	99.75

IPCC source categories	GHG	Current year (Gg CO_2 eq) (absolute values)	Level Assessment with LULUCF	Cumulative total
Field burning of agr.residues	CH4	31.08	0.02	99.78
Oher Sectors: Biomass	N2O	28.08	0.02	99.80
Energy Industries: Liquid fuels	N2O	23.13	0.02	99.82
Navigation	N2O	22.42	0.02	99.84
Manufacturing Industries & Construction: Liquid fuels	N2O	21.61	0.02	99.85
Manufacturing Industries & Construction: Other Fuels	CO2	16.41	0.01	99.87
Civil Aviation	N2O	15.55	0.01	99.88
Oher Sectors: Solid fuels	CO2	14.73	0.01	99.89
Other Mineral (Glass)	CO2	13.33	0.01	99.90
Grassland remaining Grassland	CH4	12.70	0.01	99.91
Manufacturing Industries & Construction: Biomass	N2O	12.58	0.01	99.92
Field burning of agr.residues	N2O	11.64	0.01	99.93
Railways	N2O	11.53	0.01	99.94
Forest Land remaining Forest Land	CH4	9.85	0.01	99.95
Oher Sectors: Liquid fuels	CH4	8.54	0.01	99.96
Energy Industries: Liquid fuels	CH4	7.83	0.01	99.96
Oil, Natural Gas and Other sources	CO2	7.52	0.01	99.97
Energy Industries: Solid fuels	CH4	7.04	0.01	99.97
Manufacturing Industries & Construction: Biomass	CH4	6.39	0.01	99.98
SF6 from electrical equipment	SF6	5.02	0.00	99.98
Manufacturing Industries & Construction: Gaseous fuels	N2O	3.97	0.00	99.99
Waste incineration	CO2	3.53	0.00	99.99
Energy Industries: Gaseous fuels	N2O	2.32	0.00	99.99
Manufacturing Industries & Construction: Liquid fuels	CH4	1.86	0.00	99.99
Manufacturing Industries & Construction: Solid fuels	N2O	1.67	0.00	99.99
Energy Industries: Gaseous fuels	CH4	1.57	0.00	99.99
Grassland remaining Grassland	N2O	1.29	0.00	100.00
Railways	CH4	1.13	0.00	100.00
Forest Land remaining Forest Land	N2O	1.00	0.00	100.00
Navigation	CH4	0.95	0.00	100.00
Oher Sectors: Gaseous fuels	N2O	0.52	0.00	100.00
Civil Aviation	CH4	0.51	0.00	100.00
Iron and Steel Production	CH4	0.42	0.00	100.00
Manufacturing Industries & Construction:Gaseous fuels	CH4	0.40	0.00	100.00
Oher Sectors:Gaseous fuels	CH4	0.35	0.00	100.00
Manufacturing Industries & Construction: Other Fuels	N2O	0.33	0.00	100.00
Manufacturing Industries & Construction: Other Fuels	CH4	0.15	0.00	100.00
Waste incineration	N2O	0.13	0.00	100.00
Manufacturing Industries & Construction: Solid fuels	CH4	0.08	0.00	100.00
Energy Industries: Biomass	N2O	0.07	0.00	100.00
Oher Sectors: Solid fuels	N2O	0.07	0.00	100.00
Energy Industries: Biomass	CH4	0.05	0.00	100.00
Oil, Natural Gas and Other sources	N2O	0.02	0.00	100.00

IPCC source categories	GHG	Current year (Gg CO_2 eq) (absolute values)	Level Assessment with LULUCF	Cumulative total
Waste incineration	CH4	0.01	0.00	100.00
Oher Sectors: Solid fuels	CH4	0.00	0.00	100.00
Other transportation	CO2	0.00	0.00	100.00
Other transportation	CH4	0.00	0.00	100.00
Other transportation	N2O	0.00	0.00	100.00
Other Chemicals	CH4	0.00	0.00	100.00
HFC-23 Emissions from HCFC-22 Manufacture	HFC	0.00	0.00	100.00
Conversion to Cropland	CO2	0.00	0.00	100.00
Conversion to Grassland	CO2	0.00	0.00	100.00
Conversion to Wetland	CO2	0.00	0.00	100.00
Conversion to Settlements	CO2	0.00	0.00	100.00
Conversion to Other land	CO2	0.00	0.00	100.00
TOTAL		125,611.56	100.00	

Table I.3 Key categories analysis without LULUCF – Level assessment for 1990

IPCC source categories	GHG	Base year (Gg CO_2 eq)	Level Assessment (Base Year)	Cumulative total
Energy Industries: Solid fuels	CO2	35,207.38	33.73	33.73
Road Transportation	CO2	11,742.20	11.25	44.99
Oher Sectors: Liquid fuels	CO2	8,006.48	7.67	52.66
Energy Industries: Liquid fuels	CO2	7,683.34	7.36	60.02
Cement Production	CO2	5,640.90	5.40	65.42
Manufacturing Industries & Construction: Liquid fuels	CO2	5,637.96	5.40	70.83
Manufacturing Industries & Construction: Solid fuels	CO2	3,928.07	3.76	74.59
Indirect N2O from nitrogen used in agr.	N2O	2,868.92	2.75	77.34
Wastewater handling	CH4	2,835.35	2.72	80.06
Direct N2O from agr. soils	N2O	2,761.36	2.65	82.70
Solid waste disposal on land	CH4	1,858.37	1.78	84.48
Navigation	CO2	1,824.81	1.75	86.23
Animal Production	N2O	1,821.24	1.75	87.98
Enteric fermentation: Sheep	CH4	1,655.96	1.59	89.56
Nitric Acid Production	N2O	1,109.04	1.06	90.63
Coal Mining (surface)	CH4	1,095.27	1.05	91.67
HFC-23 Emissions from HCFC-22 Manufacture	HFC	935.06	0.90	92.57
Civil Aviation	CO2	716.84	0.69	93.26
Enteric fermentation: Other	CH4	661.10	0.63	93.89
Ferroalloys	CO2	622.23	0.60	94.49
Limestone & Dolomite Use	CO2	582.80	0.56	95.05
Enteric fermentation:Non Dairy Cattle	CH4	537.47	0.51	95.56
Lime Production	CO2	431.97	0.41	95.97
Enteric fermentation:Dairy Cattle	CH4	391.75	0.38	96.35
Oher Sectors: Liquid fuels	N2O	349.81	0.34	96.69
Manure management	N2O	341.77	0.33	97.01
Manure management	CH4	337.46	0.32	97.34
Wastewater handling	N2O	328.19	0.31	97.65
Aluminium Production	PFCs	263.38	0.25	97.90
Ammonia Production	CO2	240.28	0.23	98.13
Aluminium Production	CO2	231.96	0.22	98.36
Railways	CO2	202.69	0.19	98.55
Solvent and other product use	CO2	169.71	0.16	98.71
Solvent and other product use	N2O	138.63	0.13	98.84
Energy Industries: Solid fuels	N2O	134.19	0.13	98.97
Road Transportation	N2O	122.45	0.12	99.09
Oher Sectors: Solid fuels	CO2	119.43	0.11	99.21
Energy Industries: Gaseous fuels	CO2	102.03	0.10	99.30
Iron and Steel Production	CO2	92.70	0.09	99.39
Oil, Natural Gas and Other sources	CH4	91.59	0.09	99.48
Road Transportation	CH4	89.96	0.09	99.57
Oher Sectors: Biomass	CH4	76.59	0.07	99.64
Oil, Natural Gas and Other sources	CO2	70.23	0.07	99.71
Rice Production	CH4	69.10	0.07	99.77
Oher Sectors: Biomass	N2O	31.80	0.03	99.80
Field burning of agr.residues	CH4	27.06	0.03	99.83
Railways	N2O	24.22	0.02	99.85
Other Mineral (Glass)	CO2	20.20	0.02	99.87

IPCC source categories	GHG	Base year (Gg CO_2 eq)	Level Assessment (Base Year)	Cumulative total
Energy Industries: Liquid fuels	N2O	19.40	0.02	99.89
Manufacturing Industries & Construction: Solid fuels	N2O	17.74	0.02	99.91
Manufacturing Industries & Construction: Liquid fuels	N2O	15.98	0.02	99.92
Navigation	N2O	14.21	0.01	99.94
Field burning of agr.residues	N2O	10.05	0.01	99.95
Manufacturing Industries & Construction: Biomass	N2O	9.91	0.01	99.96
Civil Aviation	N2O	7.71	0.01	99.96
Oher Sectors: Liquid fuels	CH4	7.36	0.01	99.97
Energy Industries: Liquid fuels	CH4	6.57	0.01	99.98
Energy Industries: Solid fuels	CH4	6.06	0.01	99.98
Manufacturing Industries & Construction: Biomass	CH4	5.03	0.00	99.99
Manufacturing Industries & Construction: Liquid fuels	CH4	3.10	0.00	99.99
SF6 from electrical equipment	SF6	3.07	0.00	99.99
Railways	CH4	2.38	0.00	99.99
Navigation	CH4	2.37	0.00	100.00
Manufacturing Industries & Construction: Solid fuels	CH4	0.82	0.00	100.00
Oher Sectors: Solid fuels	N2O	0.71	0.00	100.00
Other Chemicals	CH4	0.52	0.00	100.00
Civil Aviation	CH4	0.26	0.00	100.00
Iron and Steel Production	CH4	0.21	0.00	100.00
Oil, Natural Gas and Other sources	N2O	0.20	0.00	100.00
Waste incineration	CO2	0.15	0.00	100.00
Oher Sectors: Solid fuels	CH4	0.05	0.00	100.00
Energy Industries: Gaseous fuels	N2O	0.05	0.00	100.00
Energy Industries: Gaseous fuels	CH4	0.04	0.00	100.00
Waste incineration	N2O	0.01	0.00	100.00
Waste incineration	CH4	0.00	0.00	100.00
Energy Industries: Biomass	CH4	0.00	0.00	100.00
Energy Industries: Biomass	N2O	0.00	0.00	100.00
Manufacturing Industries & Construction: Gaseous fuels	CO2	0.00	0.00	100.00
Manufacturing Industries & Construction:Gaseous fuels	CH4	0.00	0.00	100.00
Manufacturing Industries & Construction: Gaseous fuels	N2O	0.00	0.00	100.00
Manufacturing Industries & Construction: Other Fuels	CO2	0.00	0.00	100.00
Manufacturing Industries & Construction: Other Fuels	CH4	0.00	0.00	100.00
Manufacturing Industries & Construction: Other Fuels	N2O	0.00	0.00	100.00
Other transportation	CO2	0.00	0.00	100.00
Other transportation	CH4	0.00	0.00	100.00
Other transportation	N2O	0.00	0.00	100.00
Oher Sectors: Gaseous fuels	CO2	0.00	0.00	100.00
Oher Sectors:Gaseous fuels	CH4	0.00	0.00	100.00
Oher Sectors: Gaseous fuels	N2O	0.00	0.00	100.00
ODS substitutes	HFC	0.00	0.00	100.00

IPCC source categories	GHG	Base year ($Gg\ CO_2$ eq)	Level Assessment (Base Year)	Cumulative total
TOTAL		104,365.21	100.00	

Table I.4 Key categories analysis with LULUCF – Level assessment for 1990

IPCC source categories	GHG	Base year (Gg CO_2 eq) (absolute values)	Level Assessment with LULUCF	Cumulative total
Energy Industries: Solid fuels	CO2	35,207.38	32.92	32.92
Road Transportation	CO2	11,742.20	10.98	43.90
Oher Sectors: Liquid fuels	CO2	8,006.48	7.49	51.39
Energy Industries: Liquid fuels	CO2	7,683.34	7.19	58.58
Cement Production	CO2	5,640.90	5.28	63.85
Manufacturing Industries & Construction: Liquid fuels	CO2	5,637.96	5.27	69.12
Manufacturing Industries & Construction: Solid fuels	CO2	3,928.07	3.67	72.80
Indirect N2O from nitrogen used in agr.	N2O	2,868.92	2.68	75.48
Wastewater handling	CH4	2,835.35	2.65	78.13
Direct N2O from agr. soils	N2O	2,761.36	2.58	80.71
Solid waste disposal on land	CH4	1,858.37	1.74	82.45
Navigation	CO2	1,824.81	1.71	84.16
Animal Production	N2O	1,821.24	1.70	85.86
Enteric fermentation: Sheep	CH4	1,655.96	1.55	87.41
Forest Land remaining Forest Land	CO2	1,327.31	1.24	88.65
Cropland remaining Cropland	CO2	1,205.41	1.13	89.78
Nitric Acid Production	N2O	1,109.04	1.04	90.82
Coal Mining (surface)	CH4	1,095.27	1.02	91.84
HFC-23 Emissions from HCFC-22 Manufacture	HFC	935.06	0.87	92.72
Civil Aviation	CO2	716.84	0.67	93.39
Enteric fermentation: Other	CH4	661.10	0.62	94.00
Ferroalloys	CO2	622.23	0.58	94.59
Limestone & Dolomite Use	CO2	582.80	0.55	95.13
Enteric fermentation:Non Dairy Cattle	CH4	537.47	0.50	95.63
Lime Production	CO2	431.97	0.40	96.04
Enteric fermentation:Dairy Cattle	CH4	391.75	0.37	96.40
Oher Sectors: Liquid fuels	N2O	349.81	0.33	96.73
Manure management	N2O	341.77	0.32	97.05
Manure management	CH4	337.46	0.32	97.37
Wastewater handling	N2O	328.19	0.31	97.67
Aluminium Production	PFCs	263.38	0.25	97.92
Ammonia Production	CO2	240.28	0.22	98.14
Aluminium Production	CO2	231.96	0.22	98.36
Railways	CO2	202.69	0.19	98.55
Solvent and other product use	CO2	169.71	0.16	98.71
Solvent and other product use	N2O	138.63	0.13	98.84
Energy Industries: Solid fuels	N2O	134.19	0.13	98.96
Road Transportation	N2O	122.45	0.11	99.08
Oher Sectors: Solid fuels	CO2	119.43	0.11	99.19
Energy Industries: Gaseous fuels	CO2	102.03	0.10	99.29
Iron and Steel Production	CO2	92.70	0.09	99.37
Oil, Natural Gas and Other sources	CH4	91.59	0.09	99.46
Road Transportation	CH4	89.96	0.08	99.54
Oher Sectors: Biomass	CH4	76.59	0.07	99.61
Oil, Natural Gas and Other sources	CO2	70.23	0.07	99.68
Rice Production	CH4	69.10	0.06	99.74
Oher Sectors: Biomass	N2O	31.80	0.03	99.77

IPCC source categories	GHG	Base year (Gg CO_2 eq) (absolute values)	Level Assessment with LULUCF	Cumulative total
Field burning of agr.residues	CH4	27.06	0.03	99.80
Railways	N2O	24.22	0.02	99.82
Other Mineral (Glass)	CO2	20.20	0.02	99.84
Energy Industries: Liquid fuels	N2O	19.40	0.02	99.86
Manufacturing Industries & Construction: Solid fuels	N2O	17.74	0.02	99.88
Manufacturing Industries & Construction: Liquid fuels	N2O	15.98	0.01	99.89
Navigation	N2O	14.21	0.01	99.90
Grassland remaining Grassland	CH4	14.03	0.01	99.92
Forest Land remaining Forest Land	CH4	10.93	0.01	99.93
Field burning of agr.residues	N2O	10.05	0.01	99.94
Manufacturing Industries & Construction: Biomass	N2O	9.91	0.01	99.95
Civil Aviation	N2O	7.71	0.01	99.95
Oher Sectors: Liquid fuels	CH4	7.36	0.01	99.96
Conversion to Other land	CO2	6.77	0.01	99.97
Energy Industries: Liquid fuels	CH4	6.57	0.01	99.97
Energy Industries: Solid fuels	CH4	6.06	0.01	99.98
Manufacturing Industries & Construction: Biomass	CH4	5.03	0.00	99.98
Manufacturing Industries & Construction: Liquid fuels	CH4	3.10	0.00	99.99
SF6 from electrical equipment	SF6	3.07	0.00	99.99
Railways	CH4	2.38	0.00	99.99
Navigation	CH4	2.37	0.00	99.99
Conversion to Settlements	CO2	2.30	0.00	99.99
Grassland remaining Grassland	N2O	1.42	0.00	100.00
Forest Land remaining Forest Land	N2O	1.11	0.00	100.00
Manufacturing Industries & Construction: Solid fuels	CH4	0.82	0.00	100.00
Oher Sectors: Solid fuels	N2O	0.71	0.00	100.00
Other Chemicals	CH4	0.52	0.00	100.00
Civil Aviation	CH4	0.26	0.00	100.00
Iron and Steel Production	CH4	0.21	0.00	100.00
Oil, Natural Gas and Other sources	N2O	0.20	0.00	100.00
Waste incineration	CO2	0.15	0.00	100.00
Oher Sectors: Solid fuels	CH4	0.05	0.00	100.00
Energy Industries: Gaseous fuels	N2O	0.05	0.00	100.00
Energy Industries: Gaseous fuels	CH4	0.04	0.00	100.00
Conversion to Cropland	CO2	0.03	0.00	100.00
Conversion to Grassland	CO2	0.01	0.00	100.00
Waste incineration	N2O	0.01	0.00	100.00
Conversion to Wetland	CO2	0.00	0.00	100.00
Waste incineration	CH4	0.00	0.00	100.00
Energy Industries: Biomass	CH4	0.00	0.00	100.00
Energy Industries: Biomass	N2O	0.00	0.00	100.00
Manufacturing Industries & Construction: Gaseous fuels	CO2	0.00	0.00	100.00
Manufacturing Industries & Construction:Gaseous fuels	CH4	0.00	0.00	100.00
Manufacturing Industries & Construction: Gaseous fuels	N2O	0.00	0.00	100.00
Manufacturing Industries &	CO2	0.00	0.00	100.00

IPCC source categories	GHG	Base year (Gg CO_2 eq) (absolute values)	Level Assessment with LULUCF	Cumulative total
Construction: Other Fuels				
Manufacturing Industries & Construction: Other Fuels	CH4	0.00	0.00	100.00
Manufacturing Industries & Construction: Other Fuels	N2O	0.00	0.00	100.00
Other transportation	CO2	0.00	0.00	100.00
Other transportation	CH4	0.00	0.00	100.00
Other transportation	N2O	0.00	0.00	100.00
Oher Sectors: Gaseous fuels	CO2	0.00	0.00	100.00
Oher Sectors:Gaseous fuels	CH4	0.00	0.00	100.00
Oher Sectors: Gaseous fuels	N2O	0.00	0.00	100.00
ODS substitutes	HFC	0.00	0.00	100.00
Conversion to Forest Land	CO2	0.00	0.00	100.00
TOTAL		106,934.54	100.00	

Table I.5 Key categories analysis without LULUCF – Trend assessment for 2009

IPCC source categories	GHG	Base year (Gg CO_2 eq)	Current year (Gg CO_2eq)	Trend Assessment	Contribution to trend (%)	Cumulative total
Road Transportation	CO2	11,742.20	20,964.70	0.07	0.20	0.20
Energy Industries: Gaseous fuels	CO2	102.03	4,392.05	0.04	0.12	0.31
Manufacturing Industries & Construction: Solid fuels	CO2	3,928.07	345.48	0.04	0.12	0.43
ODS substitutes	HFC	0.00	2,568.96	0.02	0.07	0.50
Wastewater handling	CH4	2,835.35	839.12	0.02	0.07	0.57
Cement Production	CO2	5,640.90	4,581.72	0.02	0.06	0.63
Direct N2O from agr. soils	N2O	2,761.36	1,360.48	0.02	0.05	0.68
Indirect N2O from nitrogen used in agr.	N2O	2,868.92	1,774.73	0.02	0.04	0.72
HFC-23 Emissions from HCFC-22 Manufacture	HFC	935.06	0.00	0.01	0.03	0.75
Manufacturing Industries & Construction: Gaseous fuels	CO2	0.00	1,065.30	0.01	0.03	0.78
Nitric Acid Production	N2O	1,109.04	367.42	0.01	0.03	0.81
Oher Sectors: Gaseous fuels	CO2	0.00	926.82	0.01	0.03	0.83
Navigation	CO2	1,824.81	2,808.20	0.01	0.02	0.85
Manufacturing Industries & Construction: Liquid fuels	CO2	5,637.96	5,984.75	0.01	0.02	0.87
Civil Aviation	CO2	716.84	1,451.76	0.01	0.02	0.89
Ferroalloys	CO2	622.23	356.46	0.00	0.01	0.90
Animal Production	N2O	1,821.24	1,779.65	0.00	0.01	0.91
Solid waste disposal on land	CH4	1,858.37	2,464.00	0.00	0.01	0.91
Aluminium Production	PFCs	263.38	36.13	0.00	0.01	0.92
Enteric fermentation: Sheep	CH4	1,655.96	1,673.07	0.00	0.01	0.93
Oher Sectors: Liquid fuels	CO2	8,006.48	9,668.15	0.00	0.01	0.94
Limestone & Dolomite Use	CO2	582.80	431.03	0.00	0.01	0.94
Lime Production	CO2	431.97	288.78	0.00	0.01	0.95
Oher Sectors: Liquid fuels	N2O	349.81	214.36	0.00	0.01	0.95
Enteric fermentation: Other	CH4	661.10	617.06	0.00	0.00	0.96
Energy Industries: Solid fuels	CO2	35,207.38	41,184.64	0.00	0.00	0.96
Railways	CO2	202.69	97.45	0.00	0.00	0.97
Oher Sectors: Solid fuels	CO2	119.43	14.73	0.00	0.00	0.97
Enteric fermentation:Dairy Cattle	CH4	391.75	359.93	0.00	0.00	0.97
Manure management	N2O	341.77	302.20	0.00	0.00	0.98
Ammonia Production	CO2	240.28	187.61	0.00	0.00	0.98
Coal Mining (surface)	CH4	1,095.27	1,369.57	0.00	0.00	0.98
Aluminium Production	CO2	231.96	194.66	0.00	0.00	0.98
Oil, Natural Gas and Other sources	CO2	70.23	7.52	0.00	0.00	0.98
Road Transportation	N2O	122.45	218.13	0.00	0.00	0.99
Manure management	CH4	337.46	326.67	0.00	0.00	0.99
Oil, Natural Gas and Other sources	CH4	91.59	171.98	0.00	0.00	0.99
Enteric fermentation:Non Dairy Cattle	CH4	537.47	585.41	0.00	0.00	0.99
Solvent and other product use	CO2	169.71	161.38	0.00	0.00	0.99
Rice Production	CH4	69.10	117.60	0.00	0.00	0.99
Iron and Steel Production	CO2	92.70	137.04	0.00	0.00	0.99
Road Transportation	CH4	89.96	80.34	0.00	0.00	1.00
Oher Sectors: Biomass	CH4	76.59	67.63	0.00	0.00	1.00
Energy Industries: Liquid fuels	CO2	7,683.34	9,043.01	0.00	0.00	1.00
Manufacturing Industries & Construction: Solid fuels	N2O	17.74	1.67	0.00	0.00	1.00
Railways	N2O	24.22	11.53	0.00	0.00	1.00
Manufacturing Industries &	CO2	0.00	16.41	0.00	0.00	1.00

IPCC source categories	GHG	Base year (Gg CO_2 eq)	Current year (Gg CO_2eq)	Trend Assessment	Contribution to trend (%)	Cumulative total
Construction: Other Fuels						
Other Mineral (Glass)	CO2	20.20	13.33	0.00	0.00	1.00
Oher Sectors: Biomass	N2O	31.80	28.08	0.00	0.00	1.00
Solvent and other product use	N2O	138.63	154.23	0.00	0.00	1.00
Civil Aviation	N2O	7.71	15.55	0.00	0.00	1.00
Navigation	N2O	14.21	22.42	0.00	0.00	1.00
Manufacturing Industries & Construction: Gaseous fuels	N2O	0.00	3.97	0.00	0.00	1.00
Waste incineration	CO2	0.15	3.53	0.00	0.00	1.00
Manufacturing Industries & Construction: Liquid fuels	N2O	15.98	21.61	0.00	0.00	1.00
Energy Industries: Gaseous fuels	N2O	0.05	2.32	0.00	0.00	1.00
Wastewater handling	N2O	328.19	383.17	0.00	0.00	1.00
Navigation	CH4	2.37	0.95	0.00	0.00	1.00
Manufacturing Industries & Construction: Liquid fuels	CH4	3.10	1.86	0.00	0.00	1.00
Railways	CH4	2.38	1.13	0.00	0.00	1.00
Energy Industries: Solid fuels	N2O	134.19	155.96	0.00	0.00	1.00
Energy Industries: Gaseous fuels	CH4	0.04	1.57	0.00	0.00	1.00
SF6 from electrical equipment	SF6	3.07	5.02	0.00	0.00	1.00
Manufacturing Industries & Construction: Biomass	N2O	9.91	12.58	0.00	0.00	1.00
Manufacturing Industries & Construction: Solid fuels	CH4	0.82	0.08	0.00	0.00	1.00
Oher Sectors: Solid fuels	N2O	0.71	0.07	0.00	0.00	1.00
Field burning of agr.residues	CH4	27.06	31.08	0.00	0.00	1.00
Other Chemicals	CH4	0.52	0.00	0.00	0.00	1.00
Oher Sectors: Gaseous fuels	N2O	0.00	0.52	0.00	0.00	1.00
Manufacturing Industries & Construction: Biomass	CH4	5.03	6.39	0.00	0.00	1.00
Manufacturing Industries & Construction:Gaseous fuels	CH4	0.00	0.40	0.00	0.00	1.00
Oher Sectors:Gaseous fuels	CH4	0.00	0.35	0.00	0.00	1.00
Energy Industries: Liquid fuels	N2O	19.40	23.13	0.00	0.00	1.00
Manufacturing Industries & Construction: Other Fuels	N2O	0.00	0.33	0.00	0.00	1.00
Oil, Natural Gas and Other sources	N2O	0.20	0.02	0.00	0.00	1.00
Civil Aviation	CH4	0.26	0.51	0.00	0.00	1.00
Iron and Steel Production	CH4	0.21	0.42	0.00	0.00	1.00
Field burning of agr.residues	N2O	10.05	11.64	0.00	0.00	1.00
Manufacturing Industries & Construction: Other Fuels	CH4	0.00	0.15	0.00	0.00	1.00
Waste incineration	N2O	0.01	0.13	0.00	0.00	1.00
Energy Industries: Liquid fuels	CH4	6.57	7.83	0.00	0.00	1.00
Oher Sectors: Liquid fuels	CH4	7.36	8.54	0.00	0.00	1.00
Energy Industries: Solid fuels	CH4	6.06	7.04	0.00	0.00	1.00
Energy Industries: Biomass	N2O	0.00	0.07	0.00	0.00	1.00
Oher Sectors: Solid fuels	CH4	0.05	0.00	0.00	0.00	1.00
Energy Industries: Biomass	CH4	0.00	0.05	0.00	0.00	1.00
Waste incineration	CH4	0.00	0.01	0.00	0.00	1.00
Other transportation	CO2	0.00	0.00	0.00	0.00	1.00
Other transportation	CH4	0.00	0.00	0.00	0.00	1.00
Other transportation	N2O	0.00	0.00	0.00	0.00	1.00
TOTAL		104,365.21	122,543.32	0.35	1.00	

Table I.6 Key categories analysis with LULUCF – Trend assessment for 2009

IPCC source / sink categories	GHG	Base year (Gg CO_2 eq)	Current year (Gg CO_2eq)	Trend Assessment (Absolute)	Contribution to trend (%)	Cumulative total
Road Transportation	CO2	11,742.20	20,964.70	0.07	0.19	0.19
Energy Industries: Gaseous fuels	CO2	102.03	4,392.05	0.04	0.11	0.30
Manufacturing Industries & Construction: Solid fuels	CO2	3,928.07	345.48	0.04	0.11	0.42
ODS substitutes	HFC	0.00	2,568.96	0.02	0.07	0.48
Wastewater handling	CH4	2,835.35	839.12	0.02	0.07	0.55
Cement Production	CO2	5,640.90	4,581.72	0.02	0.05	0.60
Direct N2O from agr. soils	N2O	2,761.36	1,360.48	0.02	0.05	0.65
Indirect N2O from nitrogen used in agr.	N2O	2,868.92	1,774.73	0.01	0.04	0.69
HFC-23 Emissions from HCFC-22 Manufacture	HFC	935.06	0.00	0.01	0.03	0.72
Manufacturing Industries & Construction: Gaseous fuels	CO2	0.00	1,065.30	0.01	0.03	0.75
Nitric Acid Production	N2O	1,109.04	367.42	0.01	0.02	0.78
Oher Sectors: Gaseous fuels	CO2	0.00	926.82	0.01	0.02	0.80
Forest Land remaining Forest Land	CO2	-1,327.31	-1,955.56	0.01	0.02	0.82
Navigation	CO2	1,824.81	2,808.20	0.01	0.02	0.84
Manufacturing Industries & Construction: Liquid fuels	CO2	5,637.96	5,984.75	0.01	0.02	0.86
Civil Aviation	CO2	716.84	1,451.76	0.01	0.02	0.87
Ferroalloys	CO2	622.23	356.46	0.00	0.01	0.88
Animal Production	N2O	1,821.24	1,779.65	0.00	0.01	0.89
Conversion to Forest Land	CO2	0.00	-350.63	0.00	0.01	0.90
Solid waste disposal on land	CH4	1,858.37	2,464.00	0.00	0.01	0.91
Oher Sectors: Liquid fuels	CO2	8,006.48	9,668.15	0.00	0.01	0.92
Aluminium Production	PFCs	263.38	36.13	0.00	0.01	0.92
Enteric fermentation: Sheep	CH4	1,655.96	1,673.07	0.00	0.01	0.93
Cropland remaining Cropland	CO2	-1,205.41	-737.22	0.00	0.01	0.94
Limestone & Dolomite Use	CO2	582.80	431.03	0.00	0.01	0.95
Lime Production	CO2	431.97	288.78	0.00	0.01	0.95
Oher Sectors: Liquid fuels	N2O	349.81	214.36	0.00	0.01	0.96
Enteric fermentation: Other	CH4	661.10	617.06	0.00	0.00	0.96
Railways	CO2	202.69	97.45	0.00	0.00	0.96
Oher Sectors: Solid fuels	CO2	119.43	14.73	0.00	0.00	0.97
Energy Industries: Solid fuels	CO2	35,207.38	41,184.64	0.00	0.00	0.97
Enteric fermentation:Dairy Cattle	CH4	391.75	359.93	0.00	0.00	0.97
Manure management	N2O	341.77	302.20	0.00	0.00	0.98
Ammonia Production	CO2	240.28	187.61	0.00	0.00	0.98
Coal Mining (surface)	CH4	1,095.27	1,369.57	0.00	0.00	0.98
Aluminium Production	CO2	231.96	194.66	0.00	0.00	0.98
Oil, Natural Gas and Other sources	CO2	70.23	7.52	0.00	0.00	0.98
Road Transportation	N2O	122.45	218.13	0.00	0.00	0.99
Manure management	CH4	337.46	326.67	0.00	0.00	0.99
Oil, Natural Gas and Other sources	CH4	91.59	171.98	0.00	0.00	0.99
Enteric fermentation:Non Dairy Cattle	CH4	537.47	585.41	0.00	0.00	0.99
Solvent and other product use	CO2	169.71	161.38	0.00	0.00	0.99
Rice Production	CH4	69.10	117.60	0.00	0.00	0.99
Iron and Steel Production	CO2	92.70	137.04	0.00	0.00	0.99
Energy Industries: Liquid fuels	CO2	7,683.34	9,043.01	0.00	0.00	0.99

IPCC source / sink categories	GHG	Base year (Gg CO_2 eq)	Current year (Gg CO_2eq)	Trend Assessment (Absolute)	Contribution to trend (%)	Cumulative total
Road Transportation	CH4	89.96	80.34	0.00	0.00	1.00
Oher Sectors: Biomass	CH4	76.59	67.63	0.00	0.00	1.00
Manufacturing Industries & Construction: Solid fuels	N2O	17.74	1.67	0.00	0.00	1.00
Railways	N2O	24.22	11.53	0.00	0.00	1.00
Manufacturing Industries & Construction: Other Fuels	CO2	0.00	16.41	0.00	0.00	1.00
Other Mineral (Glass)	CO2	20.20	13.33	0.00	0.00	1.00
Oher Sectors: Biomass	N2O	31.80	28.08	0.00	0.00	1.00
Solvent and other product use	N2O	138.63	154.23	0.00	0.00	1.00
Conversion to Other land	CO2	6.77	0.00	0.00	0.00	1.00
Civil Aviation	N2O	7.71	15.55	0.00	0.00	1.00
Navigation	N2O	14.21	22.42	0.00	0.00	1.00
Manufacturing Industries & Construction: Gaseous fuels	N2O	0.00	3.97	0.00	0.00	1.00
Grassland remaining Grassland	CH4	14.03	12.70	0.00	0.00	1.00
Waste incineration	CO2	0.15	3.53	0.00	0.00	1.00
Forest Land remaining Forest Land	CH4	10.93	9.85	0.00	0.00	1.00
Manufacturing Industries & Construction: Liquid fuels	N2O	15.98	21.61	0.00	0.00	1.00
Conversion to Settlements	CO2	2.30	0.00	0.00	0.00	1.00
Energy Industries: Gaseous fuels	N2O	0.05	2.32	0.00	0.00	1.00
Wastewater handling	N2O	328.19	383.17	0.00	0.00	1.00
Navigation	CH4	2.37	0.95	0.00	0.00	1.00
Manufacturing Industries & Construction: Liquid fuels	CH4	3.10	1.86	0.00	0.00	1.00
Railways	CH4	2.38	1.13	0.00	0.00	1.00
Energy Industries: Gaseous fuels	CH4	0.04	1.57	0.00	0.00	1.00
Energy Industries: Solid fuels	N2O	134.19	155.96	0.00	0.00	1.00
SF6 from electrical equipment	SF6	3.07	5.02	0.00	0.00	1.00
Manufacturing Industries & Construction: Biomass	N2O	9.91	12.58	0.00	0.00	1.00
Manufacturing Industries & Construction: Solid fuels	CH4	0.82	0.08	0.00	0.00	1.00
Oher Sectors: Solid fuels	N2O	0.71	0.07	0.00	0.00	1.00
Field burning of agr.residues	CH4	27.06	31.08	0.00	0.00	1.00
Other Chemicals	CH4	0.52	0.00	0.00	0.00	1.00
Oher Sectors: Gaseous fuels	N2O	0.00	0.52	0.00	0.00	1.00
Manufacturing Industries & Construction: Biomass	CH4	5.03	6.39	0.00	0.00	1.00
Manufacturing Industries & Construction:Gaseous fuels	CH4	0.00	0.40	0.00	0.00	1.00
Grassland remaining Grassland	N2O	1.42	1.29	0.00	0.00	1.00
Energy Industries: Liquid fuels	N2O	19.40	23.13	0.00	0.00	1.00
Oher Sectors:Gaseous fuels	CH4	0.00	0.35	0.00	0.00	1.00
Manufacturing Industries & Construction: Other Fuels	N2O	0.00	0.33	0.00	0.00	1.00
Forest Land remaining Forest Land	N2O	1.11	1.00	0.00	0.00	1.00
Oil, Natural Gas and Other sources	N2O	0.20	0.02	0.00	0.00	1.00
Civil Aviation	CH4	0.26	0.51	0.00	0.00	1.00
Iron and Steel Production	CH4	0.21	0.42	0.00	0.00	1.00
Field burning of agr.residues	N2O	10.05	11.64	0.00	0.00	1.00
Manufacturing Industries & Construction: Other Fuels	CH4	0.00	0.15	0.00	0.00	1.00

IPCC source / sink categories	GHG	Base year (Gg CO_2 eq)	Current year (Gg CO_2eq)	Trend Assessment (Absolute)	Contribution to trend (%)	Cumulative total
Energy Industries: Liquid fuels	CH4	6.57	7.83	0.00	0.00	1.00
Waste incineration	N2O	0.01	0.13	0.00	0.00	1.00
Oher Sectors: Liquid fuels	CH4	7.36	8.54	0.00	0.00	1.00
Energy Industries: Biomass	N2O	0.00	0.07	0.00	0.00	1.00
Energy Industries: Solid fuels	CH4	6.06	7.04	0.00	0.00	1.00
Oher Sectors: Solid fuels	CH4	0.05	0.00	0.00	0.00	1.00
Energy Industries: Biomass	CH4	0.00	0.05	0.00	0.00	1.00
Conversion to Cropland	CO2	0.03	0.00	0.00	0.00	1.00
Conversion to Grassland	CO2	0.01	0.00	0.00	0.00	1.00
Waste incineration	CH4	0.00	0.01	0.00	0.00	1.00
Conversion to Wetland	CO2	0.00	0.00	0.00	0.00	1.00
Other transportation	CO2	0.00	0.00	0.00	0.00	1.00
Other transportation	CH4	0.00	0.00	0.00	0.00	1.00
Other transportation	N2O	0.00	0.00	0.00	0.00	1.00
TOTAL		119,524.76	106,934.54	0.35	1.00	

The results of the key categories analysis for the year 2009 are summed up in ***Table I.7***. Finally in ***Table I.8*** the Table NIR.3 as contained in the annex to decision 6/CMP.3 can be found

Table I.7 Source Category Analysis Summary for 2009

Quantitative method used	Tier 1			
IPCC source categories	GHG	Key source category flag	If flag is yYes, Criteria for identification	Comments
ENERGY SECTOR				
Energy Industries: Liquid fuels	CO2	Yes	Level, Trend	T2
Energy Industries: Liquid fuels	CH4	No		
Energy Industries: Liquid fuels	N2O	No		
Energy Industries: Solid fuels	CO2	Yes	Level	T2
Energy Industries: Solid fuels	CH4	No		
Energy Industries: Solid fuels	N2O	No		
Energy Industries: Gaseous fuels	CO2	Yes	Level, Trend	T2
Energy Industries: Gaseous fuels	CH4	No		
Energy Industries: Gaseous fuels	N2O	No		
Energy Industries: Biomass	CH4	No		
Energy Industries: Biomass	N2O	No		
Manufacturing Industries & Construction: Liquid fuels	CO2	Yes	Level, Trend	T2
Manufacturing Industries & Construction: Liquid fuels	CH4	No		
Manufacturing Industries & Construction: Liquid fuels	N2O	No		
Manufacturing Industries & Construction: Solid fuels	CO2	Yes	Trend	T2
Manufacturing Industries & Construction: Solid fuels	CH4	No		
Manufacturing Industries & Construction: Solid fuels	N2O	No		
Manufacturing Industries & Construction: Gaseous fuels	CO2	Yes	Level, Trend	T2
Manufacturing Industries & Construction:Gaseous fuels	CH4	No		
Manufacturing Industries & Construction: Gaseous fuels	N2O	No		
Manufacturing Industries & Construction: Biomass	CH4	No		
Manufacturing Industries & Construction: Biomass	N2O	No		
Manufacturing Industries & Construction: Other Fuels	CO2	No		
Manufacturing Industries & Construction: Other Fuels	CH4	No		
Manufacturing Industries & Construction: Other Fuels	N2O	No		
Road Transportation	CO2	Yes	Level, Trend	T1
Road Transportation	CH4	No		
Road Transportation	N2O	No		
Civil Aviation	CO2	Yes	Level, Trend	T2
Civil Aviation	CH4	No		
Civil Aviation	N2O	No		
Navigation	CO2	Yes	Level, Trend	T1
Navigation	CH4	No		
Navigation	N2O	No		

Quantitative method used	Tier 1			
IPCC source categories	GHG	Key source category flag	If flag is yYes, Criteria for identification	Comments
Railways	CO2	No		
Railways	CH4	No		
Railways	N2O	No		
Other transportation	CO2	No		
Other transportation	CH4	No		
Other transportation	N2O	No		
Oher Sectors: Liquid fuels	CO2	Yes	Level	T2
Oher Sectors: Liquid fuels	CH4	No		
Oher Sectors: Liquid fuels	N2O	Yes	Trend	T2
Oher Sectors: Solid fuels	CO2	No		
Oher Sectors: Solid fuels	CH4	No		
Oher Sectors: Solid fuels	N2O	No		
Oher Sectors: Gaseous fuels	CO2	Yes	Level, Trend	T2
Oher Sectors:Gaseous fuels	CH4	No		
Oher Sectors: Gaseous fuels	N2O	No		
Oher Sectors: Biomass	CH4	No		
Oher Sectors: Biomass	N2O	No		
Coal Mining (surface)	CH4	Yes	Level	T1
Oil, Natural Gas and Other sources	CO2	No		
Oil, Natural Gas and Other sources	CH4	No		
Oil, Natural Gas and Other sources	N2O	No		
INDUSTRIAL PROCESSES SECTOR				
Cement Production	CO2	Yes	Level, Trend	CS
Lime Production	CO2	No	Trend	CS
Limestone & Dolomite Use	CO2	No	Trend	CS, T1
Other Mineral (Glass)	CO2	No		
Other Chemicals	CH4	No		
Nitric Acid Production	N2O	Yes	Trend	D
Ammonia Production	CO2	Yes		
Iron and Steel Production	CO2	No		
Iron and Steel Production	CH4	No		
Ferroalloys	CO2	No	Trend	CS
Aluminium Production	CO2	No		
Aluminium Production	PFCs	No	Trend	T3
HFC-23 Emissions from HCFC-22 Manufacture	HFC	No	Trend	NA
ODS substitutes	HFC	Yes	Level, Trend	CS, T2
SF6 from electrical equipment	SF6	No		
Solvent and other product use	CO2	No		
Solvent and other product use	N2O	No		
AGRICULTURE				
Enteric fermentation:Dairy Cattle	CH4	No		
Enteric fermentation:Non Dairy Cattle	CH4	No		
Enteric fermentation: Sheep	CH4	Yes	Level, Trend	T2
Enteric fermentation: Other	CH4	Yes	Level	T1
Manure management	CH4	No		
Manure management	N2O	No		
Field burning of agr.residues	CH4	No		
Field burning of agr.residues	N2O	No		
Direct N2O from agr. soils	N2O	Yes	Level, Trend	T1, T1a, T1b
Animal Production	N2O	Yes	Level, Trend	D
Indirect N2O from nitrogen used in agr.	N2O	Yes	Level, Trend	T1a

Quantitative method used	Tier 1			
IPCC source categories	GHG	Key source category flag	If flag is yYes, Criteria for identification	Comments
Rice Production	CH4	No		
WASTE				
Solid waste disposal on land	CH4	Yes	Level, Trend	T2
Wastewater handling	CH4	Yes	Level, Trend	CS, D
Wastewater handling	N2O	No		
Waste incineration	CO2	No		
LULUCF				
Forest Land remaining Forest Land	CO2	Yes	Level, Trend	T2
Forest Land remaining Forest Land	CH4			
Forest Land remaining Forest Land	N2O			
Cropland remaining Cropland	CO2	Yes	Level, Trend	T1, T2
Grassland remaining Grassland	CH4			
Grassland remaining Grassland	N2O			
Conversion to Forest Land	CO2	Yes	Trend	T1
Conversion to Cropland	CO2			
Conversion to Grassland	CO2			
Conversion to Wetland	CO2			
Conversion to Settlements	CO2			
Conversion to Other land	CO2			

Table I.8 Table NIR.3 for year 2009

Information type	Unit	2009
Afforestation and Reforestation		
CO2		
Associated LULUCF category		Conversion to forest land
Category contribution > than smallest UNFCCC key category		Yes
Other identification criteria		
Comments		Trend assessment
Forest Management		
CO2		
Associated LULUCF category		Forest land remaining forest land
Category contribution > than smallest UNFCCC key category		Yes
Other identification criteria		
Comments		Level assessment & Trend assessment

Annex II: Detailed discussion of methodology and data for estimating CO_2 emissions from fossil fuel combustion

The calculation of GHG emissions from the energy sector is performed by the application of a Tier 2 methodology based on IPCC guidelines, according to which the allocation of energy consumption by sector, fuel and technology is required. Emissions are then estimated multiplying the consumption per fuel and technology with the relative emission factor.

- The national energy balance is the main source of information regarding fuel consumption per fuel and sub-sector. Further analysis of fuel consumption by technology within each sub-sector is made on the basis of the assumptions presented in Chapter 3.
- Verified reports from installations under the EU ETS were used ias a source of plant specific activity data and in order to calculate plant specific CO_2 emission factors per sector (IPCC source category) and fuel. We also capitalize on them to estimate CH_4 and N_2O emission factors per sector and fuel, by using the IPCC default emission factors per technology and fuel type (tier 2 methodology with IPCC default emission factors). Thus, the emission factors for methane and nitrous oxide are differentiated per technology, while the emission factors for carbon dioxide are differentiated mainly per fuel.
- Emission factors of carbon dioxide by fuel depend exclusively on fuel characteristics (see Table 3.13 which presents emission factors of carbon dioxide by fuel).

Table II.1 presents the correspondence between the sectors of the energy balance (as it is compiled by the MEECC based on the joint questionnaires of IEA and EUROSTAT), the CORINAIR activities and the IPCC source categories. In ***Tables II.2 – II.6*** information from the national energy balance on lignite, natural gas, heavy fuel oil, diesel, and gasoline is presented.

Table II.1 Correspondence between IPCC source categories, energy balance sectors and CORINAIR activities

Energy balance sectors	IPCC source categories	CORINAIR activities
Production	Reference approach	
Imports	Reference approach	
Exports	Reference approach	
International marine bunkers	Reference approach /Bunkers	080404 – International marine bunkers
Stock changes	Reference approach	
TRANSFORMATION		
Electricity plants	1.A.1a	0101 – Public power / steam turbines, gas turbines, stationary engines
CHP plants	1.A.2a – 1.A.2f	
Heat plants	1.A.1a	
ENERGY SECTOR		
Petroleum refineries	1.A.1b	0103 – Petroleum refining plants
Oil and gas extraction	1.A.1c	010504 – Coal mining. oil/gas extraction, pipeline compressors / gas turbines 010503 – Coal mining. oil/gas extraction, pipeline compressors / boilers
INDUSTRY		
Iron and steel	1.A.2a	030302 – Reheating furnaces 030303 – Grey iron foundries
Chemical industry	1.A.2c	0301 – Industry / Combustion in boilers, gas turbines and stationary engines
of which: Feedstocks	Non-energy uses	
Non-ferrous metals	1.A.2b	0301 – Industry / Combustion in boilers, gas turbines and stationary engines 030322 – Alumina production
Non-metallic minerals	1.A.2f	030311 – Cement 030312 – Lime 030315 – Glass (container glass) 030319 – Bricks and tiles 0301 – Industry / Combustion in boilers, gas turbines and stationary engines
Transport equipment	1.A.2f	0301 – Industry / Combustion in boilers, gas turbines and stationary engines
Machinery	1.A.2f	
Mining	1.A.2f	
Food and tobacco	1.A.2e	
Paper. pulp	1.A.2d	
Wood and wood products	1.A.2f	
Construction	1.A.2f	
Textile and leather	1.A.2f	
Non-specified	1.A.2f	
TRANSPORT		
International civil aviation	Reference approach/Bunkers	080502 and 080504 – International airport/cruise traffic
Domestic air	1.A.3a	080501 and 080503 – Domestic airport/cruise traffic
Road	1.A.3b	07 (except 0707 and 0708) – Road transport per type of vehicle
Rail	1.A.3c	0802 – Diesel and gasoline machinery in railways
Internal navigation	1.A.3d	080402 – National sea traffic within EMEP area

Energy balance sectors	IPCC source categories	CORINAIR activities
OTHER SECTORS		
Agriculture	1.A.4c	0203 – Combustion plants in agriculture 0806 – Diesel and gasoline machinery in agriculture
Comm. and public. services	1.A.4a	0201 – Commercial and institutional plants
Residential	1.A.4b	0202 – Residential plants
Non-specified	1.A.4c	0203 – Plants in agriculture 0806 – Diesel and gasoline machinery in agriculture
NON-ENERGY USE	Non-energy use	

Table II.2 Energy balance of lignite (in kt) for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Primary production	51,896	52,695	55,051	54,817	56,672	57,662	59,781	58,844	60,884	62,051	63,887	66,344	70,468	68,299	70,041	69,398	64,787	66,308	65,720	64,893
Imports	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	13	30
Exports	0	0	14	0	0	0	0	22	6	21	21	0	0	0	0	0	0	0	0	0
Stock changes	157	-1,144	-544	366	1,301	-700	-1,629	-197	-254	-1,083	698	911	-1,750	1,770	814	698	-189	59	-1,101	290
DOMESTIC SUPPLY	52,053	51,551	54,493	55,183	57,973	56,962	58,152	58,625	60,624	60,947	64,564	67,255	68,718	70,069	70,855	70,096	64,598	66,373	64,632	65,213
Transfers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Statistical differences	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRANSFORMATION	50,881	50,616	53,993	54,501	57,463	56,431	57,511	58,098	60,160	60,637	64,100	67,005	68,562	69,874	70,655	69,840	64,222	66,056	64,296	65,165
Electricity plants	50,531	50,265	53,790	54,323	57,249	56,240	57,354	53,129	55,207	55,429	59,811	62,541	64,019	59,270	60,602	55,953	48,862	52,715	48,170	51,439
CHP plants[20]	0	0	0	0	0	0	0	4,800	4,820	5,084	4,053	4,199	4,198	10,185	9,631	13,476	15,094	13,153	16,087	13,726
BKB plants	350	351	203	178	214	191	157	169	133	124	236	265	345	419	422	411	266	188	39	0
FINAL CONSUMPTION	1,172	935	500	682	510	531	641	527	464	310	464	250	156	195	199	256	376	317	336	48
INDUSTRY	*515*	*432*	*379*	*552*	*406*	*408*	*503*	*418*	*362*	*235*	*381*	*172*	*156*	*195*	*195*	*224*	*345*	*313*	*304*	*29*
Iron and steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical industry	199	94	7	85	58	62	60	57	5	0	0	0	0	0	0	0	0	0	0	0
Non-ferrous metals[21]	299	318	359	445	333	342	439	359	355	233	379	170	156	195	195	224	345	313	304	29
Non-metallic minerals	17	20	13	22	15	4	4	2	2	2	2	2	0	0	0	0	0	0	0	0
TRANSPORT	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
OTHER SECTORS	*78*	*125*	*121*	*130*	*104*	*123*	*138*	*109*	*102*	*75*	*83*	*78*	*0*	*0*	*4*	*32*	*31*	*4*	*32*	*19*
Agriculture	19	25	33	40	30	40	45	30	30	48	53	50	0	0	0	20	30	0	0	0
Commercial and public	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	59	100	88	90	74	83	93	79	72	27	30	28	0	0	1	12	1	4	32	19
Non-specified	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NON-ENERGY USE	*579*	*378*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*

[20] Fuel consumption in CHP plants is included in electricity plants.
[21] Accouted in Industrial Processes sector.

Table II.3 Energy balance of natural gas in TJ (GCV) for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Primary production	6,426	6,348	5,866	4,326	2,213	2,041	2,154	2,088	1,874	117	1,968	1,870	1,973	1,442	1,337	851	1,209	1,026	681	545
Imports	0	0	0	0	0	0	357	6,017	32,111	56,575	78,551	77,680	81,622	93,138	101,125	108,495	126,604	155,138	163,122	137,833
Stock changes	0	0	0	0	0	0	-218	-150	-238	-32	-1,224	-1,255	192	-319	1,220	141	-11	336	-697	-169
DOMESTIC SUPPLY	6,426	6,348	5,866	4,326	2,213	2,041	2,293	7,955	33,747	56,660	79,295	78,295	83,787	94,261	103,682	109,487	127,802	156,500	163,106	138,209
Transfers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Statistical differences	0	0	0	0	0	0	0	0	0	-65	19	0	0	18	-220	-112	81	1,432	-1,226	1540
TRANSFORMATION	**840**	**826**	**725**	**707**	**691**	**649**	**765**	**3,266**	**16,398**	**40,311**	**59,553**	**58,848**	**62,699**	**69,017**	**74,390**	**74,679**	**87,877**	**114,104**	**116,078**	**84,511**
Electricity plants	0	0	0	0	0	0	0	2,125	15,852	39,705	58,138	57,628	61,175	68,015	73,782	73,858	87,060	113,520	112,666	76,900
CHP plants[22]	840	826	725	707	691	649	765	1,141	546	606	1,415	1,220	1,524	1,002	608	821	817	584	3,412	7,611
ENERGY SECTOR	**1,090**	**1,226**	**1,056**	**986**	**1,260**	**1,216**	**1,200**	**1,183**	**1,328**	**59**	**1,552**	**1,420**	**1,516**	**1,407**	**1,662**	**1,360**	**1,413**	**1,354**	**1,485**	**1,240**
Oil and gas extraction	1,090	1,226	1,056	986	1,260	1,216	1,200	1,183	1,328	59	1,552	1,420	1,516	1,407	1,662	1,261	1,413	1,354	1,485	1,240
Distribution losses	0	0	0	0	0	0	0	94	40	36	568	466	27	64	235	331	393	305	224	1,090
FINAL CONSUMPTION	4,496	4,296	4,085	2,633	262	176	328	3,412	15,981	16,319	17,603	17,561	19,545	23,755	27,615	33,229	38,038	39,305	46,545	49,828
INDUSTRY SECTOR	0	0	0	0	0	0	161	1,544	5,996	8,842	11,341	13,672	14,376	15,281	17,336	19,801	20,690	19,012	21,100	18,988
Iron and steel	0	0	0	0	0	0	0	115	1,326	2,302	2,572	2,956	3,069	2,751	3,057	3,252	3,166	3,639	3,475	2,932
Chemical industry	0	0	0	0	0	0	0	0	147	372	347	405	778	1,001	1,332	2,462	2,006	1,838	1,970	2,117
Non-ferrous metals	0	0	0	0	0	0	0	0	260	1,215	1,830	1,651	1,858	2,407	2,510	2,946	2,372	2,649	2,772	2,607
Non-metallic minerals	0	0	0	0	0	0	0	99	1,217	1,319	1,820	2,997	3,145	2,773	3,078	3,198	4,316	3,887	3,867	3,559
Transport equipment	0	0	0	0	0	0	0	9	74	62	46	81	55	66	68	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	81	91	0	27	75	87	139	140	140
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	213	0	0
Food and tobacco	0	0	0	0	0	0	161	1,174	1,811	2,475	2,925	2,441	2,520	3,191	3,818	5,074	5,840	3,425	3,872	4,687
Paper. pulp	0	0	0	0	0	0	0	67	423	297	561	891	1,151	1,289	1,445	1,245	1,557	1,393	1,572	1,581
Wood and wood products	0	0	0	0	0	0	0	0	0	0	0	0	0	1	26	35	28	41	38	32
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textile and leather	0	0	0	0	0	0	0	80	733	800	999	1,377	1,253	1,399	1,382	896	817	1,027	2,754	783

[22] Fuel consumption in CHP plants is added to the respective industrial sectors

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Non-specified	0	0	0	0	0	0	0	0	5	0	241	792	456	403	593	618	501	761	640	550
TRANSPORT	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*325*	*557*	*567*	*537*	*629*	*670*	*815*	*977*	*685*
Road transport	0	0	0	0	0	0	0	0	0	0	0	284	449	495	493	552	582	667	660	685
Pipeline transport	0	0	0	0	0	0	0	0	0	0	0	41	108	72	44	77	88	148	317	0
OTHER SECTOR	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**618**	**526**	**626**	**810**	**1,243**	**2,157**	**3,636**	**6,840**	**10,648**	**13,099**	**15,645**	**18,643**
Commercial and public	0	0	0	0	0	0	0	0	618	345	400	567	845	1,287	2,024	3,434	4,168	4,883	5,992	6,737
Residential	0	0	0	0	0	0	0	0	0	181	226	243	398	870	1,612	3,406	6,480	8,216	9,653	11,906
NON-ENERGY USE	4,496	4,296	4,085	2,633	262	176	167	1,868	9,367	6,951	5,636	2,754	3,369	5,750	6,106	5,959	6,030	6,379	8,823	11,512

Table II.4 Energy balance of heavy fuel oil (in kt) for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Production	5,596	5,374	5,284	4,419	5,308	6,061	7,424	7,149	6,959	6,326	7,510	7,361	7,188	7,456	7,095	6,956	6,953	7,116	6,008	5,959
Imports	2,233	1,806	2,040	1,955	1,342	733	151	435	411	298	174	169	36	184	171	264	389	677	2,304	1,845
Exports	2,026	1,217	1,710	654	832	616	1,032	696	196	280	220	255	564	649	748	604	835	979	1,301	1,583
International marine bunkers	2,063	1,846	2,052	2,444	2,557	2,641	2,399	2,413	2,798	2,452	2,898	2,933	2,624	2,757	2,809	2,542	2,761	2,860	2,815	2,359
Stock changes	-80	-223	121	196	204	81	-72	7	-41	45	-32	25	-66	-36	159	-47	16	-261	219	-191
DOMESTIC SUPPLY	2,906	3,025	2,993	2,831	2,756	2,943	2,985	2,993	3,007	2,997	2,807	2,757	2,701	2,642	2,625	2,641	2,841	2,762	2,792	2,439
Transfers	-733	-404	-287	-445	-453	-579	-653	-1,135	-1,125	-716	-1,392	-1,324	-1,050	-1,360	-955	-1,006	-465	-629	-1,257	-834
Statistical differences	-245	186	143	-14	-17	-178	139	60	-117	-89	-37	-72	-38	-68	-128	-62	-26	-163	-82	-24
TRANSFORMATION	1,455	1,608	1,564	1,665	1,619	1,755	1,645	1,580	1,513	1,609	1,661	1,558	1,536	1,522	1,405	1,601	1,631	1,581	1,795	1,347
Electricity plants	1,421	1,559	1,506	1,598	1,561	1,697	1,590	1,541	1,483	1,585	1,634	1,539	1,516	1,513	1,398	1,595	1,624	1,576	1,727	1,334
CHP plants[23]	34	49	58	67	58	58	55	39	30	24	27	19	20	9	7	6	7	5	68	13
ENERGY SECTOR	266	279	260	210	273	274	295	294	320	313	372	358	397	351	416	442	482	465	448	422
Petroleum refineries	266	279	260	210	273	274	295	294	320	313	372	358	397	351	416	442	482	465	448	422
FINAL CONSUMPTION	1,451	1,417	1,429	1,166	1,137	1,188	1,340	1,413	1,494	1,388	1,146	1,199	1,165	1,120	1,220	1,040	1,210	1,181	997	1,092
INDUSTRY	1,152	1,107	1,096	910	841	899	1,067	1,045	928	769	882	830	847	778	801	667	791	772	653	427
Iron and steel	101	96	97	86	78	47	21	16	18	8	18	19	20	17	13	4	5	5	4	3
Chemical industry	92	45	43	26	24	29	106	124	159	81	87	82	82	74	110	106	123	120	99	65
Non-ferrous metals	185	157	161	157	144	142	162	185	151	211	214	216	227	224	235	177	198	193	166	100
1Non-metallic minerals	159	174	188	177	165	179	178	182	94	67	89	86	86	78	132	138	157	153	130	92
Transport equipment	0	0	0	0	0	0	2	2	2	2	3	3	3	3	3	3	4	4	3	2
Machinery	0	0	0	0	0	0	13	13	13	12	15	15	15	10	7	6	7	7	6	5
Mining	22	21	23	21	20	50	67	52	42	42	43	43	45	3	3	3	4	4	3	2
Food and tobacco	241	250	255	257	240	235	249	224	236	181	208	187	188	205	164	104	125	122	102	67
Paper. pulp	84	81	80	71	65	59	77	85	66	66	81	66	67	64	47	42	47	46	38	24
Wood and wood products	0	3	2	2	2	4	3	1	2	2	2	2	2	2	2	2	3	3	3	2
Construction	0	27	26	22	21	50	20	17	21	18	30	30	35	30	25	28	32	31	27	19
Textile and leather	111	93	108	91	82	88	140	137	101	79	92	81	77	68	60	54	46	42	36	22

[23] Fuel consumption in CHP plants is added to the respective industrial sectors

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Non-specified	157	160	113	0	0	16	29	7	23	0	0	0	0	0	0	0	40	42	36	24
TRANSPORT	*237*	*231*	*255*	*201*	*256*	*268*	*245*	*340*	*538*	*591*	*236*	*335*	*283*	*306*	*375*	*326*	*359*	*350*	*292*	*630*
Internal navigation	237	231	255	201	256	268	245	340	538	591	236	335	283	306	375	326	359	350	292	630
OTHER SECTORS	62	79	78	55	40	21	28	28	28	28	28	34	35	36	44	47	60	59	52	35
Agriculture	0	20	21	15	15	10	15	15	15	15	15	18	18	19	21	23	31	30	30	20
Commercial and public	13	20	19	15	10	11	13	13	13	13	13	16	17	17	23	24	29	29	22	15
Residential	36	35	38	25	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-specified	13	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NON-ENERGY USE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table II.5 Energy balance of diesel (in kt) for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Production	3,663	3,289	3,786	3,259	3,723	3,987	4,760	5,144	5,544	4,866	5,647	5,452	5,624	6,053	5,369	5,653	6,503	6,656	6,593	6,529
Imports	2,303	2,474	2,042	2,370	2,198	2,293	2,788	2,292	2,539	2,738	2,013	2,435	2,993	3,003	3,672	3,757	3,594	2,629	2,598	3,137
Exports	556	496	509	201	267	342	493	185	284	586	576	794	891	1,102	1,164	1,480	2,311	2,307	2,087	3,018
International marine bunkers	510	514	657	718	801	966	776	771	758	706	750	612	549	497	472	384	398	365	339	318
Stock changes	-169	162	99	-51	-32	67	-166	-133	-468	419	108	35	-251	129	-204	-271	-204	178	-180	353
DOMESTIC SUPPLY	4,731	4,915	4,761	4,634	4,821	4,868	5,559	5,680	5,981	6,085	6,234	6,605	6,962	7,587	7,340	7,415	7,157	6,823	6,663	6,484
Transfers	0	0	0	-25	0	-171	-554	-667	-592	-646	-208	89	36	1	141	140	-20	32	78	-199
Statistical differences	7	-23	-47	-150	-2	-176	-177	-158	-244	-83	-98	-61	-16	-214	254	-59	-449	-453	-291	-270
TRANSFORMATION	315	319	339	287	272	305	381	367	371	336	382	376	465	499	452	429	438	514	425	347
Electricity plants	314	312	338	287	272	305	381	367	371	336	382	376	465	499	448	424	427	507	415	399
CHP plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	5	11	7	10	8
ENERGY SECTOR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	26	27	26	23
FINAL CONSUMPTION	4,409	4,619	4,469	4,497	4,551	4,739	5,355	5,471	5,854	5,832	5,950	6,290	6,513	7,302	6,634	7,023	7,142	6,735	6,503	6384
INDUSTRY SECTOR	354	319	290	296	320	457	490	500	525	560	504	500	500	550	227	439	486	435	419	345
Iron and steel	41	20	20	26	28	18	5	11	12	20	13	13	15	17	1	1	1	1	1	1
Chemical industry	15	12	11	11	12	8	5	3	9	10	9	9	9	9	9	10	10	9	9	9
Non-ferrous metals	0	25	24	25	27	38	28	13	21	23	23	23	20	23	1	2	2	2	2	2
Non-metallic minerals	49	30	31	31	34	48	36	40	49	53	49	48	42	48	3	4	4	4	4	4
Transport equipment	0	2	2	2	2	12	12	7	15	17	16	15	15	16	15	17	18	18	17	17
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining	43	32	31	32	35	49	43	45	41	42	41	40	40	45	38	40	41	37	36	29
Food and tobacco	33	35	33	39	42	59	45	37	49	53	51	51	50	52	22	23	23	21	20	17
Paper. pulp	12	11	10	14	15	8	5	10	9	10	10	10	10	14	2	3	3	3	3	3
Wood and wood products	0	0	0	0	0	0	2	2	2	3	2	1	1	1	0	0	0	0	0	0
Construction	0	1	1	1	1	1	75	94	118	126	130	130	135	140	131	140	142	127	122	130
Textile and leather	17	16	15	20	22	18	10	3	5	8	10	10	7	8	5	5	4	3	3	3
Non-specified	144	135	112	95	102	198	224	235	195	195	150	150	156	177	0	194	238	210	202	130

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TRANSPORT	*1,761*	*1,955*	*1,952*	*1,986*	*1,978*	*1,988*	*1,985*	*2,010*	*2,245*	*2,217*	*2,193*	*2,280*	*2,295*	*2,441*	*2,406*	*2,423*	*2,598*	*2,666*	*2,575*	*3,117*
Road	1,362	1,549	1,557	1,588	1,601	1,660	1,711	1,732	1,851	1,888	1,890	1,895	1,925	2,100	2,058	2,055	2,199	2,309	2,230	2,813
Rail	63	49	47	48	52	43	45	42	42	40	40	40	40	40	40	40	41	37	36	30
Internal navigation	336	357	348	350	325	285	229	236	352	289	263	345	330	301	308	328	358	320	309	274
OTHER SECTORS	*2,294*	*2,345*	*2,227*	*2,215*	*2,253*	*2,294*	*2,880*	*2,961*	*3,084*	*3,055*	*3,253*	*3,510*	*3,718*	*4,311*	*4,001*	*4,161*	*4,058*	*3,634*	*3,509*	*2922*
Agriculture	820	888	822	802	808	750	761	760	760	760	760	770	850	929	786	806	845	757	731	575
Commercial and public	145	167	155	150	160	165	200	192	195	195	203	270	278	300	285	365	371	332	321	233
Residential	1,292	1,290	1,250	1,263	1,285	1,379	1,919	2,009	2,129	2,100	2,290	2,470	2,590	3,082	2,930	2,990	2,842	2,545	2,457	2,144
Non-specified	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NON-ENERGY USE	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*

Table II.6 Energy balance of gasoline (in kt) for the period 1990 – 2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Production	3,379	3,128	3,581	3,445	3,543	3,545	3,383	3,607	3,671	3,205	3,758	3,770	3,802	3,653	3,629	4,058	4,327	4,318	4,251	4075
Imports	213	162	345	242	98	217	180	45	152	477	415	116	514	749	1,059	1,023	1,002	609	629	936
Exports	1,097	884	1,238	1,077	1,094	881	780	556	645	653	1,011	678	809	942	1,216	1,261	1,351	1,373	1,081	1,152
Stock changes	-45	59	-171	11	141	34	-4	-115	-69	169	-27	3	-122	53	11	1	-259	59	-32	192
DOMESTIC SUPPLY	2,423	2,501	2,582	2,644	2,695	2,774	2,940	3,035	3,156	3,215	3,280	3,385	3,543	3,685	3,763	3,918	3,959	4,137	4,059	4,070
Transfers	*0*	*0*	*0*	*0*	*0*	*0*	*42*	*4*	*28*	*17*	*22*	*167*	*153*	*166*	*121*	*99*	*140*	*76*	*161*	*27*
Statistical differences	*27*	*-36*	*-65*	*-23*	*-7*	*141*	*-119*	*-50*	*-19*	*0*	*-123*	*-7*	*-5*	*-6*	*-159*	*2*	*-100*	*-448*	*-131*	*8*
TRANSFORMATION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ENERGY SECTOR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FINAL CONSUMPTION	2,423	2,501	2,582	2,644	2,695	2,774	2,940	3,035	3,156	3,215	3,280	3,385	3,543	3,685	3,763	3,918	3,959	4,137	4,059	4,070
INDUSTRY	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
TRANSPORT	2,373	2,447	2,532	2,594	2,645	2,724	2,890	2,985	3,106	3,165	3,230	3,336	3,493	3,650	3,730	3,888	3,931	4,108	4,031	4,042
Road transport	2,373	2,447	2,532	2,594	2,645	2,724	2,890	2,985	3,106	3,165	3,230	3,336	3,493	3,650	3,730	3,888	3,931	4,108	4,031	4,042
OTHER SECTORS	50	52	50	50	50	50	50	50	50	50	50	49	50	35	33	30	28	29	28	28
Agriculture	50	52	50	50	50	50	50	50	50	50	50	49	50	35	33	30	28	29	28	28
Non specified	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NON ENERGY USE	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*

Annex III: CO_2 reference approach and comparison with sectoral approach, and relevant information on the national energy balance

The Reference Approach requires statistics for production of fuels and their external trade as well as changes in their stocks. It also needs a limited number of figures for the consumption of fuels used for non-energy purposes where carbon may be stored. It uses a simple assumption: once carbon is brought into a national economy in fuel, it is either saved in some way (e.g., in increases of fuel stocks, stored in products, left unoxidised in ash) or it must be released to the atmosphere.

The estimation process is divided in six steps that are described below.

Step 1: Estimation of apparent consumption.

This step concerns the estimation of apparent consumption in natural units or in the units commonly used for the recording of the relative fuel amounts. For secondary fuels production data are not included in the apparent consumption calculation, since they are already accounted for in the primary fuel consumption, from which they derive. Therefore, the apparent consumption of primary fuels is estimated by the following equation:

Apparent consumption = Primary production + Imports - Exports – International bunkers + Stock change

The apparent consumption of secondary fuels is estimated by the following equation:

Apparent consumption = Imports - Exports - International bunkers + Stock change

Step 2: Conversion of fuel data to a common energy unit.

This step concerns the conversion of apparent consumption, which was estimated in the first step in natural units, in a common energy unit (e.g. TJ). This conversion is based on net calorific value of fuels (see ***Tables III.1*** and ***III.2***).

Step 3: Estimation of carbon content.

Total carbon included in each fuel is calculated by multiplying energy consumption by an emission factor (see ***Table III.1***) that reflects the amount of carbon per energy unit for each fuel. The result gives the maximum amount of carbon that could be potentially released if all carbon in the fuels were converted to CO_2.

Step 4: Estimation of carbon stored in products.

Depending on the end use, non-energy uses of fuels can result in the storage of some or all of the carbon contained in the fuel to the non-energy product. The non-energy consumption of fuels is multiplied by an emission factor that reflects the amount of the carbon content of the fuel stored in

non-energy product (see ***Table III.1***). The result is the maximum amount of carbon that could potentially be sequestered if that amount of carbon were stored in the non-energy product. By subtracting this amount from the total carbon calculated in step 3, the amount of carbon that could be theoretically converted in CO_2 is calculated.

Step 5: Estimation of carbon unoxidised during fuel use.

The amount of carbon that was previously calculated is reduced by a fraction up to 2%, depending on fuel type, in order to take account of the fact that a small part of the fuel carbon entering combustion escapes oxidation (see ***Table 3.13***). It is assumed that the carbon that remains unoxidised is stored indefinitely.

Step 6: Estimation of CO_2 emissions.

Carbon emissions from all fuels are multiplied by 44/12 to be converted to CO_2 emissions. and are summed. giving the total amount of CO_2 released in the atmosphere.

As it was mentioned in Section 3.2. the net calorific value of lignite is differentiated on an annual basis according to the characteristics of the mining field from which it is extracted and therefore it is presented separately in ***Table III.1***.

Table III.1 Net calorific value of lignite (in TJ / kt) for the period 1990 - 2009

Year	Electricity generation	Industry	Other sectors
1990	5.711	8.399	5.740
1991	5.447	8.323	5.481
1992	5.225	9.504	5.288
1993	5.355	11.074	5.443
1994	5.355	11.317	5.418
1995	5.179	11.300	5.451
1996	4.915	11.204	5.037
1997	5.384	11.300	5.485
1998	5.506	11.380	5.589
1999	5.366	11.110	5.421
2000	5.346	10.902	5.388
2001	5.296	10.006	5.296
2002	5.087	8.620	5.296
2003	5.043	10.886	5.002
2004	5.182	9.807	5.109
2005	5.240	10.471	5.200
2006	5.240	10.471	5.280
2007	5.297	10.235	5.297
2008	5.179	8.025	5.179
2009	5.141	7.435	5.275

The application of the reference approach for each year is presented hereafter (Tables 1.A(b) of the Common Reporting Format).

Table III.2 Reference approach for 2009

FUEL TYPES			Unit	Production	Imports	Exports	International bunkers	Stock change	Apparent consumption	Conversion factor (TJ/Unit)	NCV/ GCV (1)	Apparent consumption (TJ)	Carbon emission factor (t C/TJ)	Carbon content (Gg C)	Carbon stored (Gg C)	Net carbon emissions (Gg C)	Fraction of carbon oxidized	Actual CO_2 emissions (Gg CO_2)
Liquid Fossil	Primary Fuels	Crude Oil	kt	80.00	17,780.00	998.00		-348.00	17,210.00	42.75	NCV	735,727.50	20.00	14,714.55	NA	14,714.55	0.99	53,413.82
		Orimulsion		NA	NA	NA		NA	NA	NA	NCV	NA	NA	NA	NA	NA	NA	NA
		Natural Gas Liquids		7.22	NA	NA		NA	7.22	41.56	NCV	299.98	17.20	5.16	NA	5.16	0.99	18.73
	Secondary Fuels	Gasoline	kt		936.00	1,152.00	NA	-184.00	-32.00	43.96	NCV	-1,406.72	18.90	-26.59	NA	-26.59	0.99	-96.51
		Jet Kerosene	kt		521.00	933.00	830.00	-91.00	-1,151.00	44.59	NCV	-51,323.09	19.46	-998.77	NA	-998.77	0.99	-3,625.55
		Other Kerosene			27.00	13.00	NA	3.00	11.00	44.75	NCV	492.25	19.60	9.65	NA	9.65	0.99	35.02
		Shale Oil			NA	NA		NA	NA	NA	NCV	NA	NA	NA	NA	NA	NA	NA
		Gas / Diesel Oil	kt		3,137.00	3,018.00	318.00	-623.00	424.00	43.00	NCV	18,232.00	20.20	368.29	NO	368.29	0.99	1,336.88
		Residual Fuel Oil	kt		1,845.00	1,583.00	2,359.00	167.00	-2,264.00	40.19	NCV	-90,990.16	21.10	-1,919.89	NA	-1,919.89	0.99	-6,969.21
		Liquefied Petroleum Gas (LPG)	kt		42.00	240.00		10.00	-208.00	47.31	NCV	-9,840.48	17.20	-169.26	NO	-169.26	0.99	-614.40
		Ethane			NA	NA		NA	NA	NA	NCV	NA	NA	NA	NO	NA,NO	NA	NA,NO
		Naphtha	kt		NA	259.00		21.00	-280.00	45.01	NCV	-12,602.80	20.00	-252.06	46.82	-298.88	0.99	-1,084.93
		Bitumen	kt		NA	394.00		16.00	-410.00	40.19	NCV	-16,477.90	20.00	-329.56	299.01	-628.57	0.99	-2,281.71
		Lubricants	kt		8.00	164.00	21.00	-13.00	-164.00	40.19	NCV	-6,591.16	20.00	-131.82	14.28	-146.10	0.99	-530.34
		Petroleum Coke	kt		891.40	NA		-39.00	930.40	32.02	NCV	29,793.03	25.83	769.44	NA	769.44	0.99	2,793.08
		Refinery Feedstocks	kt		2,758.00	NA		142.00	2,616.00	41.32	NCV	108,087.89	20.00	2,161.76	NA	2,161.76	0.99	7,847.18
		Other Oil			NA	10.00		2.00	-12.00	40.19	NCV	-482.28	20.00	-9.65	55.06	-64.71	0.99	-234.88
Other Liquid Fossil												NA		NA	NA	NA		NA
Other non-specified				NA	NA	NA	NA	NA	NA	NA	NCV	NA	NA	NA	NA	NA	NA	NA
Liquid Fossil Totals												702,918.06		14,191.25	415.17	13,776.08		50,007.17
Solid Fossil	Primary Fuels	Anthracite (2)		NA	NA	NA		NA	NA	NA	NCV	NA	NA	NA	NA	NA	NA	NA
		Coking Coal		NA	NA	NA		NA	NA	NA	NCV	NA	NA	NA	NO	NA,NO	NA	NA,NO
		Other Bituminous Coal	kt	NA	267.00	2.00	NA	37.00	228.00	26.23	NCV	5,981.48	26.33	157.51	NA	157.51	0.98	566.00
		Sub-bituminous Coal		NA	NA	NA	NA	NA	NA	NA	NCV	NA	NA	NA	NA	NA	NA	NA
		Lignite	kt	64,893.00	30.00	NA		-248.06	65,171.06	5.14	NCV	335,049.92	34.17	11,449.48	NA	11,449.48	0.98	41,141.80
		Oil Shale		NA	NA	NA		NA	NA	NA	NCV	NA	NA	NA	NA	NA	NA	NA
		Peat		NA	NA	NA		NA	NA	NA	NCV	NA	NA	NA	NA	NA	NA	NA
	Secondary Fuels	BKB (3) and Patent Fuel			NA	NA		-1.00	1.00	14.20	NCV	14.20	25.80	0.37	NA	0.37	0.98	1.32
		Coke Oven/Gas Coke	kt		5.20	NA		NA	5.20	27.84	NCV	144.82	29.50	4.27	NA	4.27	0.98	15.35
Other Solid Fossil												NA		NA	NA	NA		NA
Other non-specified				NA	NA	NA	NA	NA	NA	NA	NCV	NA	NA	NA	NA	NA	NA	NA
Solid Fossil Totals												341,190.42		11,611.63	NA,NO	11,611.63		41,724.47
Gaseous Fossil		Natural Gas (Dry)	TJ	490.50	121,447.13	NA		152.10	121,785.53	1.00	NCV	121,785.53	15.12	1,841.70	51.09	1,790.61	1.00	6,532.75
Other Gaseous Fossil												NA		NA	NA	NA		NA
Other non-specified				NA	NA	NA	NA	NA	NA	NA	NCV	NA	NA	NA	NA	NA	NA	NA
Gaseous Fossil Totals												121,785.53		1,841.70	51.09	1,790.61		6,532.75
Total												1,165,894.01		27,644.59	466.26	27,178.32		98,264.39
Biomass total												39,043.28		1,100.15	NA	1,100.15		3,993.53
		Solid Biomass		33,367.00	67.00	NA		NA	33,434.00	1.00	NCV	33,434.00	29.90	999.68	NA	999.68	0.99	3,628.83
		Liquid Biomass		3,266.28	NA	NA		NA	3,266.28	1.00	NCV	3,266.28	20.00	65.33	NA	65.33	0.99	237.13
		Gas Biomass		2,343.00	NA	NA		NA	2,343.00	1.00	NCV	2,343.00	15.00	35.15	NA	35.15	0.99	127.58

Annex IV: Uncertainty analysis

Uncertainty analysis constitutes a key activity in the annual inventory cycle. The realisation of such an analysis is foreseen in the reporting guidelines under the Convention and represents a specific function to be performed by a National System (Decision 20/CP.7).

Uncertainty information is not intended to dispute the validity of the inventory estimates, but to help prioritize efforts to improve the accuracy of inventories and guide decisions on methodological choice. This will be achieved with the correct application of the analytic calculating methods at least for the key categories.

There are two methods for the uncertainty estimation suggested by the IPCC Good Practice Guidance. a basic method (Tier 1) which is mandatory and an analytic one (Tier 2).

The Tier 2 methodology is based on Monte Carlo analysis. The principle of Monte Carlo analysis is to select random values of emission factor and activity data from within their individual probability density functions, and to calculate the corresponding emission values. This procedure is repeated many times, and the results of each calculation run build up the overall emission probability density function. Monte Carlo analysis can be performed at the source category level, for aggregations of source categories or for the inventory as a whole. This analysis is suitable for a composite system such as the calculation of GHG emissions in national level. but its application requires significant resources and time.

The application of the Tier 1 methodology for uncertainty analysis is based on the following equations.

A. Uncertainty of total emissions

$$u_{i,g} = \sqrt{u_{AD,i}^2 + u_{EF,i,g}^2}$$

$$U_{i,g} = \frac{u_{i,g} \cdot E_{i,g}}{\sum_{i,g} E_{i,g}}$$

$$U_{tot} = \sqrt{\sum_{i,g} U_{i,g}^2}$$

where. i is the index referring to emission sources, g is the index referring to GHG, $u_{i.g}$ is the combined uncertainty for emissions of g-gas and i-source, $u_{AD.i}$ is the uncertainty of activity data of the i-source, $u_{EF.i.g}$ is the uncertainty of the emission factor of g-gas and i-source, $U_{i.g}$ is the uncertainty of the calculated emissions of g-gas and i-source, $E_{i.g}$ are the emissions of g-gas and i-source and U_{tot} is the uncertainty of total emissions. Uncertainty estimations on activity data ($u_{AD.i}$) and on the emission factors ($u_{EF.i.g}$) are based on IPCC defaults using expert judgement and reasoning details and detailed explanation regarding their choice for each sector is presented in ***Table IV.1***.

B. Uncertainty in trend in emissions

$$A_{i,g} = \frac{0{,}01 \cdot E_{i,g,t} + \sum_{i,g} E_{i,g,t} - \left(0{,}01 \cdot E_{i,g,0} + \sum_{i,g} E_{i,g,0} \right)}{0{,}01 \cdot E_{i,g,0} + \sum_{i,g} E_{i,g,0}} \cdot 100 - \frac{\sum_{i,g} E_{i,g,t} - \sum_{i,g} E_{i,g,0}}{\sum_{i,g} E_{i,g,0}} \cdot 100$$

$$B_{i,g} = \frac{E_{i,g,t}}{\sum_{i,g} E_{i,g,0}}$$

$$TREF_{i,g} = A_{i,g} \cdot u_{EF,i,g}$$

$$TRAD_i = B_{i,g} \cdot u_{AD,i} \cdot \sqrt{2}$$

$$U_{TR} = \sqrt{\sum_{i,g} TREF_{i,g}^2 + TRAD_{i,g}^2}$$

where, *t* is the index referring to the inventory year, *0* is the index referring to the base year, $A_{i,g}$ is the difference (%) of emissions of *g*-gas and *i*-source in response to a 1% increase of emissions in the base year and inventory year, $E_{i,g,t}$ emissions of *g*-gas and *i*-source in the inventory year, $E_{i,g,0}$ emissions of *g*-gas and *i*-source in the base year, $B_{i,g}$ the difference (%) of emissions of *g*-gas and *i*-source in response to a 1% increase of emissions in the inventory year, $TREF_{i,g}$ the contribution of EF uncertainty of *g*-gas and *i*-source to the uncertainty in the trend of emissions, $TRAD_i$ the contribution of AD uncertainty *i*-source to the uncertainty in the trend of emissions and U_{TR} is the uncertainty in the trend of emissions.

The uncertainty analysis for the Greek GHG inventory is based on Tier 1 methodology with 1990 as base year for CO_2, CH_4, N_2O and F-gases emissions.

Moreover:

- For the estimation of uncertainties per gas, a combination of the information provided by the IPCC and critical evaluation of information from indigenous sources was applied.
- 100% of emissions are used for the uncertainty analysis.
- The uncertainty analysis was carried out both without and with the *LULUCF* sector.

In the ***Tables IV.2*** and ***IV.3***, the analytical calculations of the emissions estimates uncertainty are presented, without and with the sector of *LULUCF* respectively.

Table IV.1 Reasoning for activity data and emission factor uncertainty value

IPCC Source category	Gass	Reasoning for activity data uncertainty	Reasoning for emission factor uncertainty
Stationary Combustion - solid fuels	CO_2	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	Default carbon content per fuel has been used acc to IPCC guidelines with 95% confidence intervals. The % uncertainty is estimated < 5%. For conservative reasons we select 5%.
Stationary Combustion - liquid fuels	CO_2	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	Default carbon content per fuel has been used acc to IPCC guidelines with 95% confidence intervals. The % uncertainty is estimated < 5%. For conservative reasons we select 5%.
Stationary Combustion - gaseous fuels	CO_2	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	Default carbon content per fuel has been used acc to IPCC guidelines with 95% confidence intervals. The % uncertainty is estimated < 5%. For conservative reasons we select 5%.
Stationary Combustion - Other fuels	CO_2	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	Default carbon content per fuel has been used acc to IPCC guidelines with 95% confidence intervals. The % uncertainty is estimated < 5%. For conservative reasons we select 5%.
Road transport	CO_2	Default IPCC uncertainty is 5%.	Uncertainty of emissions of CO2 is 5% (IPCC default)
Navigation	CO_2	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default uncertainty.
Civil Aviation	CO_2	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default uncertainty.
Railway	CO_2	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default
Other transportation	CO_2	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default uncertainty.
Oil and Natural gas	CO_2	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	In IPCC GPG is mentioned that the EF used (from Table 2.16 p. 2.84) may be expected to limit uncertainties to within an order of magnitude. However. in order to be conservative. the value 300% is selected.
Cement Production	CO_2	Plant level production data (IPCC GPG).	Plant level production data (IPCC GPG)
Lime Production	CO_2	According to IPCC GPG is higher than EF's uncertainty.	IPCC default uncertainty.
Limestone & Dolomite Use	CO_2	Uncertainty of plant-level weighing of raw materials. Correction for LKD. CS assessment.	Stoichiometric EF. CS assessment.
Glass Production	CO_2	Uncertainty associated with weighing or proportioning the carbonates for any given industry. Increased CS assessment in order to account for any missed non marketed products.	The emission factor is the stoichiometric ratio reflecting the amount of CO2 released upon calcination of the carbonate. CS assessment.
Ammonia Production	CO_2	Uncertainty of plant level weighting of glass production data. CS assessment.	Stoichiometric EF. CS assessment.
Iron and Steel Production	CO_2	Data obtained by the plant and therefore low uncertainty of AD is assumed.	Gaseous inputs and outputs have generally higher uncertainties than for solid or liquid inputs and outputs, so the E's uncertainty is a little higher than the one in the mineral production. CS

IPCC Source category	Gass	Reasoning for activity data uncertainty	Reasoning for emission factor uncertainty
			assessment.
Ferroalloys	CO_2	Plant specific data (IPCC GPG)	The exact carbon content of all sources is reported. CS assessment.
Aluminium Production	CO_2	Detailed plant specific AD for years 2000-2008. Uncertainty is reported higher due to the estimation of the previous years. CS assessment.	Plant specific, source-specific carbon content availability for years 2000-2008. However the previous years have been estimated using the Ni production as a driver. CS assessment.
Waste incineration	CO_2	According to Good Practice Guidance. Page 5.30	According to Good Practice Guidance. Page 5.30
Forest Land remaining Forest Land	CO_2	Conservative expert judgement based on a national research study	Uncertainty from GPG LULUCF and data provider
Conversion to Forest Land	CO_2	Conservative expert judgement based on suggestions by GPG LULUCF.	The respective EF uncertainty was combined based on suggestions by GPG LULUCF.
Cropland remaining Cropland	CO_2	The respective AD uncertainty was combined based on suggestions by GPG LULUCF.	The respective EF uncertainty was combined based on suggestions by GPG LULUCF.
Stationary Combustion - all fuels	CH_4	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	Acc to Table 2.5 of IPCC GPG p 2.41 the default uncertainty for stationary combustion EF is 50-150%. We select the mean 100%.
Road transport	CH_4	Default IPCC uncertainty is 5%.	IPCC default
Navigation	CH_4	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default
Civil Aviation	CH_4	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default
Railway	CH_4	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default
Other transportation	CH_4	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default
Oil and Natural gas	CH_4	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	In IPCC GPG is mentioned that the EF used (from Table 2.16 p. 2.84) may be expected to limit uncertainties to within an order of magnitude. However. in order to be conservative. the value 300% is selected.
Coal Mining	CH_4	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range. Data are checked with plant level data from PPC. so the uncertainty is improved to 2%.	Acc to Table 2.14 of IPCC GPG p 2.77 the default uncertainty for surface Tier 1 methodology was used.
Organic chemicals production	CH_4	Values provided by the NSSG. CS assessment.	Use of default EF. CS assessment.
Iron and Steel Production	CH_4	Plant specific production data (IPCC GPG)	Default (SNAP 040207).
Enteric	CH_4	Uncertainty given by NSSG for the livestock	According to Good Practice Guidance. Page 4.27

IPCC Source category	Gass	Reasoning for activity data uncertainty	Reasoning for emission factor uncertainty
fermentation		population data	
Manure management	CH_4	Uncertainty given by NSSG for the livestock population data	Country specific data taking into account that there is a wide variety of manure management systems and that the situation in Greece is not absolute clear.
Rice cultivation	CH_4	Uncertainty given by NSSG for the rice cultivation data	IPCC Rev. 1996. P. 4.58
Field burning of agr. residues	CH_4	Uncertainty given by NSSG for the crop production data	According to Good Practice Guidance. Page 4.82. Table 4.22
Managed solid waste disposal	CH_4	Good Practice Guidance Page 5.12. Table 5.2 (Use of a multiplying factor of two on the suggested value)	Estimated value according to Good Practice Guidance Page 5.12. Table 5.2
Unmanaged solid waste disposal	CH_4	Good Practice Guidance Page 5.12. Table 5.2 (Use of a multiplying factor of two on the suggested value)	Estimated value according to Good Practice Guidance . Page 5.12. Table 5.2
Municipal Sludge Disposal on Land	CH_4	Good Practice Guidance Page 5.12. Table 5.2 (Use of a multiplying factor of two on the suggested value)	Estimated value according to Good Practice Guidance Page 5.12. Table 5.2
Wastewater handling	CH_4	According to Good Practice Guidance. Page 5.19 Table 5.3 and Page 5.23 Table 5.5	Estimated value according to Good Practice Guidance. Page 5.19 Table 5.3 and Page 5.23 Table 5.5
Waste incineration	CH_4	According to Good Practice Guidance. Page 5.30	Country Specific
Forest Land remaining Forest Land	CH_4	The respective EF uncertainty was combined based on uncertainty given by data provider and suggestions by GPG LULUCF	Suggested default value by GPG LULUCF
Stationary Combustion - all fuels	N_2O	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	Although in IPCC GPG is mentioned that EF from Table 2.16 may be expected to limit uncertainties to within an order of magnitude. in order to be conservative we select 300% as uncertainty.
Road transport	N_2O	Default IPCC uncertainty is 5%.	IPCC default.
Navigation	N_2O	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default.
Civil Aviation	N_2O	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default.
Railway	N_2O	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default
Other transportation	N_2O	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default.
Nitric Acid	N_2O	Plant specific data (IPCC GPG)	N2O may be generated as by product and the Nox abatement may or may note reduce N2O (IPCC GPG).
Manure management	N_2O	Country specific data taking into account that there is a wide variety of manure management systems and	According to Good Practice Guidance. Page 4.43. Table 4.12 and Page 4.44. Table 4.13

IPCC Source category	Gass	Reasoning for activity data uncertainty	Reasoning for emission factor uncertainty
		that the situation in Greece is not absolute clear.	
Agricultural soils - direct emissions	N_2O	Uncertainty given by NSSG for the crop production data	Country specific data.
Agricultural soils - indirect emissions	N_2O	Uncertainty given by NSSG for the fertilizers consumption data	According to Good Practice Guidance. Page 4.75
Animal Production	N_2O	Country specific data taking into account that there is a wide variety of manure management systems and that the situation in Greece is not absolute clear.	According to Good Practice Guidance. Page 4.43. Table 4.12 and Page 4.44-Table 4.13
Field burning of agr. residues	N_2O	Uncertainty given by NSSG for the crop production data	According to Good Practice Guidance. Page 4.90 Chapter 4A.2.1.6
Wastewater handling	N_2O	According to Good Practice Guidance . Page 5.19 Table 5.3 and Page 5.23 Table 5.5	Country specific
Waste incineration	N_2O	According to Good Practice Guidance. Page 5.30	According to Good Practice Guidance. Page 5.30
Forest Land remaining Forest Land	N_2O	The respective EF uncertainty was combined based on uncertainty given by data provider and suggestions by GPG LULUCF	Suggested default value by GPG LULUCF
Grassland remaining Grassland	N_2O	Uncertainty given by data provider.	Uncertainty given by data provider.
HFC-23 Emissions from HCFC-22 Manufacture	HFC	IPCC GPG: Tier 1. absolute knowledge of variability of emissions from different industries (1 plant).	IPCC GPG: Tier 1. absolute knowledge of variability of emissions from different industries (1 plant).
Substitutes for ODS	HFC	Market surveys performed by ICAP. Include information from total manufacturer/importers	"Estimation from National Association of Refrigerating and Cooling Technicians
PFC from Aluminium	PFC	Plant specific data. measurements by plant.	give an overall guidance but are not updated each year."
SF6 from electrical equipment	SF6	Uncertainty of the values provided by PPC regarding the transmission system. CS assessment.	IPCC GPG default for use of SF_6.

Table IV.2 Uncertainty analysis without LULUCF

A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
1A1,2,4	Stationary Combustion - solid fuels	CO_2	39,254.88	41,544.85	5	5	7.1	2.4	-0.0434	0.3981	-0.22	2.81	2.82
1A1,2,4	Stationary Combustion - liquid fuels	CO_2	21,327.77	24,695.91	5	5	7.1	1.4	-0.0033	0.2366	-0.02	1.67	1.67
1A1,2,4	Stationary Combustion - gaseous fuels	CO_2	102.03	6,384.17	5	5	7.1	0.4	0.0600	0.0612	0.30	0.43	0.53
1A2	Stationary Combustion – Other fuels	CO_2	0.00	16.41	5	5	7.1	0.0	0.0002	0.0002	0.00	0.00	0.00
1A3	Road transport	CO_2	11,742.20	20,964.70	5	5	7.1	1.2	0.0687	0.2009	0.34	1.42	1.46
1A3	Navigation	CO_2	1,824.81	2,808.20	5	5	7.1	0.2	0.0064	0.0269	0.03	0.19	0.19
1A3	Civil Aviation	CO_2	716.84	1,451.76	5	5	7.1	0.1	0.0058	0.0139	0.03	0.10	0.10
1A3	Railway	CO_2	202.69	97.45	5	5	7.1	0.0	-0.0013	0.0009	-0.01	0.01	0.01
1A3	Other transportation	CO_2	0.00	0.00	5	5	7.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1B	Oil and Natural gas	CO_2	70.23	7.52	5	300	300.0	0.0	-0.0007	0.0001	-0.22	0.00	0.22
2A1	Cement Production	CO_2	5,640.90	4,581.72	2	2	2.8	0.1	-0.0196	0.0439	-0.04	0.12	0.13
2A2	Lime Production	CO_2	431.97	288.78	5	6	7.8	0.0	-0.0021	0.0028	-0.01	0.02	0.02
2A3	Limestone & Dolomite Use	CO_2	582.80	431.03	10	5	11.2	0.0	-0.0024	0.0041	-0.01	0.06	0.06
1A7	Other Mineral (Glass)	CO_2	20.20	13.33	5	3	5.8	0.0	-0.0001	0.0001	0.00	0.00	0.00
2B1	Ammonia Production	CO_2	240.28	187.61	3	6	6.7	0.0	-0.0009	0.0018	-0.01	0.01	0.01
2C1	Iron and Steel Production	CO_2	92.70	137.04	5	5	7.1	0.0	0.0003	0.0013	0.00	0.01	0.01
2C2	Ferroalloys	CO_2	622.23	356.46	7	7	9.9	0.0	-0.0036	0.0034	-0.03	0.03	0.04
2C3	Aluminium Production	CO_2	231.96	194.66	3	5	5.8	0.0	-0.0007	0.0019	0.00	0.01	0.01
3	Solvent and other product use	CO_2	169.71	161.38	5	300	300.0	0.4	-0.0004	0.0015	-0.11	0.01	0.11
6C	Waste incineration	CO_2	0.15	3.53	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
		Total CO_2	83274.33	104326.51									

A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
1A 1,2,4	Stationary Combustion - all fuels	CH_4	105.62	101.90	5	100	100.1	0.1	-0.0002	0.0010	-0.02	0.01	0.02
1A3	Road transport	CH_4	89.96	80.34	4	40	40.2	0.0	-0.0002	0.0008	-0.01	0.00	0.01
1A3	Navigation	CH_4	2.37	0.95	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1A3	Civil Aviation	CH_4	0.26	0.51	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1A3	Railway	CH_4	2.38	1.13	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1A3	Other transportation	CH_4	0.00	0.00	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1B	Oil and Natural gas	CH_4	91.59	171.98	5	300	300.0	0.4	0.0006	0.0016	0.19	0.01	0.19
1B	Coal Mining	CH_4	1,095.27	1,369.57	2	300	300.0	3.4	0.0008	0.0131	0.24	0.04	0.24
2B5	Other Chemicals (Organic chemicals production)	CH_4	0.52	0.00	5	5	7.1	0.0	0.0000	0.0000	0.00	0.00	0.00
2C1	Iron and Steel Production	CH_4	0.21	0.42	5	4	6.4	0.0	0.0000	0.0000	0.00	0.00	0.00
4A	Enteric fermentation	CH_4	3,246.28	3,235.47	5	30	30.4	0.8	-0.0055	0.0310	-0.17	0.22	0.27
4B	Manure management	CH_4	337.46	326.67	5	50	50.2	0.1	-0.0007	0.0031	-0.03	0.02	0.04
4C	Rice cultivation	CH_4	69.10	117.60	2	40	40.0	0.0	0.0003	0.0011	0.01	0.00	0.01
4F	Field burning of agr. residues	CH_4	27.06	31.08	20	20	28.3	0.0	0.0000	0.0003	0.00	0.01	0.01
6A1	Managed solid waste disposal	CH_4	58.37	640.26	20	40	44.7	0.2	0.0055	0.0061	0.22	0.17	0.28
6A2	Unmanaged solid waste disposal	CH_4	1,787.03	1,579.42	20	72	74.7	1.0	-0.0050	0.0151	-0.36	0.43	0.56
6A3	Municipal Sludge Disposal on Land	CH_4	12.97	244.32	20	40	44.7	0.1	0.0022	0.0023	0.09	0.07	0.11
6B	Wastewater handling	CH_4	2,835.35	839.12	30	100	104.4	0.7	-0.0239	0.0080	-2.39	0.34	2.41
6C	Waste incineration	CH_4	0.00	0.01	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
		Total CH_4	9,761.78	8,740.74									

	A	B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
1A1,2,4	Stationary Combustion - all fuels	N_2O	579.58	464.67	5	300	300.0	1.1	-0.0021	0.0045	-0.62	0.03	0.62
1A3	Road transport	N_2O	122.45	218.13	5	50	50.2	0.1	0.0007	0.0021	0.04	0.01	0.04
1A3	Navigation	N_2O	14.21	22.42	5	300	300.0	0.1	0.0001	0.0002	0.02	0.00	0.02
1A3	Civil Aviation	N_2O	7.71	15.55	5	300	300.0	0.0	0.0001	0.0001	0.02	0.00	0.02
1A3	Railway	N_2O	24.22	11.53	5	300	300.0	0.0	-0.0002	0.0001	-0.05	0.00	0.05
1A3	Other transportation	N_2O	0.00	0.00	5	300	300.0	0.0	0.0000	0.0000	0.00	0.00	0.00
1B	Oil and Natural gas	N_2O	0.20	0.02	5	300	300.0	0.0	0.0000	0.0000	0.00	0.00	0.00
2B	Nitric Acid	N_2O	1,109.04	367.42	2	20	20.1	0.1	-0.0090	0.0035	-0.18	0.01	0.18
3	Solvent and other product use	N_2O	138.63	154.23	5	300	300.0	0.4	-0.0001	0.0015	-0.02	0.01	0.03
4B	Manure management	N_2O	341.77	302.20	50	100	111.8	0.3	-0.0009	0.0029	-0.09	0.20	0.23
4D	Agricultural soils - direct emissions	N_2O	2,761.36	1,360.48	20	400	400.5	4.4	-0.0180	0.0130	-7.21	0.37	7.22
4D	Agricultural soils - indirect emissions	N_2O	2,868.92	1,774.73	20	50	53.9	0.8	-0.0153	0.0170	-0.76	0.48	0.90
4D	Animal Production	N_2O	1,821.24	1,779.65	50	100	111.8	1.6	-0.0034	0.0171	-0.34	1.21	1.25
4F	Field burning of agr. residues	N_2O	10.05	11.64	20	20	28.3	0.0	0.0000	0.0001	0.00	0.00	0.00
6B	Wastewater handling	N_2O	328.19	383.17	5	10	11.2	0.0	0.0000	0.0037	0.00	0.03	0.03
6C	Waste incineration	N_2O	0.01	0.13	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
		Total N_2O	10,127.58	6,865.96									
2E	HFC-23 Emissions from HCFC-22 Manufacture	HFC	935.06	0.00	50	50	70.7	0.0	-0.0105	0.0000	-0.53	0.00	0.53
2F	Substitutes for ODS	HFC	0.00	2,568.96	150	200	250.0	5.2	0.0246	0.0246	4.92	5.22	7.18
		Total HFC	935.06	2,568.96									
2C	PFC from Aluminium	PFC	263.38	36.13	3	6	6.7	0.0	-0.0026	0.0003	-0.02	0.00	0.02
2F	SF6 from electrical equipment	SF6	3.07	5.02	100	50	111.8	0.0	0.0000	0.0000	0.00	0.01	0.01
	TOTAL		104,365.21	122,543.32				8.671					11.245

Table IV.3 Uncertainty analysis with LULUCF

A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
1A1,2,4	Stationary Combustion - solid fuels	CO_2	39,254.88	41,544.85	5	5	7.1	2.5	-0.0441	0.4078	-0.22	2.88	2.89
1A1,2,4	Stationary Combustion - liquid fuels	CO_2	21,327.77	24,695.91	5	5	7.1	1.5	-0.0032	0.2424	-0.02	1.71	1.71
1A1,2,4	Stationary Combustion - gaseous fuels	CO_2	102.03	6,384.17	5	5	7.1	0.4	0.0615	0.0627	0.31	0.44	0.54
1A2	Stationary Combustion – Other fuels	CO_2	0.00	16.41	5	5	7.1	0.0	0.0002	0.0002	0.00	0.00	0.00
1A3	Road transport	CO_2	11,742.20	20,964.70	5	5	7.1	1.2	0.0705	0.2058	0.35	1.46	1.50
1A3	Navigation	CO_2	1,824.81	2,808.20	5	5	7.1	0.2	0.0065	0.0276	0.03	0.19	0.20
1A3	Civil Aviation	CO_2	716.84	1,451.76	5	5	7.1	0.1	0.0060	0.0143	0.03	0.10	0.11
1A3	Railway	CO_2	202.69	97.45	5	5	7.1	0.0	-0.0014	0.0010	-0.01	0.01	0.01
1A3	Other transportation	CO_2	0.00	0.00	5	5	7.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1B	Oil and Natural gas	CO_2	70.23	7.52	5	300	300.0	0.0	-0.0007	0.0001	-0.22	0.00	0.22
2A1	Cement Production	CO_2	5,640.90	4,581.72	2	2	2.8	0.1	-0.0200	0.0450	-0.04	0.13	0.13
2A2	Lime Production	CO_2	431.97	288.78	5	6	7.8	0.0	-0.0021	0.0028	-0.01	0.02	0.02
2A3	Limestone & Dolomite Use	CO_2	582.80	431.03	10	5	11.2	0.0	-0.0025	0.0042	-0.01	0.06	0.06
1A7	Other Mineral (Glass)	CO_2	20.20	13.33	5	3	5.8	0.0	-0.0001	0.0001	0.00	0.00	0.00
2B1	Ammonia Production	CO_2	240.28	187.61	3	6	6.7	0.0	-0.0009	0.0018	-0.01	0.01	0.01
2C1	Iron and Steel Production	CO_2	92.70	137.04	5	5	7.1	0.0	0.0003	0.0013	0.00	0.01	0.01
2C2	Ferroalloys	CO_2	622.23	356.46	7	7	9.9	0.0	-0.0037	0.0035	-0.03	0.03	0.04
2C3	Aluminium Production	CO_2	231.96	194.66	3	5	5.8	0.0	-0.0008	0.0019	0.00	0.01	0.01
3	Solvent and other product use	CO_2	169.71	161.38	5	300	300.0	0.4	-0.0004	0.0016	-0.11	0.01	0.11
5.A.1	Forest Land remaining Forest Land	CO_2	-1,327.31	-1,955.56	5	34	34.0	-0.6	-0.0039	-0.0192	-0.13	-0.14	0.19
5.A.2	Conversion to Forest Land	CO_2	0.00	-350.63	5	113	112.8	-0.3	-0.0034	-0.0034	-0.39	-0.02	0.39
5.B.1	Cropland remaining Cropland	CO_2	-1,205.41	-737.22	12	53	54.0	-0.3	0.0066	-0.0072	0.35	-0.13	0.37

A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
5.B.2	Conversion to Cropland	CO_2	0.03	0.00	10	50	51.0	0.0	0.0000	0.0000	0.00	0.00	0.00
5.C.2	Conversion to Grassland	CO_2	0.01	0.00	10	50	51.0	0.0	0.0000	0.0000	0.00	0.00	0.00
5.D.2	Land converted to Wetlands	CO_2	0.00	0.00	10	50	51.0	0.0	0.0000	0.0000	0.00	0.00	0.00
5.E.2	Conversion to Settlements	CO_2	2.30	0.00	10	50	51.0	0.0	0.0000	0.0000	0.00	0.00	0.00
5.F.2	Conversion to Other Land	CO_2	6.77	0.00	10	50	51.0	0.0	-0.0001	0.0000	0.00	0.00	0.00
6C	Waste incineration	CO_2	0.15	3.53	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
		Total CO_2	80,750.73	101,283.11									
1A 1,2,4	Stationary Combustion - all fuels	CH_4	105.62	101.90	5	100	100.1	0.1	-0.0002	0.0010	-0.02	0.01	0.02
1A3	Road transport	CH_4	89.96	80.34	4	40	40.2	0.0	-0.0002	0.0008	-0.01	0.00	0.01
1A3	Navigation	CH_4	2.37	0.95	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1A3	Civil Aviation	CH_4	0.26	0.51	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1A3	Railway	CH_4	2.38	1.13	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1A3	Other transportation	CH_4	0.00	0.00	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1B	Oil and Natural gas	CH_4	91.59	171.98	5	300	300.0	0.4	0.0006	0.0017	0.19	0.01	0.19
1B	Coal Mining	CH4	1,095.27	1,369.57	2	300	300.0	3.4	0.0008	0.0134	0.25	0.04	0.25
2B5	Other Chemicals (Organic chemicals production)	CH_4	0.52	0.00	5	5	7.1	0.0	0.0000	0.0000	0.00	0.00	0.00
2C1	Iron and Steel Production	CH_4	0.21	0.42	5	4	6.4	0.0	0.0000	0.0000	0.00	0.00	0.00
4A	Enteric fermentation	CH_4	3,246.28	3,235.47	5	30	30.4	0.8	-0.0056	0.0318	-0.17	0.22	0.28
4B	Manure management	CH_4	337.46	326.67	5	50	50.2	0.1	-0.0007	0.0032	-0.03	0.02	0.04
4C	Rice cultivation	CH_4	69.10	117.60	2	40	40.0	0.0	0.0004	0.0012	0.01	0.00	0.01
4F	Field burning of agr. residues	CH_4	27.06	31.08	20	20	28.3	0.0	0.0000	0.0003	0.00	0.01	0.01
5.A.1	Forest Land remaining Forest Land	CH_4	10.93	9.85	11	70	70.9	0.0	0.0000	0.0001	0.00	0.00	0.00
5.C.1	Grassland remaining Grassland	CH_4	14.03	12.70	10	70	70.7	0.0	0.0000	0.0001	0.00	0.00	0.00
6A1	Managed solid waste disposal	CH_4	58.37	640.26	20	40	44.7	0.2	0.0056	0.0063	0.22	0.18	0.29

A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
6A2	Unmanaged solid waste disposal	CH_4	1,787.03	1,579.42	20	72	74.7	1.0	-0.0051	0.0155	-0.37	0.44	0.57
6A3	Municipal Sludge Disposal on Land	CH_4	12.97	244.32	20	40	44.7	0.1	0.0022	0.0024	0.09	0.07	0.11
6B	Wastewater handling	CH_4	2,835.35	839.12	30	100	104.4	0.7	-0.0244	0.0082	-2.44	0.35	2.47
6C	Waste incineration	CH_4	0.00	0.01	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
		Total CH_4	9,786.74	8,763.28									
1A 1,2,4	Stationary Combustion - all fuels	N_2O	579.58	464.67	5	300	300.0	1.2	-0.0021	0.0046	-0.63	0.03	0.64
1A3	Road transport	N_2O	122.45	218.13	5	50	50.2	0.1	0.0007	0.0021	0.04	0.02	0.04
1A3	Navigation	N_2O	14.21	22.42	5	300	300.0	0.1	0.0001	0.0002	0.02	0.00	0.02
1A3	Civil Aviation	N_2O	7.71	15.55	5	300	300.0	0.0	0.0001	0.0002	0.02	0.00	0.02
1A3	Railway	N_2O	24.22	11.53	5	300	300.0	0.0	-0.0002	0.0001	-0.05	0.00	0.05
1A3	Other transportation	N_2O	0.00	0.00	5	300	300.0	0.0	0.0000	0.0000	0.00	0.00	0.00
1B	Oil and Natural gas	N_2O	0.20	0.02	5	300	300.0	0.0	0.0000	0.0000	0.00	0.00	0.00
2B	Nitric Acid	N_2O	1,109.04	367.42	2	20	20.1	0.1	-0.0092	0.0036	-0.18	0.01	0.18
3	Solvent and other product use	N_2O	138.63	154.23	5	300	300.0	0.4	-0.0001	0.0015	-0.02	0.01	0.03
4B	Manure management	N_2O	341.77	302.20	50	100	111.8	0.3	-0.0010	0.0030	-0.10	0.21	0.23
4D	Agricultural soils - direct emissions	N_2O	2,761.36	1,360.48	20	400	400.5	4.6	-0.0184	0.0134	-7.38	0.38	7.39
4D	Agricultural soils - indirect emissions	N_2O	2,868.92	1,774.73	20	50	53.9	0.8	-0.0156	0.0174	-0.78	0.49	0.92
4D	Animal Production	N_2O	1,821.24	1,779.65	50	100	111.8	1.7	-0.0035	0.0175	-0.35	1.24	1.28
4F	Field burning of agr. residues	N_2O	10.05	11.64	20	20	28.3	0.0	0.0000	0.0001	0.00	0.00	0.00
5.A.1	Forest Land remaining Forest Land	N_2O	1.11	1.00	11	70	70.9	0.0	0.0000	0.0000	0.00	0.00	0.00
5.C.1	Grassland remaining Grassland	N_2O	1.42	1.29	10	70	70.7	0.0	0.0000	0.0000	0.00	0.00	0.00
6B	Wastewater handling	N_2O	328.19	383.17	5	10	11.2	0.0	0.0000	0.0038	0.00	0.03	0.03
6C	Waste incineration	N_2O	0.01	0.13	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
		Total N_2O	10,130.11	6,868.25									

A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
2E	HFC-23 Emissions from HCFC-22 Manufacture	HFC	935.06	0.00	50	50	70.7	0.0	-0.0108	0.0000	-0.54	0.00	0.54
2F	Substitutes for ODS	HFC	0.00	2,568.96	150	200	250.0	5.4	0.0252	0.0252	5.04	5.35	7.35
		Total HFC	935.06	2,568.96									
2C	PFC from Aluminium	PFC	263.38	36.13	3	6	6.7	0.0	-0.0027	0.0004	-0.02	0.00	0.02
2F	SF6 from electrical equipment	SF6	3.07	5.02	100	50	111.8	0.0	0.0000	0.0000	0.00	0.01	0.01
	TOTAL		101,869.10	119,524.76				8.920					11.528

Legend

A: IPCC Source category 2002
B: Gas
C: Base year emissions 1990
D: Year t emissions 2001
E: Activity data uncertainty
F: Emission factor uncertainty
G: Combined uncertainty
H: Combined uncertainty as % of total national emissions in year t
I: Type A sensitivity
J: Type B sensitivity
K: Uncertainty in trend in national emissions introduced by emission factor uncertainty
L: Uncertainty in trend in national emissions introduced by activity data uncertainty
M: Uncertainty introduced into the trend in total national emissions

Annex V: Indirect greenhouse gases and SO_2

Nitrogen oxides

Emissions of nitrogen oxides in 2009 increased by 13.49% compared to 1990 levels, with an average annual rate of increase estimated at 0.71% for the period 1990 - 2009. Emissions of NO_x derive by 99.32% from the energy sector and especially from transport, which is responsible for the 51.64% of total NO_x emissions. In ***Table V.1*** NO_x emissions by source category for the period 1990 – 2009 are presented.

- The calculation of NO_x emissions from *Energy* (area sources) is based emission factors per source, fuel type and technology suggested by CORINAIR. For point sources, measurement data from the relative plants were used.
- In the sector *Industrial processes*, the NO_x emission factor for paper and pulp production, 1500 gr/t, derives from IPCC Guidelines, while the emissions factors for steel (200 kg/kt) and aluminium production (2150 kg/kt) derive from CORINAIR. NO_x emission factor for nitric acid production (2540 kg/kt) is calculated based on NO_x measurements taking place in the industrial plants.
- Emissions estimates for field burning of agricultural residues and of forest and grassland conversion are calculated by using the emission factors suggested by the IPCC Guidelines and the CORINAIR methodology (grassland conversion).

Carbon monoxide

Emissions of carbon monoxide in 2009 decreased by 52.07% approximately compared to 1990 levels, with an average annual rate of decrease estimated at 2.74% for the period 1990 – 2009. CO emissions derive by 90.19% from the energy sector and especially from transport, which is responsible for the 64.33% of total CO emissions. In ***Table V.2*** CO emissions by source category for the period 1990 – 2009 are presented.

- The calculation of CO emissions from *Energy* is based on emission factors per source, fuel type and technology suggested by CORINAIR.
- In the sector *Industrial processes*, the CO emission factors for paper and pulp and ammonia production. 5600 and 7900 gr/t of product respectively, come from the IPCC Guidelines, while the emission factors for glass and aluminium production (100 kg/kt and 135 kg/t respectively) derive from CORINAIR. CO emission factor for steel production (2.3 kg/kt) derives from the BREF report about Best Available Techniques in the sector of iron and steel production.
- Emissions estimates for field burning of agricultural residues and of forest and grassland conversion are calculated by using the emission factors suggested by the IPCC Guidelines and the CORINAIR methodology (grassland conversion).

Non-methane volatile organic compounds

NMVOC emissions decreased by 24.24% in 2009 compared to 1990, with an average annual rate of decrease estimated at 1.28%. NMVOC emissions derive by 53.60% from the energy sector and especially from transport, which is responsible for the 28.29% of total NMVOC emissions. In ***Table V.3*** NMVOC emissions by source category for the period 1990 – 2009 are presented.

- For the calculation of NMVOC emissions from *Energy* the emission factors per source, fuel type and technology suggested by CORINAIR were used.
- In the sector *Industrial processes*, the NMVOC emission factor for the production of glass (4500 gr/t), ammonia (4700 gr/t) paper and pulp (3700 gr/t), as well as the emission factors for organic chemicals, food and drinks, are those suggested by the IPCC Good Practice Guidance. NMVOC emission factor for steel production (90 kg/t) derives from CORINAIR.
- NMVOC emission factors for the Solvents and other products use have been already presented in Chapter 5 of the present inventory.

Sulphur dioxide

Sulphur dioxide emissions in 2009 decreased by 10.50% compared to 1990 levels, with an average annual rate of decrease estimated at 0.55% for the period 1990 - 2009. SO_2 emissions derive by 98.68% from the energy sector and mainly from the energy industries, which are responsible for the 78.09% of total SO_2 emissions. In ***Table V.4*** SO_2 emissions by source category for the period 1990 – 2009 are presented.

- The calculation of SO_2 emissions from the energy sector (area sources) is based on the sulphur content of the fuel. For point sources, measurement data from the relative plants were used.
- In the sector *Industrial processes*, the SO_2 emission factors for the production of cement (300 gr/t), ammonia (30 gr/t) and paper pulp (7000 gr/t) are those suggested by the IPCC Guidelines, while emission factors for glass (1700 gr/t), aluminium (14.2 kg/t) and steel production (130 kg/t) derive from CORINAIR. Emission factor for sulphuric acid production (3800 gr/t) is based on data from the relevant industries.

Table V.1 NOx emissions (in kt) by source category. for the period 1990 – 2009

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TOTAL	330.9	340.7	347.8	345.3	353.3	332.9	336.9	350.2	372.9	370.0	364.1	385.7	386.7	396.3	402.4	419.2	415.5	418.7	395.1	375.5
Energy	327.6	337.3	344.2	342.0	350.0	329.9	333.9	347.1	369.6	367.4	360.3	382.9	383.9	393.7	399.6	416.3	412.8	414.2	392.0	373.0
Fuel combustion	327.2	336.9	343.8	341.4	349.6	329.4	333.5	346.7	369.2	366.9	359.8	382.5	383.4	393.2	399.1	415.9	412.2	413.5	391.3	372.2
Energy industries	73.6	79.9	88.9	86.5	92.2	82.0	85.1	90.4	94.9	94.5	104.7	114.7	117.2	125.2	132.4	146.3	139.1	149.7	140.0	129.6
Industry	22.2	21.5	21.1	21.3	21.0	23.6	25.5	25.6	24.2	21.9	24.5	24.6	24.6	22.3	22.6	30.8	28.8	28.8	27.2	21.7
Transport	184.0	186.3	187.8	188.8	191.4	181.5	178.8	186.5	205.7	206.2	186.0	197.5	191.9	191.1	196.6	190.0	195.5	191.0	181.9	193.9
Other sectors	47.5	49.2	45.9	44.8	45.0	42.3	44.0	44.1	44.3	44.2	44.6	45.6	49.7	54.6	47.5	48.8	48.8	44.0	42.2	27.0
Fugitive emissions	0.4	0.4	0.5	0.5	0.4	0.5	0.4	0.4	0.5	0.5	0.5	0.4	0.5	0.5	0.4	0.5	0.6	0.7	0.7	0.7
Industrial processes	1.9	1.6	1.7	1.6	1.5	1.5	1.6	1.5	1.4	1.4	1.5	1.4	1.5	1.4	1.4	1.5	1.4	1.4	1.3	0.9
Nitric acid production	1.3	1.1	1.1	1.1	1.0	1.0	1.2	1.0	0.8	0.9	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4
Steel production	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.3	0.4	0.5	0.5	0.5	0.5	0.2
Aluminium production	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3
Paper and pulp	0.1	0.0	0.0	0.0	0.0	0.0	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Agriculture	1.2	1.6	1.3	1.3	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.3	1.3	1.2	1.3	1.3	1.2	1.2	1.4	1.4
Field burning of agricultural residues	1.2	1.6	1.3	1.3	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.3	1.3	1.2	1.3	1.3	1.2	1.2	1.4	1.4
LULUCF	0.3	0.2	0.6	0.4	0.4	0.2	0.2	0.3	0.7	0.1	1.1	0.2	0.0	0.0	0.1	0.1	0.1	1.9	0.2	0.3
Forest and grassland conversion	0.3	0.2	0.6	0.4	0.4	0.2	0.2	0.3	0.7	0.1	1.1	0.2	0.0	0.0	0.1	0.1	0.1	1.9	0.2	0.3

Table V.2 CO emissions (in kt) by source category. for the period 1990 – 2009

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TOTAL	1250.5	1231.8	1185.9	1183.8	1168.3	1069.0	1061.9	1068.4	1087.9	1061.2	1054.1	1020.2	975.1	932.8	923.0	722.5	740.9	748.0	630.1	599.3
Energy	1190.2	1164.4	1112.8	1117.9	1101.8	1012.5	1007.3	1008.4	1011.9	1007.7	964.6	961.7	922.3	881.1	866.0	667.0	685.9	630.9	566.6	540.5
Fuel combustion	1190.0	1164.2	1112.6	1117.6	1101.6	1012.2	1007.0	1008.1	1011.7	1007.5	964.4	961.5	922.0	880.8	865.7	666.8	685.6	630.6	566.2	540.1
Energy industries	36.4	34.8	36.8	37.0	38.8	37.2	36.2	39.7	42.3	42.5	46.0	46.8	46.2	47.0	48.7	48.8	45.5	49.0	47.0	45.6
Industry	9.5	9.5	9.4	9.4	9.1	9.7	10.1	10.2	10.0	9.7	10.9	11.4	11.3	9.4	9.4	15.8	12.3	12.3	11.3	11.0
Transport	878.9	849.9	801.0	806.3	788.4	701.4	695.0	691.9	693.8	690.8	642.0	639.3	600.0	579.0	566.8	501.2	519.2	455.4	405.8	385.6
Other sectors	265.2	269.9	265.4	265.0	265.3	264.0	265.7	266.3	265.6	264.4	265.5	264.1	264.5	245.3	240.9	101.0	108.6	113.9	102.2	97.9
Fugitive emissions	0.2	0.2	0.2	0.3	0.2	0.3	0.2	0.2	0.2	0.3	0.3	0.2	0.3	0.3	0.2	0.2	0.3	0.4	0.4	0.4
Industrial processes	22.9	22.8	22.2	20.6	18.7	18.6	18.7	18.9	21.7	23.5	23.1	22.4	22.9	23.7	23.8	23.5	23.6	23.7	23.1	18.3
Glass production	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ammonia production	2.5	2.0	1.3	0.6	NO	0.8	1.1	1.0	1.9	1.8	1.2	0.5	0.7	1.2	1.3	1.1	1.3	1.3	1.0	0.8
Steel production	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aluminium production	20.2	20.6	20.7	19.9	18.6	17.7	17.7	17.9	19.7	21.6	21.9	21.9	22.1	22.5	22.5	22.3	22.3	22.4	22.1	17.5
Paper and pulp	0.2	0.2	0.2	0.1	0.1	0.2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Agriculture	27.1	37.9	30.9	29.5	32.2	30.3	29.7	30.0	28.1	27.6	29.2	29.9	28.9	26.7	29.8	30.1	27.6	26.9	32.4	31.1
Field burning of agricultural residues	27.1	37.9	30.9	29.5	32.2	30.3	29.7	30.0	28.1	27.6	29.2	29.9	28.9	26.7	29.8	30.1	27.6	26.9	32.4	31.1
LULUCF	10.4	6.7	20.0	15.7	15.5	7.6	6.2	11.2	26.2	2.4	37.2	6.1	1.0	1.4	3.5	2.0	3.8	66.4	7.9	9.4
Forest and grassland conversion	10.4	6.7	20.0	15.7	15.5	7.6	6.2	11.2	26.2	2.4	37.2	6.1	1.0	1.4	3.5	2.0	3.8	66.4	7.9	9.4

Table V.3 NMVOC emissions (in kt) by source category. for the period 1990 – 2009

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TOTAL	279.2	281.1	276.9	276.3	274.8	269.1	269.4	271.2	277.4	279.3	273.9	271.4	268.2	256.0	255.7	221.8	231.7	220.6	228.4	211.6
Energy	195.6	194.1	189.8	189.4	188.9	179.7	180.1	181.1	182.3	180.9	170.9	169.3	163.8	158.6	152.5	134.3	133.9	129.1	119.1	113.4
Fuel combustion	173.4	172.5	167.0	167.4	165.5	154.4	154.2	154.6	154.9	154.4	142.3	141.0	134.6	128.6	123.6	102.6	100.7	94.2	85.5	79.9
Energy industries	5.1	5.2	5.2	5.1	5.4	5.3	5.3	5.7	5.6	5.8	6.1	6.3	5.9	6.2	6.4	6.7	6.5	6.7	6.7	6.1
Industry	4.9	4.9	4.9	4.8	4.7	4.9	5.2	5.2	5.1	4.9	5.6	5.4	5.5	4.7	4.6	4.5	4.5	4.7	5.4	4.5
Transport	139.1	137.5	132.8	133.5	131.5	120.7	120.0	120.0	120.5	120.1	106.9	105.6	99.1	94.0	90.0	79.4	77.0	70.2	61.8	59.8
Other sectors	24.3	24.8	24.2	24.0	24.0	23.6	23.8	23.8	23.7	23.6	23.7	23.7	24.1	23.7	22.6	12.0	12.7	12.6	11.5	9.5
Fugitive emissions	22.2	21.6	22.8	22.0	23.4	25.3	25.9	26.5	27.4	26.5	28.6	28.3	29.2	30.0	29.0	31.8	33.2	34.9	33.7	33.5
Industrial processes	27.0	28.8	29.6	30.7	31.6	37.7	38.2	38.8	43.7	44.6	49.8	49.8	51.8	44.8	50.4	34.4	44.1	37.6	55.3	43.9
Asphalt roofing	0.8	0.9	1.0	1.0	1.0	1.2	1.2	1.3	1.4	1.4	1.7	1.7	1.8	1.5	1.7	1.1	1.5	1.2	1.9	1.5
Road paving with asphalt	22.4	24.4	25.8	27.3	27.7	32.8	33.2	33.6	37.8	38.8	44.5	45.4	47.2	40.3	45.4	30.3	39.7	33.2	51.4	40.8
Glass production	0.6	0.6	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.5	0.4
Ammonia production	1.5	1.2	0.8	0.3	NO	0.8	0.6	0.6	1.2	1.1	0.7	0.3	0.4	0.7	0.8	0.7	0.8	0.8	0.6	0.5
Organic chemicals production	0.9	0.9	0.9	1.0	1.7	1.7	1.9	2.0	2.0	1.9	1.5	0.9	0.9	0.9	1.1	1.0	0.9	1.0	NA	NA
Steel production	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
Paper and pulp	0.1	0.1	0.1	0.1	0.1	0.1	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Food - Drinks	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.7	0.6	0.6	0.6	0.6	0.6
Solvents and other products use	56.6	58.3	57.5	56.2	54.3	51.6	51.1	51.4	51.4	53.8	53.2	52.3	52.5	52.6	52.7	53.1	53.7	53.9	54.0	54.2

Table V.4 SO_2 emissions (in kt) by source category. for the period 1990 – 2009

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TOTAL	477	518	535	532	523	541	531	530	537	556	497	505	516	555	549	528	534	539	446	427
Energy	468	509	527	524	515	532	522	521	528	547	489	497	508	546	540	518	527	531	439	422
Fuel combustion	461	502	519	515	508	525	517	514	520	538	480	489	499	537	533	510	516	519	427	408
Energy industries	299	341	362	373	382	407	387	379	378	405	371	372	383	422	414	414	402	406	366	334
Industry	94.5	91.2	89.7	78.5	65.7	70.7	79.6	79.5	70.7	59.0	68.6	67.4	69.3	64.2	63.4	43.4	58.5	62.5	18.8	11.8
Transport	39.0	39.0	41.3	38.6	43.0	32.3	30.9	37.9	52.7	56.6	21.6	28.9	25.3	26.8	31.9	28.0	30.6	27.7	23.5	47.0
Other sectors	28.6	30.7	26.3	24.6	17.7	15.1	19.4	17.5	18.1	17.6	18.8	20.4	20.6	23.8	23.4	24.1	24.9	22.3	18.3	15.9
Fugitive emissions	6.5	7.4	8.3	9.4	6.8	6.9	5.8	6.4	8.3	8.4	9.0	7.8	9.2	9.5	7.4	8.4	10.8	12.6	12.5	13.3
Industrial processes	9.6	9.1	8.3	7.9	8.1	8.8	8.6	8.9	9.1	9.3	8.5	8.4	8.5	8.6	8.7	10.1	7.7	7.7	7.4	5.6
Cement production	3.2	3.2	3.2	3.3	3.3	3.5	3.5	3.5	3.5	3.5	3.6	3.6	3.5	3.5	3.5	3.7	3.7	3.6	3.4	2.6
Glass production	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Ammonia production	0.0	0.0	0.0	0.0	NO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sulphuric acid production	3.6	3.2	2.3	2.1	2.4	2.9	2.9	3.1	3.1	3.2	2.1	2.0	2.2	2.2	2.3	3.5	1.2	1.2	1.1	0.9
Steel production	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.2
Aluminium production	2.1	2.2	2.2	2.1	2.0	1.9	1.9	1.9	2.1	2.3	2.3	2.3	2.3	2.4	2.4	2.3	2.3	2.4	2.3	1.8
Paper and pulp	0.3	0.2	0.2	0.1	0.1	0.2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Annex VI: Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded for the annual inventory submission and also for the KP-LULUCF inventory

Table VI shows sources of GHGs that are not estimated in the Greek GHG inventory, and the reasons for those sources being omitted. This table is taken from the CRF; "Table9(a)".

Table VI Assessment of Completeness

Sources and sinks not estimated (NE)			
GHG	**Sector**	**Source/sink category**	**Explanation**
Carbon	5 LULUCF	5.A.2.2 Grassland converted to Forest Land	Lack of AD
Carbon	5 LULUCF	5.E.1 5.E.1 Settlements remaining Settlements	Parties do not have to prepare estimates of emissions and removals from Settlements remaining Settlements
Carbon	5 LULUCF	5.F.2.2 Cropland converted to Other Land	
Carbon	5 LULUCF	5.A.2.2 Grassland converted to Forest Land	Lack of AD
Carbon	5 LULUCF	5.D.1 5.D.1 Wetlands remaining Wetlands	Parties do not have to prepare estimates of emissions and removals from Wetlands remaining Wetlands
Carbon	5 LULUCF	5.D.2.2 Cropland converted to Wetlands	
Carbon	5 LULUCF	5.D.2.4 Settlements converted to Wetlands	
Carbon	5 LULUCF	5.D.2.5 Other Land converted to Wetlands	
Carbon	5 LULUCF	5.E.1 5.E.1 Settlements remaining Settlements	Parties do not have to prepare estimates of emissions and removals from Settlements remaining Settlements
Carbon	5 LULUCF	5.E.2.2 Cropland converted to Settlements	
Carbon	5 LULUCF	5.F.2.2 Cropland converted to Other Land	
Carbon	5 LULUCF	5.A.2.2 Grassland converted to Forest Land	Lack of AD
Carbon	5 LULUCF	5.D.2.1 Forest Land converted to Wetlands	
Carbon	5 LULUCF	5.E.2.1 Forest Land converted to Settlements	
Carbon	5 LULUCF	5.F.2.1 Forest Land converted to Other Land	
Carbon	5 LULUCF	5.D.2.1 Forest Land converted to Wetlands	
Carbon	5 LULUCF	5.D.2.2 Cropland converted to Wetlands	

Sources and sinks not estimated (NE)			
GHG	**Sector**	**Source/sink category**	**Explanation**
Carbon	5 LULUCF	5.D.2.3 Grassland converted to Wetlands	Loss of carbon in Lands converted to Wetlands have not been estimated due to lack of sufficient data. However, this is expected to be relative small since peat extraction does not occur in the country and area flooded after 1990 is small.
Carbon	5 LULUCF	5.D.2.4 Settlements converted to Wetlands	
Carbon	5 LULUCF	5.D.2.5 Other Land converted to Wetlands	
Carbon	5 LULUCF	5.E.2.1 Forest Land converted to Settlements	
Carbon	5 LULUCF	5.E.2.3 Grassland converted to Settlements	
Carbon	5 LULUCF	5.F.2.1 Forest Land converted to Other Land	
Carbon	5 LULUCF	5.F.2.2 Cropland converted to Other Land	
Carbon	5 LULUCF	5.F.2.3 Grassland converted to Other Land	
CH4	1 Energy	1.B.2.D Geothermal	Lack of background information and methodogical approach
CH4	4 Agriculture	4.D.1 Direct Soil Emissions	There has not been any method for the estimation of CH4 emissions from this source.
CH4	4 Agriculture	4.D.3 Indirect Emissions	There has not been any method for the estimation of CH4 emissions from this source.
CH4	5 LULUCF	5.D.2 5.D.2 Land converted to Wetlands	
CO2	1 Energy	1.B.2.D Geothermal	Lack of background information and methodogical approach
CO2	2 Industrial Processes	2.A.5 Asphalt Roofing	Not available methodology in the IPCC guidelines.
CO2	2 Industrial Processes	2.A.6 Road Paving with Asphalt	Not available methodology in the IPCC guidelines.
CO2	2 Industrial Processes	2.B.5 Organic chemicals production	No method in the IPCC Guidelines
HFCs	2 Industrial Processes	2.F.1 Refrigeration and Air Conditioning Equipment	Lack of AD for potential emisisons.
HFCs	2 Industrial Processes	2.F.2 Foam Blowing	Lack of activity data
HFCs	2 Industrial Processes	2.F.3 Fire Extinguishers	Lack of AD for potential emisisons.
HFCs	2 Industrial Processes	2.F.4 Aerosols/ Metered Dose Inhalers	Lack of AD for potential emisisons.

Sources and sinks not estimated (NE)			
GHG	**Sector**	**Source/sink category**	**Explanation**
N2O	1 Energy	1.B.2.D Geothermal	Lack of background information and methodogical approach
N2O	5 LULUCF	5.D.2 5.D.2 Land converted to Wetlands	
SF6	2 Industrial Processes	2.F.8 Electrical Equipment	Lack of AD for potential emissions.
SF6	2 Industrial Processes	2.F.P2.1 In bulk	Lack of AD for potential emissions.
SF6	2 Industrial Processes	2.F.P2.2 In products	Lack of AD for potential emissions.
SF6	2 Industrial Processes	2.F.P4 Destroyed amount	Lack of AD for potential emissions.

Sources and sinks reported elsewhere (IE)				
GHG	**Source/sink category**	**Allocation as per IPCC Guidelines**	**Allocation used by the Party**	**Explanation**
Carbon	5.B.2.2 Grassland converted to Cropland			
Carbon	5.A.1 Forest Land remaining Forest Land		Included in Gains	
CH4	1.B.1.A.2.2 Post-Mining Activities	Post mining activities	Mining activities	Good Practice Guidance, p.2.75
CH4	1.B.1.B Solid Fuel Transformation		Emissions from this sub-source category are assumed to be negligible, as the gas content of surface coal are typically very low. Emissions can be viewed as being accommodated within the surface emission factor of mining activities.	
CH4	1.B.2.B.5.1 at industrial plants and power stations		Included in category 1.B.2.B.3 & 4	
CH4	1.B.2.B.5.2 in residential and commercial sectors		Included in category 1.B.2.B.3 & 4	
CH4	6.A.2.2 shallow (<5 m)	Unmanaged Waste Disposal on Land - Uncategorized SWDS		
CH4	6.B.2.1 Domestic and Commercial (w/o human sewage)	Domestic and commercial wastewater handling	Solid waste disposal on land	Sludge from domestic wastewater handling is landfilled on managed waste disposal sites
CH4	1.AA.2.B Non-Ferrous Metals	Reallocation from Energy to IP sector (as non-energy use of fuels).	Reallocation from Energy to IP sector (as non-energy use of fuels).	Reallocation from Energy to IP sector (as non-energy use of fuels).
CH4	1.AA.3.B Road Transportation		CH4 and N2O emissions are calculated with COPERT and are based on the distance travelled and not on the statistical fuel consumption, as emission factors are determined experimentally with measurements of the gas mass exhausted per kilometre at the end-of-pipe. Therefore, the CH4 and N2O emissions are incorporated in the total emissions amount for each gas of gasoline, diesel and LPG.	CH4 and N2O emissions are calculated with COPERT and are based on the distance travelled and not on the statistical fuel consumption, as emission factors are determined experimentally with measurements of the gas mass exhausted per kilometre at the end-of-pipe. Therefore, the CH4 and N2O emissions are incorporated in the total emissions amount for each gas of gasoline, diesel and LPG.
CH4	Other non-specified		For confidentiality reasons, military fuel use is not reported separately	

Sources and sinks reported elsewhere (IE)				
GHG	**Source/sink category**	**Allocation as per IPCC Guidelines**	**Allocation used by the Party**	**Explanation**
			but included under the relevant categories in the energy sector.	
CO2	1.B.2.A.4 Refining / Storage		Inluded in fuel combustion sector.	
CO2	1.B.2.B.5.1 at industrial plants and power stations		Included in category 1.B.2.B.3 & 4	
CO2	1.B.2.B.5.2 in residential and commercial sectors		Included in category 1.B.2.B.3 & 4	
CO2	2.A.4.2 Soda Ash Use	2 A 4 2 Soda ash use	2 A 7 1 Glass production	Emissions from soda ash use are included in emissions from glass production.
CO2	1.AA.2.B Non-Ferrous Metals	Reallocation from Energy to IP sector (as non-energy use of fuels).	Reallocation from Energy to IP sector (as non-energy use of fuels).	Reallocation from Energy to IP sector (as non-energy use of fuels).
CO2	SO2 scrubbing	Reallocated to IP 2.A.3 category.	Reallocated to IP 2.A.3 category.	Reallocated to IP 2.A.3 category.
CO2	Other non-specified		For confidentiality reasons, military fuel use is not reported separately but included under the relevant categories in the energy sector.	
CO2	5.A.1 Forest Land remaining Forest Land			
N2O	6.B.1 Industrial Wastewater			Emissions from sludge are reported in Industrial wastewater/wastewater
N2O	6.B.2.1 Domestic and Commercial (w/o human sewage)	IE		N2O emissions are reported in Human sewage
N2O	1.AA.2.B Non-Ferrous Metals	Reallocation from Energy to IP sector (as non-energy use of fuels).	Reallocation from Energy to IP sector (as non-energy use of fuels).	Reallocation from Energy to IP sector (as non-energy use of fuels).
N2O	1.AA.3.B Road Transportation		CH4 and N2O emissions are calculated with COPERT and are based on the distance travelled and not on the statistical fuel consumption, as emission factors are determined experimentally with measurements of the gas mass exhausted per kilometre at the end-of-pipe. Therefore, the CH4 and N2O emissions are incorporated in the total emissions amount for each gas of gasoline, diesel and LPG.	CH4 and N2O emissions are calculated with COPERT and are based on the distance travelled and not on the statistical fuel consumption, as emission factors are determined experimentally with measurements of the gas mass exhausted per kilometre at the end-of-pipe. Therefore, the CH4 and N2O emissions are incorporated in the total emissions amount for each gas of gasoline, diesel and LPG.
N2O	Other non-specified		For confidentiality reasons, military fuel use is not reported separately	

Sources and sinks reported elsewhere (IE)				
GHG	**Source/sink category**	**Allocation as per IPCC Guidelines**	**Allocation used by the Party**	**Explanation**
			but included under the relevant categories in the energy sector.	
SF6	2.F.8 Electrical Equipment		Not enough data to permit the separate reporting of installation emissions in manufacture. See also Planned Improvements of the Category in NIR 2011.	