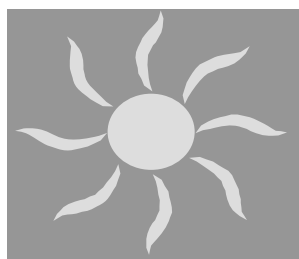


**MINISTRY OF ENVIRONMENT, ENERGY
AND CLIMATE CHANGE**

CLIMATE CHANGE



EMISSIONS INVENTORY

**ANNUAL INVENTORY SUBMISSION UNDER
THE CONVENTION AND THE KYOTO
PROTOCOL FOR GREENHOUSE AND OTHER
GASES FOR THE YEARS 1990-2008**

APRIL 2010

**ANNUAL INVENTORY SUBMISSION
UNDER THE CONVENTION AND
THE KYOTO PROTOCOL
FOR GREENHOUSE AND OTHER GASES
FOR YEARS 1990-2008**

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 1990-2008. **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 centralised review of the GHG inventory submitted in 2009, held from 21 to 26 of September 2009, 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 (CO₂, CH₄, N₂O, HFC, PFC and SF₆) 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 CO₂ 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 $15\% \pm 3\%$ by 2000 compared to 1990 levels. The measures taken in order to achieve this restriction in the CO₂ emissions were described in the 1st Greek National Action Plan for the abatement of CO₂ 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 CO₂, CH₄ and N₂O 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: Elpida Politi, Address: Villa Kazouli, Kifisias 241, Athens, Greece, e-mail: e.politi@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 has 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 National Statistical Service of Greece (NSSG), 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. National Statistical Service of Greece 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.

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.

Regarding LULUCF and Article 3.3 and 3.4 activities, the General Directorate for the Development and Protection of Forests of MEECC prepares the specific sections of the NIR and CRF tables concerning 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.

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 (CO₂, CH₄, N₂O, HFC, PFC and SF₆) for the period 1990 - 2008 are presented in **Table ES.1** (in kt CO₂ 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 CO₂, CH₄, and N₂O - 1995 for F-gases) were estimated at 105.44 Mt CO₂ 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 2008, GHG emissions (without *LULUCF*) amounted to 126.89 Mt CO₂ eq showing an increase of 20.34 % compared to base year emissions and of 22.85% compared to 1990 levels. If emissions / removals from *LULUCF* were to be included then the increase would be 22.72 % (from 100.81 Mt CO₂ eq in 1990 to 123.71 Mt CO₂ eq in 2008).

Carbon dioxide emissions accounted for 86.50% of total GHG emissions in 2008 (without *LULUCF*) and increased by approximately 32.41% from 1990. Methane emissions accounted for 6.20% of total GHG emissions in 2008 and decreased by 12.55% from 1990, while nitrous oxide emissions accounted for 5.60 % of the total GHG emissions in 2008 and decreased by 30.38% from 1990. Finally, F-gases emissions that accounted for 1.70% of total GHG emissions in 2008, decreased by 35.47% from 1995 (base year for F-gases), due to cease of HCFC-22 production.

Table ES.1a *Total GHG emissions in Greece (in kt CO₂ 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	82896.10	82660.21	84415.62	83781.85	86108.06	86529.43	88687.28	93483.50	98340.40	97699.49	103001.54
CH ₄	8995.52	8995.17	8923.29	8916.78	9011.15	9034.64	9196.23	9182.99	9239.69	9057.93	8891.59
N ₂ O	10199.86	9880.49	9714.56	8853.99	8669.98	8957.13	9191.97	8972.94	8872.01	8808.37	8658.44
HFC	935.06	1106.82	908.39	1606.64	2143.91	3259.05	3764.10	4019.62	4503.28	5296.54	4149.68
PFC	257.62	257.56	252.30	152.59	93.62	82.97	71.74	165.34	203.75	131.72	148.38
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	103287.23	102903.42	104217.41	103315.20	106030.16	107866.80	110915.00	115828.12	121162.91	120997.92	124853.62
B. GHG emissions/removals from LULUCF											
CO ₂	-2504.65	-2587.33	-2889.81	-3238.30	-2861.07	-3200.05	-2926.53	-2986.95	-3303.36	-3540.60	-3132.65
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 ₂ O	2.53	1.63	4.87	3.83	3.78	1.86	1.52	2.72	6.37	0.58	9.05
Total	-2477.16	-2569.67	-2836.94	-3196.71	-2820.03	-3179.85	-2910.04	-2957.47	-3234.20	-3534.28	-3034.38
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	16.73	15.37	17.67	20.55	21.83	23.39	20.62	20.76	23.14	20.72	23.83
N ₂ O	90.21	81.50	91.52	104.26	113.64	118.06	106.04	105.86	116.41	109.99	118.83
Total	10582.24	9575.47	10774.91	12337.14	13387.00	14004.00	12525.96	12469.78	13734.57	12816.03	13999.80

Table ES.1b *Total GHG emissions in Greece (in kt CO₂ eq) for the period 2001-2008*

	2001	2002	2003	2004	2005	2006	2007	2008
A. GHG emissions per gas (excluding LULUCF)								
CO ₂	105340.31	104973.06	109137.72	109429.40	113178.02	111280.61	114275.13	109760.98
CH ₄	8492.34	8464.82	8343.26	8236.02	8083.62	8048.10	7953.96	7866.53
N ₂ O	8498.32	8382.99	8260.72	8212.37	7893.12	7638.02	7877.59	7100.96
HFC	3756.59	3947.36	3732.36	3889.62	3595.15	1646.48	1700.82	2077.34
PFC	91.38	88.33	77.30	71.38	71.31	71.16	58.66	74.17
SF ₆	4.06	4.25	4.25	4.47	6.45	8.37	9.92	7.53
Total	126183.01	125860.81	129555.62	129843.27	132827.66	128692.73	131876.07	126887.50
B. GHG emissions/removals from LULUCF								
CO ₂	-3221.16	-3320.22	-2998.71	-3172.58	-3154.05	-3242.40	-3202.44	-3197.14
CH ₄	14.74	2.43	3.31	8.29	4.70	9.04	159.33	19.03
N ₂ O	1.50	0.25	0.34	0.84	0.48	0.92	16.17	1.93
Total	-3204.92	-3317.54	-2995.06	-3163.45	-3148.87	-3232.45	-3026.95	-3176.18
C. GHG emissions from International Transport								
CO ₂	13351.48	12214.71	13150.47	13327.28	11465.99	12663.40	12934.93	12387.32
CH ₄	23.17	20.80	21.34	21.53	19.07	20.59	21.00	20.48
N ₂ O	114.49	105.12	114.16	115.76	92.76	101.43	108.74	103.88
Total	13489.14	12340.63	13285.97	13464.57	11577.82	12785.42	13064.67	12511.68

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 2008 accounted for 81.98% of total GHG emissions (without LULUCF) and increased by approximately 34.13% 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 and the introduction of natural gas in the Greek energy system represent the basic factors affecting emissions trends from *Energy*.

The evolution of GHG emissions from Energy can be distinguished into three 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 0.85% 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 increase of GDP for the same period (3.4%). Finally, the average annual rate of emissions increase for the period 2000 – 2008 decreased at 0.9% while GDP increased with higher rate (approximately 4%).

The majority of GHG emissions (55.5%) in 2008 derived from energy industries, while the contribution of transport, manufacturing industries and construction and other sectors is estimated at 21.8%, 9.0% and 12.2% 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. However, the positive results from the improvement of the vehicles performance are reduced by the high use of passenger cars in transportation activity. The implemented, adopted and planned measures for the improvement of public transport means is expected to moderate the high use of passenger cars.

- ↳ Emissions from *Industrial processes* in 2008 accounted for 8.40% of the total emissions (without LULUCF) and increased by approximately 10.69% compared to 1990 levels. Intense fluctuation is observed mainly due to the cease of HCFC-22 production. Emissions in 2008 are lower than emissions of 2008, with a decrease of 2.70%.
- ↳ The contribution of the *Solvents and other products use* sector to total GHG emissions is minor (0.25% of the total emissions) and has slightly increased compared to 1990 level of emissions.
- ↳ Emissions from *Agriculture* that accounted for 7.03% of total emissions in 2008 (without LULUCF), decreased by approximately 21.42% compared to 1990 levels. Emissions reduction is mainly due to the reduction of N₂O 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 sector *Waste* (2.34% of the total emissions, without *LULUCF*), decreased by approximately 33.16% 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 – 2008. During this period, the *LULUCF* sector offset about 2.3-3.1% of the total national emissions (without *LULUCF*). The magnitude of this sink increased from approximately 2.5 Mt CO₂ eq in 1990, to 3.2 Mt CO₂ eq in 2008, i.e. an increase of 28%. 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 CO₂ eq) by sector for the period 1990-2000*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy	77556.50	77372.33	79092.68	78658.51	80876.16	80850.63	83107.14	87852.87	92656.25	92121.84	97134.02
Industrial processes	9631.07	9586.39	9520.14	9839.67	10449.86	12022.94	12685.18	12985.91	13517.96	14194.97	13491.21
Solvents	308.34	315.54	314.37	312.95	307.39	299.82	298.22	300.20	300.40	308.73	306.61
Agriculture	11348.67	11166.71	10945.42	10172.86	10011.76	10328.65	10425.84	10288.48	10294.45	10173.30	9988.70
Waste	4442.65	4462.44	4344.80	4331.20	4384.99	4364.75	4398.62	4400.65	4393.85	4199.08	3933.08
Total ¹⁾	103287.23	102903.42	104217.41	103315.20	106030.16	107866.80	110915.00	115828.12	121162.91	120997.92	124853.62
LULUCF	-2477.16	-2569.67	-2836.94	-3196.71	-2820.03	-3179.85	-2910.04	-2957.47	-3234.20	-3534.28	-3034.38
Index per sector											
Energy	100.00	99.76	101.98	101.42	104.28	104.25	107.16	113.28	119.47	118.78	125.24
Industrial processes	100.00	99.54	98.85	102.17	108.50	124.83	131.71	134.83	140.36	147.39	140.08
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	98.40	96.45	89.64	88.22	91.01	91.87	90.66	90.71	89.64	88.02
Waste	100.00	100.45	97.80	97.49	98.70	98.25	99.01	99.05	98.90	94.52	88.53
Total ²⁾	100.00	99.63	100.90	100.03	102.66	104.43	107.39	112.14	117.31	117.15	120.88

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 CO₂ eq) by sector for the period 2001-2008*

Year	2001	2002	2003	2004	2005	2006	2007	2008
Energy	99562.16	99322.50	103282.00	103500.94	106695.31	104921.93	107995.53	104025.19
Industrial processes	12913.45	12993.76	12896.83	13049.21	13260.83	10984.35	10955.99	10660.45
Solvents	304.28	305.13	305.93	306.75	309.29	311.92	313.41	314.13
Agriculture	9930.74	9862.91	9736.34	9764.69	9441.75	9297.65	9576.20	8918.26
Waste	3472.37	3376.51	3334.53	3221.67	3120.49	3176.88	3034.93	2969.47
Total ¹⁾	126183.01	125860.81	129555.62	129843.27	132827.66	128692.73	131876.07	126887.50
LULUCF	-3204.92	-3317.54	-2995.06	-3163.45	-3148.87	-3232.45	-3026.95	-3176.18
Index per sector								
Energy	128.37	128.06	133.17	133.45	137.57	135.28	139.25	134.13
Industrial processes	134.08	134.92	133.91	135.49	137.69	114.05	113.76	110.69
Solvents	98.68	98.96	99.22	99.48	100.31	101.16	101.64	101.88
Agriculture	87.51	86.91	85.79	86.04	83.20	81.93	84.38	78.58
Waste	78.16	76.00	75.06	72.52	70.24	71.51	68.31	66.84
Total ²⁾	122.17	121.86	125.43	125.71	128.60	124.60	127.68	122.85

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 (NO_x), carbon monoxide (CO), non-methane organic volatile compounds (NMVOC) and sulphur dioxide (SO₂) emissions for the period 1990-2008.

The key features of emissions trends for indirect greenhouse gases and SO₂ are the following:

- ↪ NO_x emissions increased by 20.76% from 1990 to 2008. Energy sector accounts for the high majority of emissions (99.19%). 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 40.37% of total NO_x emissions in 2008). Emissions from *Industrial processes* decreased by 35.18% 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 48.67% from 1990 to 2008 and as a result total CO emissions in 2008 decreased by 46.06%. Emissions from industrial processes in 2008 increased by 1.02% compared to 1990 levels. The variation of CO emissions from *LULUCF* is related to the intensity and number of forest fires. In 2008 emissions from *LULUCF* accounted for 1.14% of total CO emissions (incl *LULUCF*), and are by 23.75% higher than emissions of 1990.
- ↪ NMVOC emissions decreased by 27.21% from 1990 to 2008. Emissions from transport (23.81% of total NMVOC emissions in 2008), decreased by 67.52% compared to 1990 levels, while emissions from *Energy* decreased by 49.53% from 1990 to 2008. The significant increase of NMVOC emissions from *Industrial processes* (approximately 104.86% from 1990 to 2008) is attributed to the non-energy use of bitumen in the construction sector. Emissions from Solvents and other products use decreased by 4.65% compared to 1990 levels.
- ↪ SO₂ emissions decreased by 5.09% from 1990 to 2008. Emissions from electricity generation, which is the main source of SO₂ emissions in Greece (74.06 % of total SO₂ emissions for 2008, increased with a mean annual rate of increase of 1.1% for the period 1990 – 2008. The operation of desulphurisation plants at large installations for electricity generation since 1998 resulted in the restriction of the increase of SO₂ 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 SO₂ emissions from manufacturing industry and construction and transport by 80.12% and 25.27% respectively for the period 1990 – 2008. Emissions from *Industrial processes* decreased by 23.20% from 1990 due to decrease of sulphuric acid industrial production.

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PART I: ANNUAL INVENTORY SUBMISSION

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 (CO₂), methane (CH₄), nitrous oxide (N₂O) and ozone (O₃). In the last few years, a new category of greenhouse gases has emerged that includes hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulphur hexafluoride (SF₆). 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 (NO_x), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO₂).

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 (CO₂, CH₄, N₂O, HFC, PFC and SF₆) 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 CO₂ 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 CO₂ 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 $15\% \pm 3\%$ by 2000 compared to 1990 levels. The measures taken in order to achieve this restriction in the CO₂ emissions were described in the 1st Greek National Action Plan for the abatement of CO₂ and other greenhouse gases emissions (MINENV / NTUA 1995).

With respect to the EU target under the Kyoto Protocol (i.e. 8% reduction of emissions 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 CO₂, CH₄ and N₂O 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 1990-2008, and the mandatory supplementary information required for the 2010 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 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: Elpida Politi, Address: Villa Kazouli, Kifisias 241, Athens, Greece, e-mail: e.politi@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 has 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 contribute 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 focal persons 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.

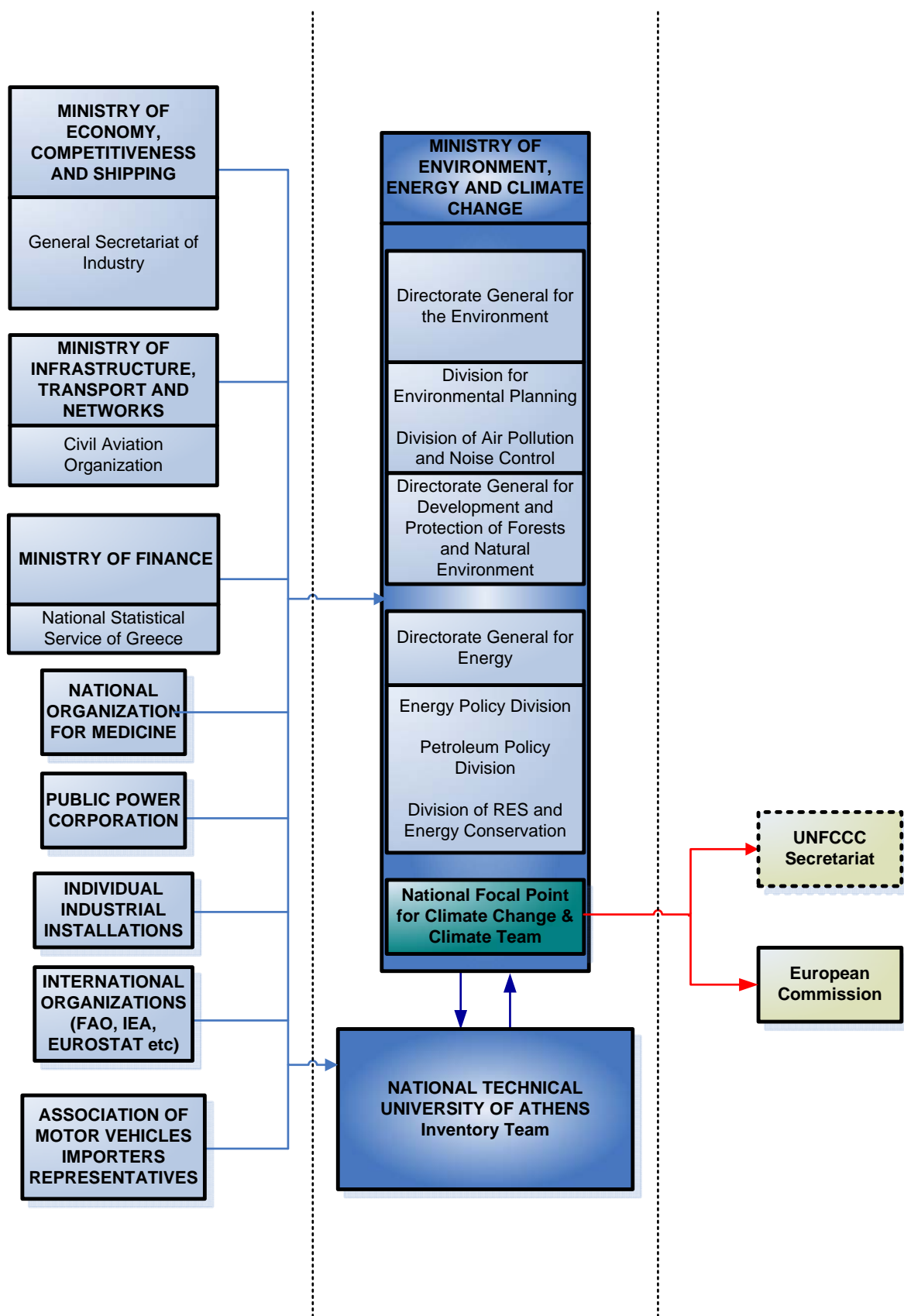


Figure 1.1 *Organizational Structure of the National Inventory System*

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/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. Elpida Politi, National UNFCCC focal point, *Co-ordinator*

2. Afroditi Kotidou
3. Nektaria Efthymiou-Charalampopoulou
4. Christina Moraiti
5. Dionisios Ballas

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 Division of Air pollution and Noise Control. 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 fulfill 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:

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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 and ministries and agencies, 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: Konstantinos Chatzigianakis (alternate Loukas Georgalas), Ioannis Macheras, Eirini Nikolaou) 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 SO₂ emissions (Division of Air pollution and Noise control)
 - data for solid waste management (Department of Solid Waste Management)
 - data for wastewater treatment (Central Water Agency)

- activity data and emissions of the installations included in the Emissions Trading system (Emissions Trading Office)
 - data for f-gases use (Division of Air pollution and Noise control)
 - LULUCF and emissions / removals from activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol. The above-mentioned 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, which are incorporated by the inventory team to the NIR and CRF tables submitted to the MEECC Climate team for approval and submission.
- The National Statistical Service of Greece (Contact person: Ioanna Papanagnou -alternate Konstantina Kantartzi), supervised by the Ministry of Finance, 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 (Contact person: Evaggelia Papadopoulou – alternate Konstantinos Stavropoulos) provides information and data 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: Panagiotis Tselikas) provides information and data for the vehicle fleet and its technical characteristics. The Civil Aviation Organization (Contact person: Anastasios Kokkinos), 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 Organization 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 National Statistical Service of Greece (NSSG), 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. National Statistical Service of Greece 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.

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.

Regarding LULUCF and Article 3.3 and 3.4 activities, the General Directorate for the Development and Protection of Forests of MEECC prepares the specific sections of the

NIR and CRF tables concerning 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.

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.

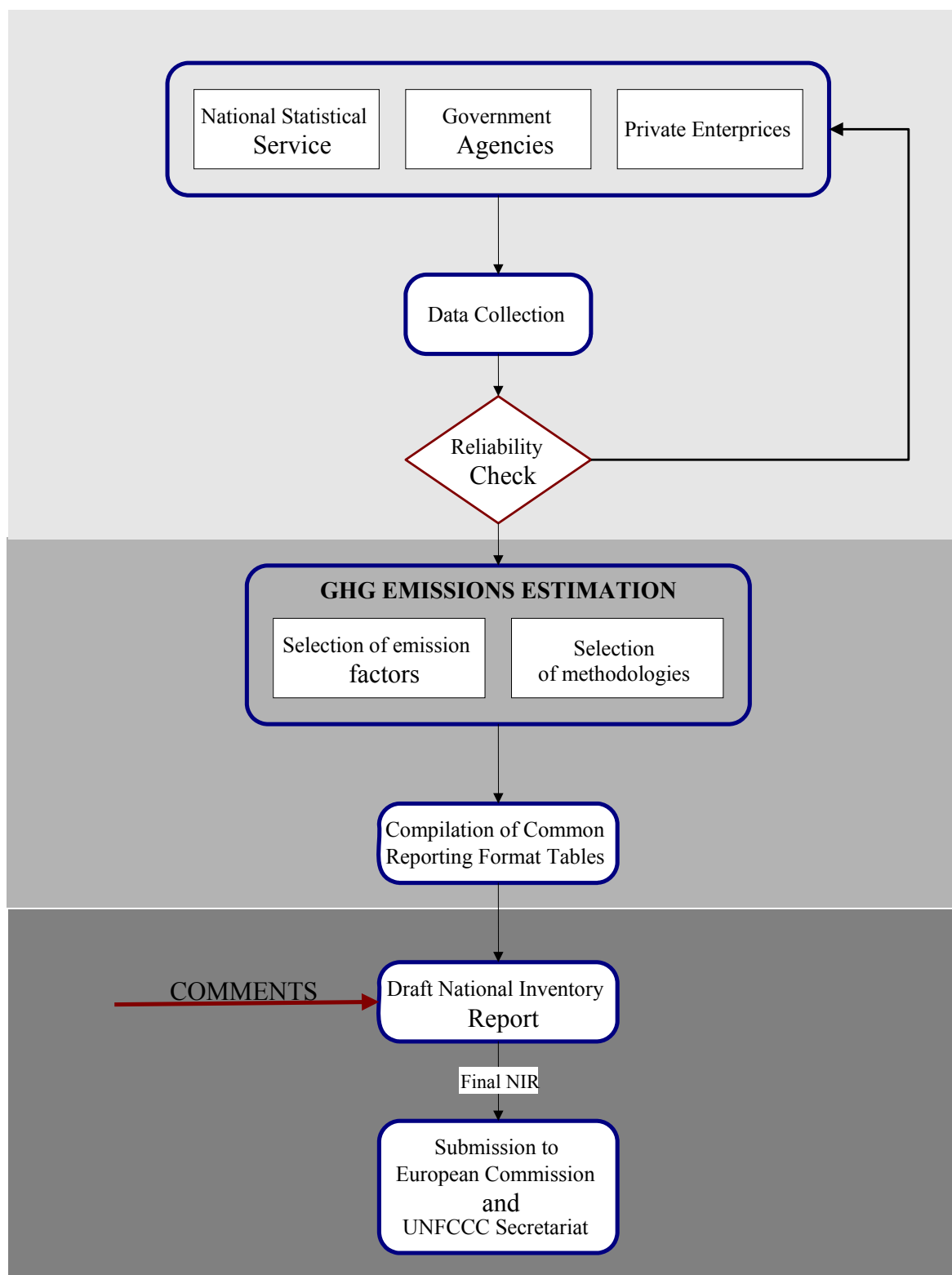


Figure 1.2 *GHG emissions inventory preparation process in Greece*

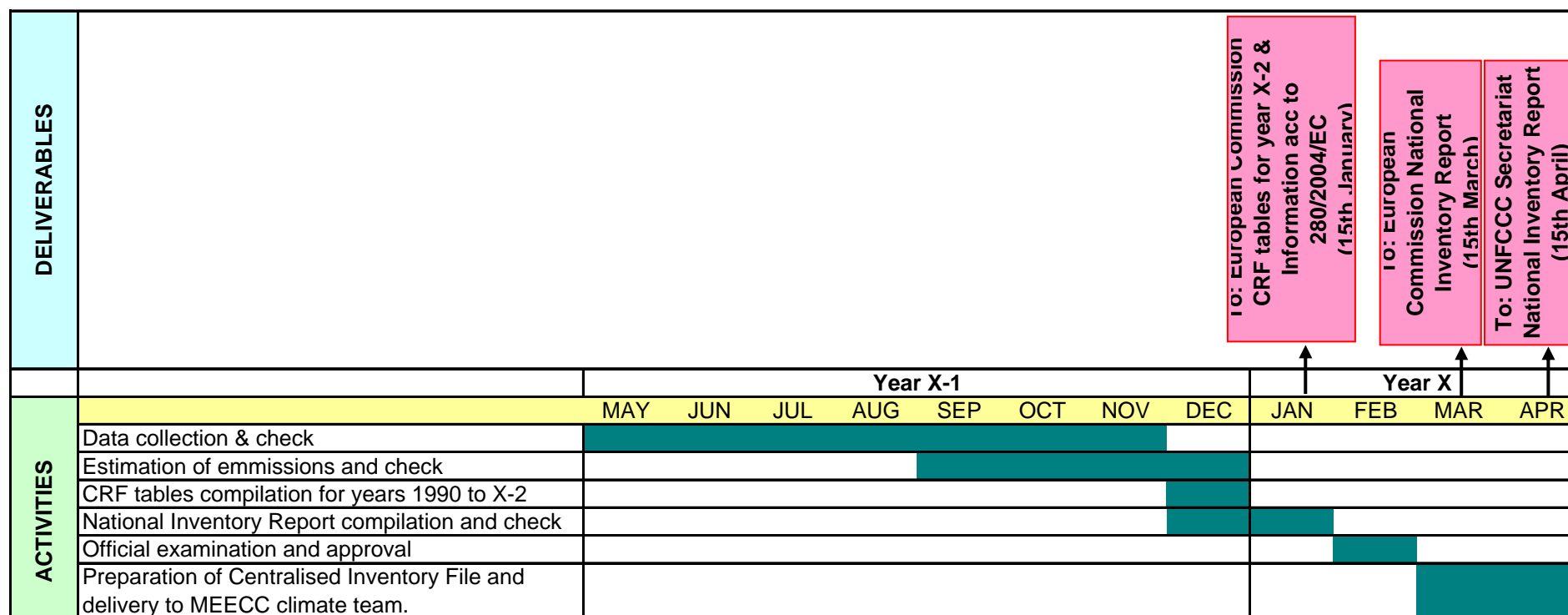


Figure 1.3 *Timetable for the preparation and submission of GHG emissions/removals inventory in Greece*

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.minenv.gr/4/41/g4130.html>).

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 handled 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 methodology¹. 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	T2	CS,PS	T2	D	T2	D		
2. Manufacturing industries and Construction	T2	CS,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	T2	CS,D	T2	D	T2	D		
B. Fugitive emissions from fuels								
1. Solid fuels	IE, NO	IE, NO	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,PS	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, NO	D, NO
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	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	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	CS	T1	D	T1	D		
D. Wetlands	T2	CS	NA	NA	NA	NA		
E. Settlements	T2	CS	NA	NA	NA	NA		
F. Other Land	T2	CS	NA	NA	NA	NA		
6. Waste								
A. Solid waste disposal on land	NA	NA	T2	CS,D				
B. Wastewater handling			D	D	D	D		
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 2005-2008 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	<ul style="list-style-type: none"> Public Power Corporation Ministry of Environment, Energy and Climate Change ETS verified reports
1.A2	Manufacturing industry and construction	Fuel consumption	<ul style="list-style-type: none"> Ministry of Environment, Energy and Climate Change ETS verified reports
1.A3	Transport	Number of vehicles	<ul style="list-style-type: none"> Ministry of Infrastructure, Transport and Networks National Statistical Service of Greece Association of Greek Auto Importers
		Aircraft landing and take off cycles	<ul style="list-style-type: none"> Civil Aviation Organization
1.A4	Residential / Tertiary sector / Agriculture	Fuel consumption	<ul style="list-style-type: none"> Ministry of Environment, Energy and Climate Change
1.B	Fugitive emissions from fuels	Amount of fuels Transmission/distribution pipelines length	<ul style="list-style-type: none"> Ministry of Environment, Energy and Climate Change
2	Industrial processes	Industrial production	<ul style="list-style-type: none"> National Statistical Service of Greece 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	<ul style="list-style-type: none"> National Statistical Service of Greece Ministry of Environment, Energy and Climate Change
4	Agriculture	Cultivated areas Agricultural production Livestock population Fertilizer use	<ul style="list-style-type: none"> National Statistical Service of Greece Ministry of Rural Development and Food 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	<ul style="list-style-type: none"> Ministry of Environment, Energy and Climate Change National Statistical Service of Greece
6	Waste	Quantities - composition of solid waste generated Recycling Population Industrial production	<ul style="list-style-type: none"> Ministry of Environment, Energy and Climate Change Association of Communities and Municipalities in the Attica Region (ACMAR) National Statistical Service of Greece 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 (NO_x, 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 CO₂ eq) for the 100-year horizon*

Gas	GWP
Carbon dioxide (CO ₂)	1
Methane (CH ₄)	21
Nitrous oxide (N ₂ O)	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 ₂ F ₆	9200
C ₄ F ₁₀	7000
C ₆ F 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 2008 are presented in **Table 1.4**. Differences compared to the results of the analysis presented in the

previous submissions are mainly attributed to the inclusion of "new" sources in the inventory and in general to the recalculation of emissions performed.

Seven key sources are found in the energy sector, being responsible for 81.98% of total GHG emissions in 2008 (without *LULUCF*).

Table 1.4 *Key categories for the Greek inventory system without LULUCF for 2008*

Source categories	Gas	Criteria
Energy		
Stationary combustion – Solid fuels	CO ₂	Level, Trend
Stationary combustion – Liquid fuels	CO ₂	Level, Trend
Stationary combustion – 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
Industrial processes		
Cement production	CO ₂	Level, Trend
Ammonia production	CO ₂	Trend
Nitric acid production	N ₂ O	Trend
Ozone depleting substances substitutes	F-gases	Level, Trend
Agriculture		
Enteric fermentation	CH ₄	Level, Trend
Agricultural soils – Direct emissions	N ₂ O	Level, Trend
Agricultural soils – Animal production	N ₂ O	Level, Trend
Agricultural soils – Indirect emissions	N ₂ O	Level, Trend
Waste		
Solid waste disposal on land	CH ₄	Level
Wastewater handling	CH ₄	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 2008 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 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 2008*

Source categories	Gas	Criteria
Energy		
Stationary combustion – Solid fuels	CO ₂	Level, Trend
Stationary combustion – Liquid fuels	CO ₂	Level, Trend
Stationary combustion – 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
Industrial processes		
Cement production	CO ₂	Level, Trend
Ammonia production	CO ₂	Trend
Nitric acid production	N ₂ O	Trend
Ozone depleting substances substitutes	F-gases	Level, Trend
Agriculture		
Enteric fermentation	CH ₄	Level, Trend
Agricultural soils – Direct emissions	N ₂ O	Level, Trend
Agricultural soils – Animal production	N ₂ O	Level, Trend
Agricultural soils – Indirect emissions	N ₂ O	Level, Trend
Waste		
Solid waste disposal on land	CH ₄	Level
Wastewater handling	CH ₄	Trend
LULUCF		
Forest land remaining forest land	CO ₂	Level, Trend
Cropland remaining cropland	CO ₂	Level, Trend
Conversion to forestland	CO ₂	Trend

It should be noted that the analysis has been also performed for all the years of the inventory. The results 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 fluctuation 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 fluctuation 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.

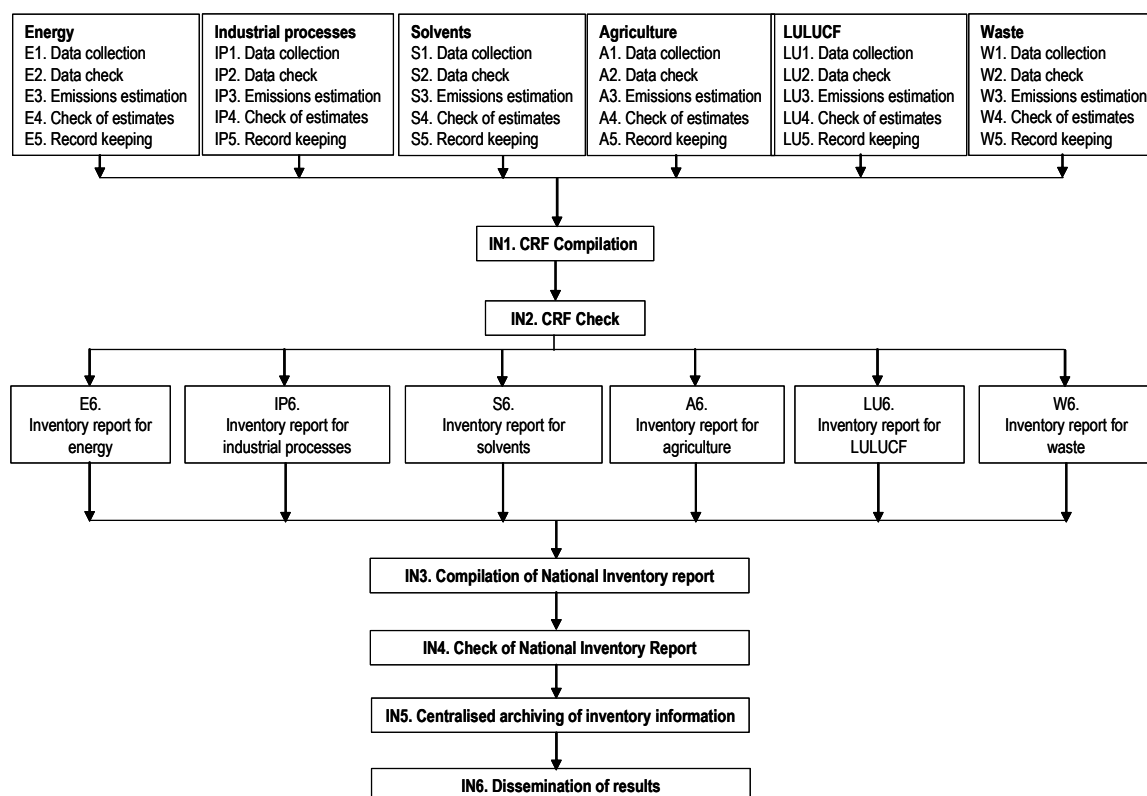


Figure 1.4

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 recent independent audit was carried out between 6-9 July 2009 by NTUA professor D. Marinos - Kouris. The findings are presented in **Table 1.8**. As described in the next chapters all these findings were addressed in this submission.

Table 1.8 *Finding and recommendations of independent audit that was carried out between 6-9 July 2009*

Sector	Areas of Further Improvement
General	1. Perform a key categories analysis for all years 1990-2008 and include in 2010 submission.
Energy	2. Establish a tier 2 QA/QC procedure for the estimation of CO ₂ EF for NG combustion by using data for different sources. 3. Use the tier 2 QA/QC procedure for the cross-checking of national energy balance with ETS energy consumption data to improve 2005-2007 inventories. Recalculate if needed. 4. Limestone use for desulphurization of flue gases to be reallocated from energy sector to industrial processes in 2010 submission. (from 1.B.1.C to 2.A.3).
Industrial Processes	5. Ferroalloys production (2.C.2) : CO ₂ to be reallocated from the energy sector. 6. (2.C.1): Collect plant specific information.
Agriculture	7. Investigation for information related to manure management systems applied in Greece per animal species.
Waste	8. Cross checking information provided by the waste management department of MEECC and by the Ministry of Development, regarding the biogas recovered in MSW disposal sites which is used for energy generation 9. Exploring of reasonable approaches to estimate CH ₄ and N ₂ O emissions from the incineration of clinical waste.
LULUCF	10. Improve notification keys in 5.A category

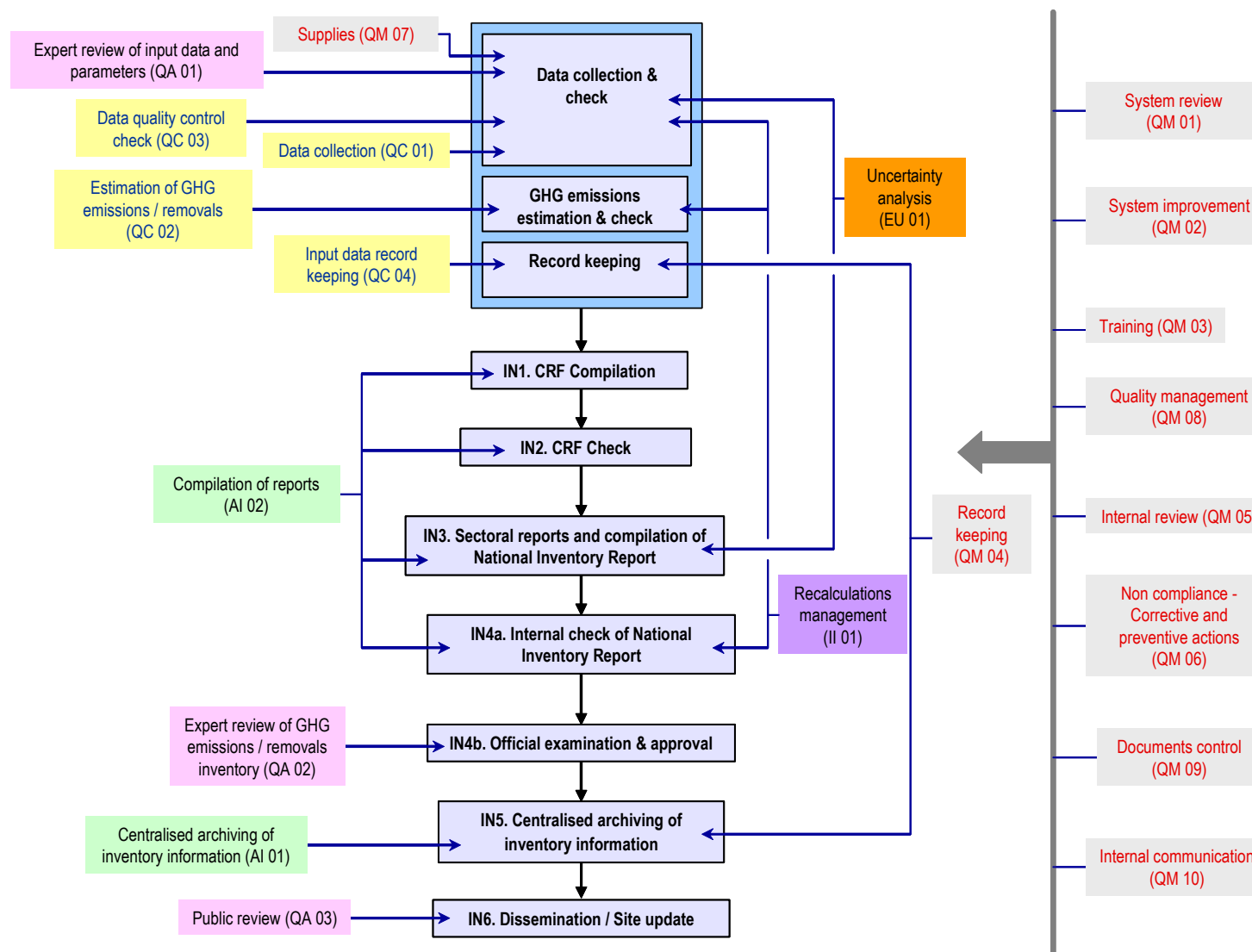


Figure 1.5 QA/QC processes and procedures and inventory related activities

1.6.2 Treatment of confidentiality issues

Confidentiality issues concern mainly the Industrial Processes sector in cases where 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 National Statistical Service. 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 arises, the inventory system is working in close cooperation with the Prodcom Section of the NSSG throughout all the stages of the inventory preparation and during the reviews if necessary. It should be also mentioned that in any case, the NSSG 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.

In the last years 2009-2010, steps are being implemented, as part of the continuing improvement of the Greek inventory system, in order to achieve a closer cooperation between the External Trade Section of NSSG and the inventory team, that would enable reporting of potential f-gases emissions. However, this procedure is quite more time-consuming than the previous one regarding the cooperation with the Prodcom department, since the data that need to be collected include additional economic activity data.

Finally, it should be noted, that in a number of cases activity data are reported as confidential in the inventory files. This is the case whenever the inventory team has not received an official approval by the corresponding industry in order to publish direct activity data. However, 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.

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 CO₂, CH₄, N₂O and F-gases emissions. In previous submissions, 1995 was used as base year for F-gases emissions. However, following the recommendation made by the Expert Review Team (ERT) during the centralized review of the GHG inventories carried out in September 2009, in the current analysis 1990 was used as base year for all gases.

In previous submissions 1995 was used as base year for F-gases emissions but in the current emissions it changed after a recommendation made by the Expert Review Team (ERT) during the centralized review of the GHG inventories submitted in 2009.

✎ 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.

✎ In this submission for the first time the 100% of emissions were used for the uncertainty analysis. This improvement was performed after a recommendation made by the Expert Review Team (ERT) during the centralized review in September 2009.

✎ 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 2008, were estimated at:

3.6% for CO₂ emissions

56.7% for CH₄ emissions

87.5% for N₂O emissions and

240.5% 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
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 CO₂		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		41.8
Unmanaged solid waste disposal on land		73.0
Municipal Sludge Disposal on Land		41.8
Wastewater handling		104.4

Waste incineration		100.1
Total CH₄		56.7
Fuel combustion	N₂O	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 N₂O		87.5
HFC-23 emissions from production of HCFC-22	F-gases	70.7
Ozone depleting substances substitutes		250
PFC from Aluminium production		6.7
SF ₆ from electrical equipment		111.8
Total F-gases		240.5
Total uncertainty (%)		7.92

In general, the uncertainties associated with CO₂ are very low, while the least accurate estimations are those for N₂O 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 CO₂ depends only on the type of fuel, while CH₄ and N₂O factors depend heavily on the technology of the engine used. As a result, the uncertainty in emissions factors for marine transport is 5% for CO₂ and an order of magnitude for CH₄ and N₂O.

Total uncertainty is 7.92% (without *LULUCF*), while the uncertainty that carried over into the GHG emissions trend is 10.91%. To be mentioned that the uncertainty analysis in this submission 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 2008, were estimated at (the detailed calculations are presented in Annex IV):

- ↳ 3.8% for CO₂ emissions,
- ↳ 56.6% for CH₄ emissions,
- ↳ 87.4% for N₂O emissions and
- ↳ 240.5% for the F-gases emissions.

Total uncertainty is 8.2%, while the uncertainty that carried over into the GHG emissions trend is 11.2%.

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
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 ₂ O	71
Grassland remaining Grassland	N ₂ O	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 ₂ O	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 1990-2008 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 SO₂.

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

- ✎ CO₂ from *organic chemicals production* and *asphalt roofing-road paving with asphalt* are not estimated due to lack of emission factors in the IPCC GPG.
- ✎ F-gases emissions from *solvents* are not estimated due to lack of activity data. However it should be mentioned that various categories have been estimated for the first time in the current submission (foam blowing, fire extinguishers, aerosols).
- ✎ *Potential emissions* of F-gases are not estimated, as, for the time being, imports/exports of the relative chemical compounds are not recorded separately. Some steps are being implemented in order to approach activity data. Further information on that is provided in paragraph 4.1.3.
- ✎ N₂O emissions from industrial wastewater handling due to lack of IPCC methodology.
- ✎ CH₄ and N₂O emissions from the sludge component of industrial wastewater due to lack of activity data and IPCC 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 (CO₂, CH₄, N₂O, HFC, PFC and SF₆) for the period 1990 - 2008 are presented in **Table 2.1** (in kt CO₂ 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 CO₂, CH₄, and N₂O - 1995 for F-gases) were estimated at 105.44 Mt CO₂ 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 2008, GHG emissions (without *LULUCF*) amounted to 126.89 Mt CO₂ eq showing an increase of 20.34 % compared to base year emissions and of 22.85% compared to 1990 levels. If emissions / removals from *LULUCF* were to be included then the increase would be 22.72 % (from 100.81 Mt CO₂ eq in 1990 to 123.71 Mt CO₂ eq in 2008).

Carbon dioxide emissions accounted for 86.50% of total GHG emissions in 2008 (without *LULUCF*) and increased by approximately 32.41% from 1990. Methane emissions accounted for 6.20% of total GHG emissions in 2008 and decreased by 12.55% from 1990, while nitrous oxide emissions accounted for 5.60 % of the total GHG emissions in 2008 and decreased by 30.38% from 1990. Finally, F-gases emissions that accounted for 1.70% of total GHG emissions in 2008, decreased by 35.47% from 1995 (base year for F-gases), due to cease of HCFC-22 production.

Table 2.1a *Total GHG emissions in Greece (in kt CO₂ 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	82896.10	82660.21	84415.62	83781.85	86108.06	86529.43	88687.28	93483.50	98340.40	97699.49	103001.54
CH ₄	8995.52	8995.17	8923.29	8916.78	9011.15	9034.64	9196.23	9182.99	9239.69	9057.93	8891.59
N ₂ O	10199.86	9880.49	9714.56	8853.99	8669.98	8957.13	9191.97	8972.94	8872.01	8808.37	8658.44
HFC	935.06	1106.82	908.39	1606.64	2143.91	3259.05	3764.10	4019.62	4503.28	5296.54	4149.68
PFC	257.62	257.56	252.30	152.59	93.62	82.97	71.74	165.34	203.75	131.72	148.38
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	103287.23	102903.42	104217.41	103315.20	106030.16	107866.80	110915.00	115828.12	121162.91	120997.92	124853.62
B. GHG emissions/removals from LULUCF											
CO ₂	-2504.65	-2587.33	-2889.81	-3238.30	-2861.07	-3200.05	-2926.53	-2986.95	-3303.36	-3540.60	-3132.65
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 ₂ O	2.53	1.63	4.87	3.83	3.78	1.86	1.52	2.72	6.37	0.58	9.05
Total	-2477.16	-2569.67	-2836.94	-3196.71	-2820.03	-3179.85	-2910.04	-2957.47	-3234.20	-3534.28	-3034.38
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	16.73	15.37	17.67	20.55	21.83	23.39	20.62	20.76	23.14	20.72	23.83
N ₂ O	90.21	81.50	91.52	104.26	113.64	118.06	106.04	105.86	116.41	109.99	118.83
Total	10582.24	9575.47	10774.91	12337.14	13387.00	14004.00	12525.96	12469.78	13734.57	12816.03	13999.80

Table 2.1b *Total GHG emissions in Greece (in kt CO₂ eq) for the period 2001-2008*

	2001	2002	2003	2004	2005	2006	2007	2008
A. GHG emissions per gas (excluding LULUCF)								
CO ₂	105340.31	104973.06	109137.72	109429.40	113178.02	111280.61	114275.13	109760.98
CH ₄	8492.34	8464.82	8343.26	8236.02	8083.62	8048.10	7953.96	7866.53
N ₂ O	8498.32	8382.99	8260.72	8212.37	7893.12	7638.02	7877.59	7100.96
HFC	3756.59	3947.36	3732.36	3889.62	3595.15	1646.48	1700.82	2077.34
PFC	91.38	88.33	77.30	71.38	71.31	71.16	58.66	74.17
SF ₆	4.06	4.25	4.25	4.47	6.45	8.37	9.92	7.53
Total	126183.01	125860.81	129555.62	129843.27	132827.66	128692.73	131876.07	126887.50
B. GHG emissions/removals from LULUCF								
CO ₂	-3221.16	-3320.22	-2998.71	-3172.58	-3154.05	-3242.40	-3202.44	-3197.14
CH ₄	14.74	2.43	3.31	8.29	4.70	9.04	159.33	19.03
N ₂ O	1.50	0.25	0.34	0.84	0.48	0.92	16.17	1.93
Total	-3204.92	-3317.54	-2995.06	-3163.45	-3148.87	-3232.45	-3026.95	-3176.18
C. GHG emissions from International Transport								
CO ₂	13351.48	12214.71	13150.47	13327.28	11465.99	12663.40	12934.93	12387.32
CH ₄	23.17	20.80	21.34	21.53	19.07	20.59	21.00	20.48
N ₂ O	114.49	105.12	114.16	115.76	92.76	101.43	108.74	103.88
Total	13489.14	12340.63	13285.97	13464.57	11577.82	12785.42	13064.67	12511.68

2.2 Description and interpretation of emission trends by category

GHG emissions trends by sector for the period 1990 - 2008 are presented in *Table 2.2*.

- ✎ Emissions from *Energy* in 2008 (*Figure 2.1*) accounted for 81.98% of total GHG emissions (without LULUCF) and increased by approximately 34.13% 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 and the introduction of natural gas in the Greek energy system represent the basic factors affecting emissions trends from *Energy*.

The evolution of GHG emissions from Energy can be distinguished into three 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 0.85% 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 increase of GDP for the same period (3.4%). Finally, the average annual rate of emissions increase for the period 2000 – 2008 decreased at 0.9% while GDP increased with higher rate (approximately 4%).

The majority of GHG emissions (55.5%) in 2008 derived from energy industries, while the contribution of transport, manufacturing industries and construction and other sectors is estimated at 21.8%, 9.0% and 12.2% 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. However, the positive results from the improvement of the vehicles performance are reduced by the high use of passenger cars in transportation activity. The implemented, adopted and planned measures for the improvement of public transport means is expected to moderate the high use of passenger cars.

- ✎ Emissions from *Industrial processes* in 2008 accounted for 8.40% of the total emissions (without LULUCF) and increased by approximately 10.69% compared to 1990 levels. Intense fluctuation is observed mainly due to the cease of HCFC-22 production. Emissions in 2008 are lower than emissions of 2007, with a decrease of 2.70%.
- ✎ The contribution of the *Solvents and other products use* sector to total GHG emissions is minor (0.25% of the total emissions) and has slightly increased compared to 1990 level of emissions.
- ✎ Emissions from *Agriculture* that accounted for 7.03% of total emissions in 2008 (without LULUCF), decreased by approximately 21.42% compared to 1990 levels. Emissions reduction is mainly due to the reduction of N₂O 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 sector *Waste* (2.34% of the total emissions, without *LULUCF*), decreased by approximately 33.16% 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 – 2008. During this period, the *LULUCF* sector offset about 2.3-3.1% of the total national emissions (without *LULUCF*). The magnitude of this sink increased from approximately 2.5 Mt CO₂ eq in 1990, to 3.2 Mt CO₂ eq in 2008, i.e. an increase of 28%. 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.

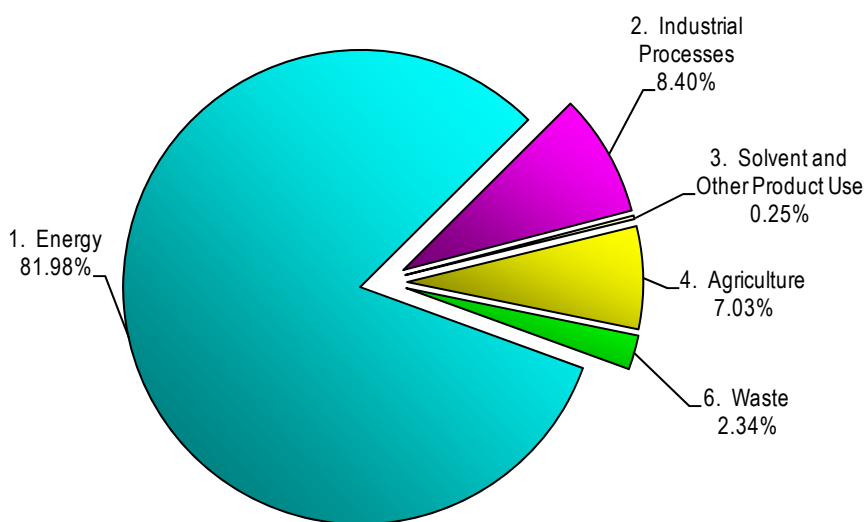


Figure 2.1 *Relative contribution of activity sectors to total GHG emissions (without LULUCF) in 2008*

Table 2.2a *Total GHG emissions (in kt CO₂ eq) by sector for the period 1990-2000*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy	77556.50	77372.33	79092.68	78658.51	80876.16	80850.63	83107.14	87852.87	92656.25	92121.84	97134.02
Industrial processes	9631.07	9586.39	9520.14	9839.67	10449.86	12022.94	12685.18	12985.91	13517.96	14194.97	13491.21
Solvents	308.34	315.54	314.37	312.95	307.39	299.82	298.22	300.20	300.40	308.73	306.61
Agriculture	11348.67	11166.71	10945.42	10172.86	10011.76	10328.65	10425.84	10288.48	10294.45	10173.30	9988.70
Waste	4442.65	4462.44	4344.80	4331.20	4384.99	4364.75	4398.62	4400.65	4393.85	4199.08	3933.08
Total ¹⁾	103287.23	102903.42	104217.41	103315.20	106030.16	107866.80	110915.00	115828.12	121162.91	120997.92	124853.62
LULUCF	-2477.16	-2569.67	-2836.94	-3196.71	-2820.03	-3179.85	-2910.04	-2957.47	-3234.20	-3534.28	-3034.38
Index per sector											
Energy	100.00	99.76	101.98	101.42	104.28	104.25	107.16	113.28	119.47	118.78	125.24
Industrial processes	100.00	99.54	98.85	102.17	108.50	124.83	131.71	134.83	140.36	147.39	140.08
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	98.40	96.45	89.64	88.22	91.01	91.87	90.66	90.71	89.64	88.02
Waste	100.00	100.45	97.80	97.49	98.70	98.25	99.01	99.05	98.90	94.52	88.53
Total ²⁾	100.00	99.63	100.90	100.03	102.66	104.43	107.39	112.14	117.31	117.15	120.88

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 CO₂ eq) by sector for the period 2001-2008*

Year	2001	2002	2003	2004	2005	2006	2007	2008
Energy	99562.16	99322.50	103282.00	103500.94	106695.31	104921.93	107995.53	104025.19
Industrial processes	12913.45	12993.76	12896.83	13049.21	13260.83	10984.35	10955.99	10660.45
Solvents	304.28	305.13	305.93	306.75	309.29	311.92	313.41	314.13
Agriculture	9930.74	9862.91	9736.34	9764.69	9441.75	9297.65	9576.20	8918.26
Waste	3472.37	3376.51	3334.53	3221.67	3120.49	3176.88	3034.93	2969.47
Total ¹⁾	126183.01	125860.81	129555.62	129843.27	132827.66	128692.73	131876.07	126887.50
LULUCF	-3204.92	-3317.54	-2995.06	-3163.45	-3148.87	-3232.45	-3026.95	-3176.18
Index per sector								
Energy	128.37	128.06	133.17	133.45	137.57	135.28	139.25	134.13
Industrial processes	134.08	134.92	133.91	135.49	137.69	114.05	113.76	110.69
Solvents	98.68	98.96	99.22	99.48	100.31	101.16	101.64	101.88
Agriculture	87.51	86.91	85.79	86.04	83.20	81.93	84.38	78.58
Waste	78.16	76.00	75.06	72.52	70.24	71.51	68.31	66.84
Total ²⁾	122.17	121.86	125.43	125.71	128.60	124.60	127.68	122.85

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 2008 by source category is presented in **Table 2.3**. Total CO₂ emissions increased from 82.90 Mt in 1990 to 109.76 Mt in 2008 (without LULUCF). This upward trend (increase of 32.41 % from 1990 to 2008) is mainly attributed to the increased electricity production as well as to the increased energy consumption in the residential and transport sectors.

CO₂ emissions from *Energy* increase almost continuously, from 75.40 Mt in 1990 to 101.46 Mt in 2008, presenting a total increase of 34.57% from 1990 to 2008. Carbon dioxide emissions from *Industrial processes* in 2008 increased by 11.03% compared to 1990 levels. On the contrary, emissions from *Solvents and other products use* decreased by 5.32% compared to 1990 levels. Finally, emissions from *Waste* in 2008 show a continuous increase from 1990. (**Figure 2.2**).

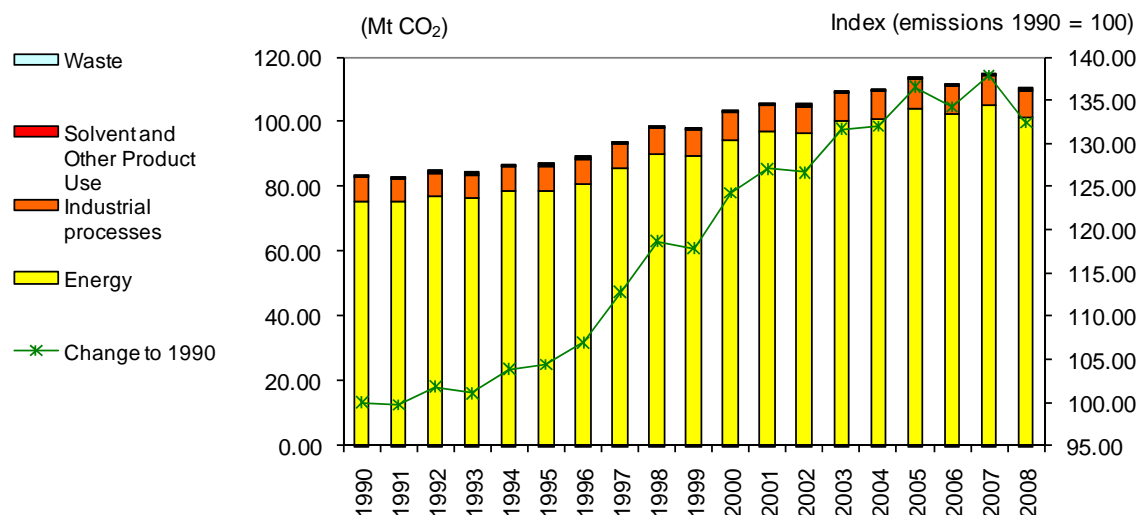


Figure 2.2 CO₂ emissions by sector (in Mt) for the years 1990 – 2008 (without LULUCF)

Table 2.3a *CO₂ 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)	80391.45	80072.89	81525.81	80543.55	83246.99	83329.38	85760.75	90496.55	95037.04	94158.89	99868.89
Total (without LULUCF)	82896.10	82660.21	84415.62	83781.85	86108.06	86529.43	88687.28	93483.50	98340.40	97699.49	103001.54
1. Energy	75400.68	75180.59	76843.36	76443.29	78619.39	78576.58	80693.33	85414.98	90106.58	89530.04	94426.44
A. Fuel combustion	75330.46	75109.69	76785.15	76395.97	78574.17	78537.86	80649.72	85375.84	90079.40	89528.60	94402.28
1. Energy industries	42992.74	41850.29	44131.81	44030.08	46006.63	44769.81	43948.69	47385.19	49904.80	50199.06	54629.23
2. Man. Industry and Construction	9725.27	9619.52	8973.55	8620.43	8447.41	9212.67	9766.42	10026.66	10103.07	9008.46	9717.97
3. Transport	14486.54	15218.73	15620.29	15826.75	16141.96	16503.89	16981.63	17746.03	19506.31	19929.80	19058.22
4. Other sectors	8125.91	8421.16	8059.51	7918.71	7978.16	8051.48	9952.98	10217.96	10565.23	10391.28	10996.86
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	7325.55	7303.69	7399.28	7168.29	7325.30	7798.04	7841.64	7915.29	8081.27	8009.35	8417.62
A. Mineral products	6378.66	6343.37	6465.98	6415.96	6392.42	6829.33	6859.36	6918.78	6963.14	6980.86	7169.77
B. Chemical production									195.28	158.63	294.37
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	-2504.65	-2587.33	-2889.81	-3238.30	-2861.07	-3200.05	-2926.53	-2986.95	-3303.36	-3540.60	-3132.65
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⁾	10475.30	9478.60	10665.71	12212.33	13251.52	13862.55	12399.31	12343.16	13595.02	12685.32	13857.13
Aviation	2447.55	2110.50	2201.85	2343.60	2781.45	2608.20	2497.95	2416.05	2535.75	2847.60	2497.95
Marine	8027.75	7368.10	8463.86	9868.73	10470.07	11254.35	9901.36	9927.11	11059.27	9837.72	11359.18

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

Table 2.3b *CO₂ emissions / removals by sector for the period 2001-2008 (in kt)*

Year	2001	2002	2003	2004	2005	2006	2007	2008
Total (with LULUCF)	102119.16	101652.84	106139.02	106256.82	110023.97	108038.21	111072.69	106563.83
Total (without LULUCF)	105340.31	104973.06	109137.72	109429.40	113178.02	111280.61	114275.13	109760.98
1. Energy	96772.42	96488.02	100474.78	100736.75	103976.82	102303.57	105365.20	101463.15
A. Fuel combustion	96755.37	96470.17	100463.16	100725.28	103967.36	102294.46	105358.24	101457.83
1. Energy industries	55149.40	54572.12	55809.09	57129.73	57959.31	55309.79	59250.34	57516.78
2. Man. industry and Construction	9894.62	9424.61	9130.83	8488.69	10171.13	10385.73	10085.04	9307.55
3. Transport	19867.22	20087.27	21238.59	21619.30	21707.03	22572.85	23365.12	22342.19
4. Other sectors	11844.13	12386.16	14284.64	13487.56	14129.89	14026.09	12657.74	12291.30
B. Fugitive emissions	17.04	17.85	11.62	11.47	9.46	9.11	6.96	5.32
2. Industrial processes	8413.07	8329.51	8506.66	8535.80	9041.64	8815.14	8746.52	8133.53
A. Mineral products	7217.96	6972.31	7033.60	7048.75	7546.14	7300.67	7162.44	6775.18
B. Chemical production	137.13	187.90	293.03	311.18	285.24	314.89	321.45	244.30
C. Metal production	1057.98	1169.30	1180.03	1175.87	1210.26	1199.57	1262.64	1114.06
3. Solvents	154.67	155.12	155.50	155.87	157.70	159.64	160.34	160.68
5. LULUCF	-3221.16	-3320.22	-2998.71	-3172.58	-3154.05	-3242.40	-3202.44	-3197.14
6. Waste	0.15	0.41	0.79	0.98	1.87	2.26	3.06	3.61
International transport ¹⁾	13351.48	12214.71	13150.47	13327.28	11465.99	12663.40	12934.93	12387.32
Aviation	2321.55	2321.55	3021.87	3106.36	2387.08	2862.92	2923.24	2619.12
Marine	11029.93	9893.16	10128.61	10220.92	9078.91	9800.48	10011.69	9768.20

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

2.3.2 Methane

The trend of methane emissions from 1990 to 2008 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 2001 (with enteric fermentation being the main source category in the sector), accounting for 44.88% of total methane emissions in 2008 (without *LULUCF*). Methane emissions from *Agriculture* in 2008 increased by 1.72% compared to 1990 levels. Methane emissions from *Waste* in 2008 accounted for 32.90% of total methane emissions and decreased by 37.15% 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 22.22% of the total methane emissions. Finally the contribution of CH₄ emissions from Iron and Steel, that have been estimated for the first time, can be considered negligible.

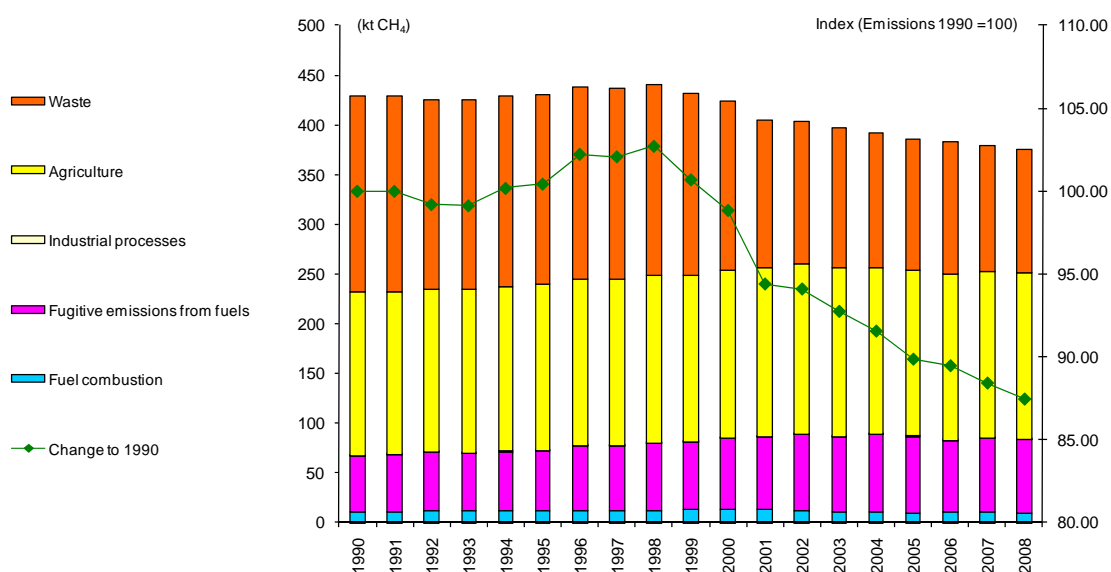


Figure 2.3 *CH₄ emissions by sector (in kt) for the period 1990 – 2008 (without LULUCF)*

Table 2.4a *CH₄ 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)	429.55	429.10	427.20	426.41	430.88	431.09	438.63	438.56	442.98	431.60	427.66
Total (without LULUCF)	428.36	428.34	424.92	424.61	429.10	430.22	437.92	437.29	439.99	431.33	423.41
1. Energy	67.00	67.99	71.06	69.89	71.30	72.32	77.49	76.79	79.74	80.49	84.42
A. Fuel combustion	10.48	10.81	11.99	11.80	11.53	11.73	12.26	12.21	12.41	13.01	13.67
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	0.41	0.44	0.45	0.44	0.42	0.48
3. Transport	5.45	5.76	6.13	6.36	6.51	6.77	7.16	7.30	7.60	7.66	7.62
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	165.25	163.60	163.04	164.50	165.66	166.87	167.72	168.07	168.18	168.47	169.19
A. Enteric fermentation	137.02	135.54	135.47	135.94	136.32	137.19	137.59	137.80	138.44	139.22	140.57
B. Manure management	23.66	23.30	23.15	23.11	23.07	23.01	23.00	23.03	23.15	23.27	23.25
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	196.07	196.72	190.79	190.18	192.10	190.99	192.66	192.38	192.03	182.34	169.78
A. Solid waste disposal on land	85.64	88.68	84.51	87.46	90.55	91.97	95.39	98.78	101.21	97.33	101.47
B. Wastewater handling	110.43	108.03	106.28	102.72	101.55	99.02	97.27	93.60	90.82	85.01	68.30
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⁾	0.80	0.73	0.84	0.98	1.04	1.11	0.98	0.99	1.10	0.99	1.13
Aviation	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
Marine	0.77	0.71	0.81	0.95	1.01	1.08	0.95	0.96	1.07	0.95	1.09

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

Table 2.4b *CH₄ emissions by source category for the period 2001-2008 (in kt)*

Year	2001	2002	2003	2004	2005	2006	2007	2008
Total (with LULUCF)	405.10	403.20	397.46	392.59	385.16	383.67	386.35	375.50
Total (without LULUCF)	404.40	403.09	397.30	392.19	384.93	383.24	378.76	374.60
1. Energy	86.10	88.79	86.62	88.34	86.64	82.15	84.37	83.24
A. Fuel combustion	12.82	11.40	11.11	10.84	9.78	9.94	10.03	9.81
1. Energy industries	0.78	0.78	0.80	0.80	0.83	0.83	0.90	0.89
2. Manufacturing industry and Construction	0.47	0.48	0.41	0.42	0.48	0.45	0.45	0.49
3. Transport	7.21	6.70	6.37	5.66	5.00	4.78	4.89	4.77
4. Other sectors	4.37	3.45	3.52	3.97	3.46	3.87	3.79	3.66
B. Fugitive emissions from fuels	73.27	77.39	75.51	77.50	76.87	72.21	74.33	73.43
1. Solid fuels	66.68	70.82	68.64	70.39	69.74	64.84	66.80	66.05
2. Oil and natural gas	6.60	6.57	6.87	7.10	7.12	7.37	7.53	7.38
2. Industrial processes	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.02
4. Agriculture	170.32	170.91	169.36	167.97	167.54	167.76	167.95	168.10
A. Enteric fermentation	141.41	141.89	140.45	138.90	138.39	138.85	138.62	138.54
B. Manure management	23.27	23.16	23.12	23.10	23.09	23.13	23.05	23.02
C. Rice cultivation	4.22	4.48	4.52	4.55	4.62	4.46	5.00	5.00
F. Field burning of agricultural residues	1.42	1.38	1.27	1.42	1.43	1.32	1.28	1.54
5. LULUCF	0.70	0.12	0.16	0.39	0.22	0.43	7.59	0.91
6. Waste	147.96	143.37	141.30	135.87	130.73	133.31	126.42	123.23
A. Solid waste disposal on land	105.94	107.16	111.27	111.31	110.02	114.46	110.35	107.48
B. Wastewater handling	42.03	36.21	30.03	24.55	20.71	18.85	16.07	15.75
C. Waste Incineration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
International Transport ¹⁾	1.10	0.99	1.02	1.03	0.91	0.98	1.00	0.98
Aviation	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03
Marine	1.06	0.95	0.98	0.98	0.88	0.95	0.97	0.95

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 2008 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 (75.88% approximately of the total nitrous oxide emissions in 2008, without *LULUCF*). Emissions from this sector decreased by 31.61 % 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 11.46% of total nitrous oxide emissions in 2008) increased by 8.73% from 1990. However, emissions from the *Energy* sector tend to decrease in recent years (2004-2008), 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 5.17% of total N_2O emissions in 2008. 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 2008 (5.32% of total emissions without *LULUCF*) increased by 16.30% compared to 1990 levels.

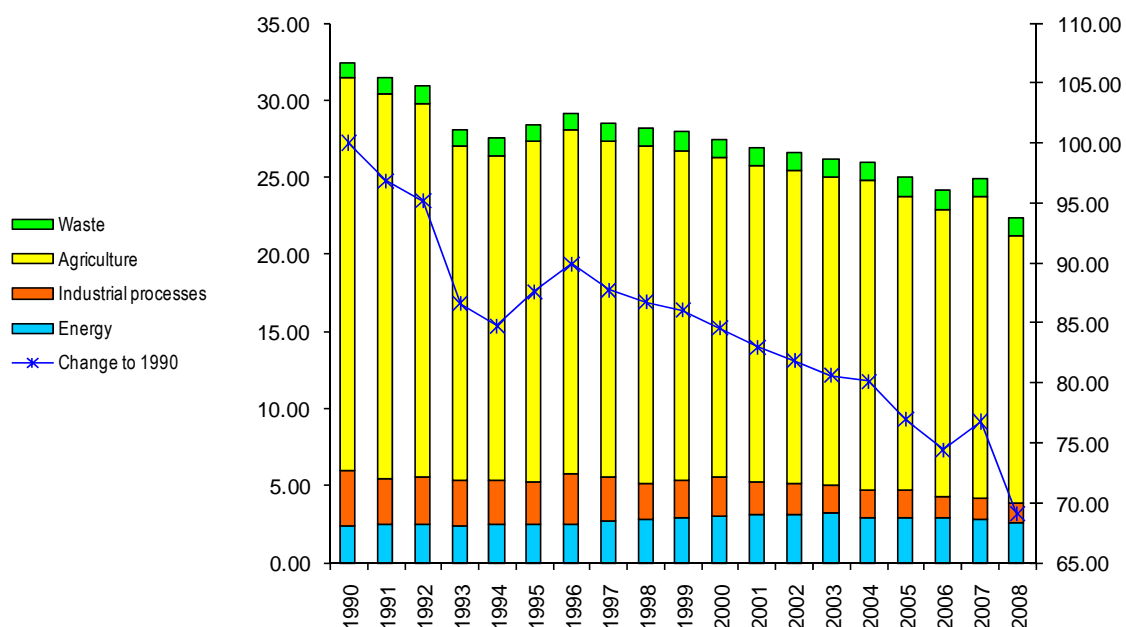


Figure 2.4 *N₂O emissions by sector (in kt) for the period 1990 – 2008 (without LULUCF)*

Table 2.5a *N₂O 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)	32.91	31.88	31.35	28.57	27.98	28.90	29.66	28.95	28.64	28.42	27.96
Total (without LULUCF)	32.90	31.87	31.34	28.56	27.97	28.89	29.65	28.94	28.62	28.41	27.93
1. Energy	2.42	2.46	2.44	2.41	2.45	2.44	2.54	2.66	2.82	2.91	3.02
A. Fuel combustion	2.41	2.46	2.44	2.41	2.45	2.44	2.54	2.66	2.82	2.91	3.02
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	0.17	0.16	0.17
3. Transport	0.55	0.56	0.57	0.58	0.60	0.67	0.74	0.83	0.96	1.05	1.09
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	25.41	24.94	24.26	21.67	21.07	22.01	22.27	21.80	21.82	21.40	20.76
B. Manure management	0.97	0.95	0.93	0.92	0.91	0.91	0.91	0.91	0.92	0.93	0.94
D. Agricultural soils	24.41	23.95	23.30	20.72	20.12	21.07	21.32	20.86	20.87	20.45	19.79
F. Field burning of agr. residues	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03
5. LULUCF	0.01	0.01	0.02	0.01	0.01	0.01	0.00	0.01	0.02	0.00	0.03
6. Waste	1.05	1.07	1.09	1.09	1.13	1.14	1.14	1.16	1.16	1.19	1.19
International transport ¹⁾	0.29	0.26	0.30	0.34	0.37	0.38	0.34	0.34	0.38	0.35	0.38
Aviation	0.09	0.07	0.08	0.08	0.10	0.09	0.09	0.09	0.09	0.10	0.09
Marine	0.21	0.19	0.22	0.25	0.27	0.29	0.25	0.25	0.28	0.25	0.29

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

Table 2.5b *N₂O emissions by source category for the period 2001-2008 (in kt)*

Year	2001	2002	2003	2004	2005	2006	2007	2008
Total (with LULUCF)	27.42	27.04	26.65	26.49	25.46	24.64	25.46	22.91
Total (without LULUCF)	27.41	27.04	26.65	26.49	25.46	24.64	25.41	22.91
1. Energy	3.17	3.13	3.19	2.93	2.90	2.88	2.77	2.63
A. Fuel combustion	3.17	3.13	3.19	2.93	2.90	2.88	2.77	2.63
1. Energy industries	0.61	0.60	0.61	0.63	0.63	0.59	0.62	0.60
2. Man. industry and Construction	0.17	0.16	0.15	0.14	0.15	0.15	0.15	0.15
3. Transport	1.22	1.13	1.07	0.98	0.93	0.90	0.88	0.79
4. Other sectors	1.16	1.24	1.35	1.18	1.19	1.24	1.12	1.08
B. Fugitive emissions from fuels	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	1.19
4. Agriculture	20.50	20.24	19.93	20.12	19.11	18.63	19.51	17.38
B. Manure management	0.94	0.95	0.94	0.93	0.93	0.94	0.94	0.94
D. Agricultural soils	19.52	19.26	18.96	19.15	18.14	17.65	18.54	16.40
F. Field burning of agr. residues	0.04	0.03	0.03	0.04	0.04	0.03	0.03	0.04
5. LULUCF	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.01
6. Waste	1.18	1.18	1.18	1.19	1.20	1.21	1.22	1.22
International transport ¹⁾	0.37	0.34	0.37	0.37	0.30	0.33	0.35	0.34
Aviation	0.09	0.09	0.11	0.11	0.07	0.07	0.09	0.08
Marine	0.28	0.25	0.26	0.26	0.23	0.25	0.26	0.25

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 SF₆, 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 CF₄ and C₂F₆). 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 and the 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 2007, following the substitution of ODS. Other aerosol application 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 SF₆ in the electricity transmission / distribution system of the Public Power Corporation of Greece. Emissions mainly derive from the use of SF₆ 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 SF₆ leakages.
- ✎ Finally, the emissions from fire extinguishers, which have been estimated for the first time in the current directory.

Table 2.6 *Actual F-gases emissions for the period 1990-2008 (in kt CO₂ eq)*

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
HFC	935.06	1106.82	908.39	1606.64	2143.91	3259.05	3764.10	4019.62	4503.28	5296.54
HFC-23	935.06	1106.82	908.39	1606.64	2143.91	3253.07	3746.34	3960.22	4359.89	5023.04
HFC-32										
HFC-125										
HFC-134a						5.98	17.76	59.41	143.39	269.32
HFC-152a										
HFC-227ea										4.18
PFC	257.62	257.56	252.30	152.59	93.62	82.97	71.74	165.34	203.75	131.72
SF₆	3.07	3.16	3.26	3.35	3.45	3.59	3.68	3.73	3.78	3.87
Total	1195.75	1367.54	1163.95	1762.59	2240.97	3345.60	3839.52	4188.69	4710.81	5432.13

	2000	2001	2002	2003	2004	2005	2006	2007	2008
HFC	4149.68	3756.59	3947.36	3732.36	3889.62	3595.15	1646.48	1700.82	2077.34
HFC-23	3735.11	3181.46	3194.57	2661.05	2550.60	2157.48			
HFC-32	2.37	4.16	8.46	14.08	19.60	26.08	36.66	41.84	52.91
HFC-125	11.05	19.44	39.49	65.74	91.46	121.67	171.07	195.09	246.60
HFC-134a	395.18	542.09	664.26	937.49	1174.97	1229.79	1365.52	1390.51	1701.55
HFC-152a		1.67	30.40	40.90	35.19	37.69	46.73	41.22	40.91
HFC-227ea	5.97	7.75	10.17	13.09	17.81	22.44	26.50	32.15	35.37
PFC	148.38	91.38	88.33	77.30	71.38	71.31	71.16	58.66	74.17
SF₆	3.99	4.06	4.25	4.25	4.47	6.45	8.37	9.92	7.53
Total	4302.05	3852.03	4039.94	3813.91	3965.47	3672.91	1726.00	1769.40	2159.04

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

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 SO₂ are presented in **Table 2.7**, while more information on the emissions of indirect greenhouse gases and SO₂ is provided in Annex V.

- ✎ NO_x emissions increased by 20.76% from 1990 to 2008. Energy sector accounts for the high majority of emissions (99.19%). 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 40.37% of total NO_x emissions in 2008). Emissions from *Industrial processes* decreased by 35.18% 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 48.67% from 1990 to 2008 and as a result total CO emissions in 2008 decreased by 46.06%. Emissions from industrial processes in 2008 increased by 1.02% compared to 1990 levels. The variation of CO emissions from *LULUCF* is related to the intensity and number of forest fires. In 2008 emissions from *LULUCF* accounted for 1.14% of total CO emissions (incl *LULUCF*), and are by 23.75% higher than emissions of 1990.
- ✎ NMVOC emissions decreased by 27.21% from 1990 to 2008. Emissions from transport (23.81% of total NMVOC emissions in 2008), decreased by 67.52% compared to 1990 levels, while emissions from *Energy* decreased by 49.53% from 1990 to 2008. The significant increase of NMVOC emissions from *Industrial processes* (approximately 104.86% from 1990 to 2008) is attributed to the non-energy use of bitumen in the construction sector. Emissions from Solvents and other products use decreased by 4.65% compared to 1990 levels.
- ✎ SO₂ emissions decreased by 5.09% from 1990 to 2008. Emissions from electricity generation, which is the main source of SO₂ emissions in Greece (74.06 % of total SO₂ emissions for 2008, increased with a mean annual rate of increase of 1.1% for the period 1990 – 2008. The operation of desulphurisation plants at large installations for electricity generation since 1998 resulted in the restriction of the increase of SO₂ 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 SO₂ emissions from

manufacturing industry and construction and transport by 80.12% and 25.27% respectively for the period 1990 – 2008. Emissions from *Industrial processes* decreased by 23.20% from 1990 due to decrease of sulphuric acid industrial production.

Table 2.7a Emissions trends for indirect greenhouse gases and SO₂ (in kt) for the period 1990-2000

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
NO_x	295.81	312.73	322.29	319.51	327.33	314.45	319.43	328.96	352.04	343.81	335.62
1. Energy	292.46	309.32	318.72	316.18	323.99	311.42	316.36	325.83	348.71	341.13	331.84
Transport	148.87	158.28	162.29	163.02	165.39	163.06	161.32	165.27	184.82	179.99	157.50
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	1284.82	1303.53	1326.25	1325.84	1323.26	1321.53	1351.72	1346.62	1358.66	1308.99	1324.35
1. Energy	1224.45	1236.14	1253.20	1259.96	1256.77	1265.02	1297.09	1286.61	1282.70	1255.53	1234.84
Transport	913.16	921.61	941.31	948.35	943.36	953.89	984.81	970.14	964.53	938.63	912.22
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
NM VOC	300.45	311.78	320.59	325.67	334.51	336.00	341.60	343.13	351.39	350.01	351.22
1. Energy	216.84	224.74	233.52	238.83	248.60	246.61	252.33	252.95	256.30	251.66	248.26
Transport	160.30	168.13	176.47	182.90	191.14	187.54	192.23	191.85	194.53	190.80	184.25
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
SO₂	471.60	512.79	528.87	524.64	516.30	539.19	529.14	522.49	529.97	548.37	499.47
1. Energy	462.03	503.69	520.58	516.77	508.25	530.41	520.52	513.56	520.89	539.02	490.99
Transport	33.21	33.43	34.85	31.09	36.21	30.47	29.06	30.64	45.28	48.68	23.93
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 SO₂ (in kt) for the period 2001-2008

Year	2001	2002	2003	2004	2005	2006	2007	2008
NO_x	350.63	350.40	361.19	359.40	394.80	369.73	378.03	357.21
1. Energy	347.81	347.67	358.60	356.60	391.97	367.04	373.57	354.32
Transport	162.38	155.64	155.97	153.66	165.61	149.77	150.37	144.19
Other energy sectors	185.43	192.03	202.63	202.94	226.36	217.27	223.20	210.13
2. Industrial processes	1.36	1.45	1.37	1.39	1.45	1.35	1.37	1.22
4. Agriculture	1.29	1.25	1.19	1.31	1.33	1.23	1.21	1.45
5. LULUCF	0.17	0.03	0.04	0.10	0.06	0.11	1.89	0.23
CO	1262.51	1229.88	1192.13	1153.82	933.39	838.57	792.39	693.07
1. Energy	1204.02	1177.07	1140.40	1096.79	877.86	783.60	675.32	629.57
Transport	881.54	854.76	838.34	797.58	712.07	616.88	499.77	468.73
Other energy sectors	322.47	322.31	302.06	299.20	165.79	166.72	175.55	160.83
2. Industrial processes	22.44	22.89	23.66	23.78	23.47	23.56	23.74	23.15
4. Agriculture	29.91	28.91	26.69	29.80	30.09	27.64	26.94	32.43
5. LULUCF	6.14	1.01	1.38	3.45	1.96	3.77	66.39	7.93
NM VOC	346.21	342.52	334.35	327.94	274.20	211.61	205.88	218.69
1. Energy	244.09	238.19	236.95	224.82	186.71	113.81	114.35	109.43
Transport	180.40	173.47	172.36	162.33	131.80	56.90	55.49	52.07
Other energy sectors	63.69	64.72	64.59	62.49	54.90	56.92	58.86	57.36
2. Industrial processes	49.78	51.84	44.79	50.39	34.44	44.12	37.63	55.24
3. Solvents	52.35	52.49	52.61	52.73	53.05	53.68	53.90	54.01
SO₂	504.49	515.74	554.08	548.34	529.50	535.67	540.47	447.60
1. Energy	496.13	507.21	545.49	539.62	519.44	528.01	532.73	440.25
Transport	28.32	24.66	26.30	31.20	29.18	31.86	28.96	24.82
Other energy sectors	467.81	482.55	519.19	508.42	490.26	496.15	503.77	415.43
2. Industrial processes	8.35	8.54	8.60	8.72	10.06	7.67	7.73	7.35

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 2008 net removals from afforestation, reforestation and deforestation activities (ARD) was 346.75 Kt CO₂ eq. and from Forest Management activities (FM) 2044.82 Kt CO₂ 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.

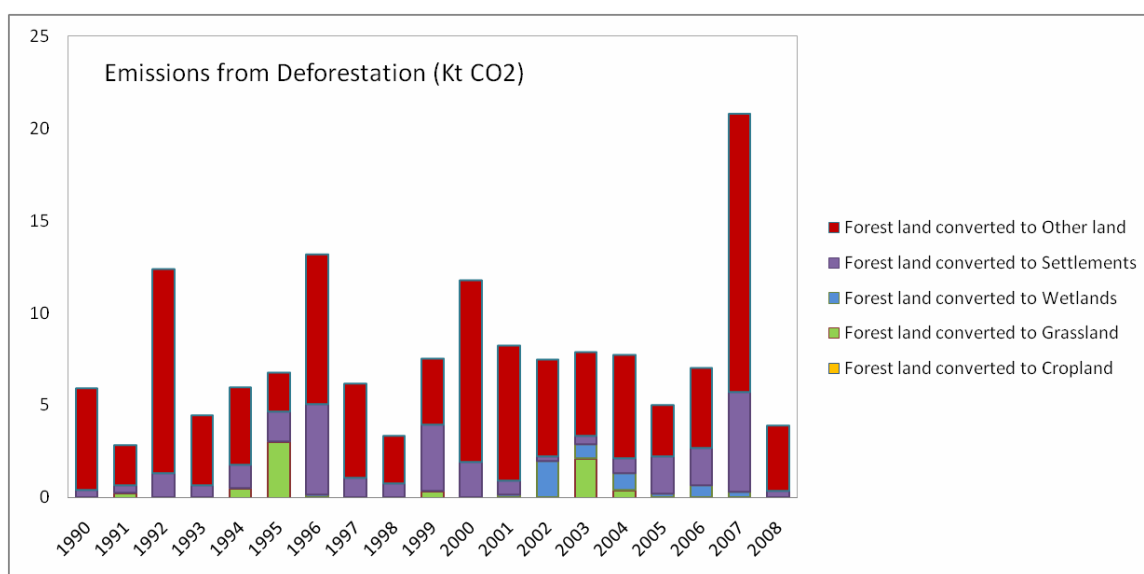


Figure 2.5 *CO₂ emissions (in kt) from deforestation for the period 1990 – 2008*

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 combustion², 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 2008 amounted to approximately 1282 PJ. The consumption of solid fuels and oil products accounts for 83% of total consumption, while the contribution of biomass and of the rest renewable energy sources (mostly hydropower, solar and wind energy) are 2% and 2.4% respectively. Finally, the share of natural gas in gross inland consumption is more than 11% while the rest 1.6% of gross inland consumption is covered by electricity (net imports – exports). In 2008, gross inland consumption increased by approximately 44% compared to 1990, presenting a 2.1% 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.

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

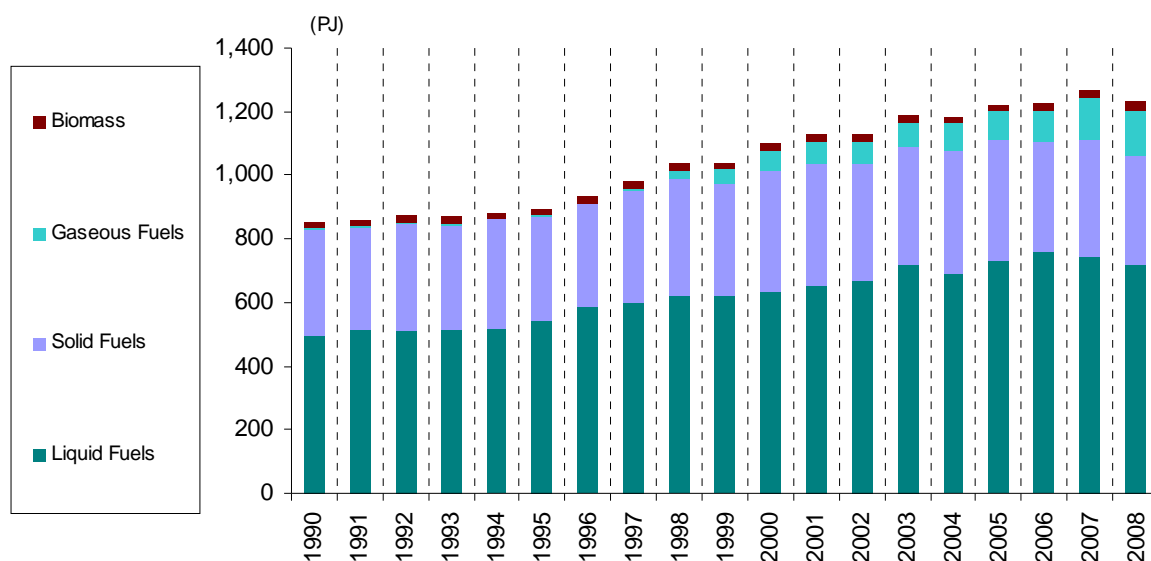


Figure 3.1 Gross inland consumption (in PJ) by energy type for the period 1990 - 2008

GHG emissions from *Energy* in 2008 increased by 34.3% compared to 1990 (**Figure 3.2**), while the average annual rate of increase for the period 1990 – 2008 was 1.7%. The highest increase on an annual basis (compared to the previous year) was recorded in 2000 (emissions increased by 5.8%), due to the significant increase in electricity demand as a result of particular weather conditions (very high summer temperatures).

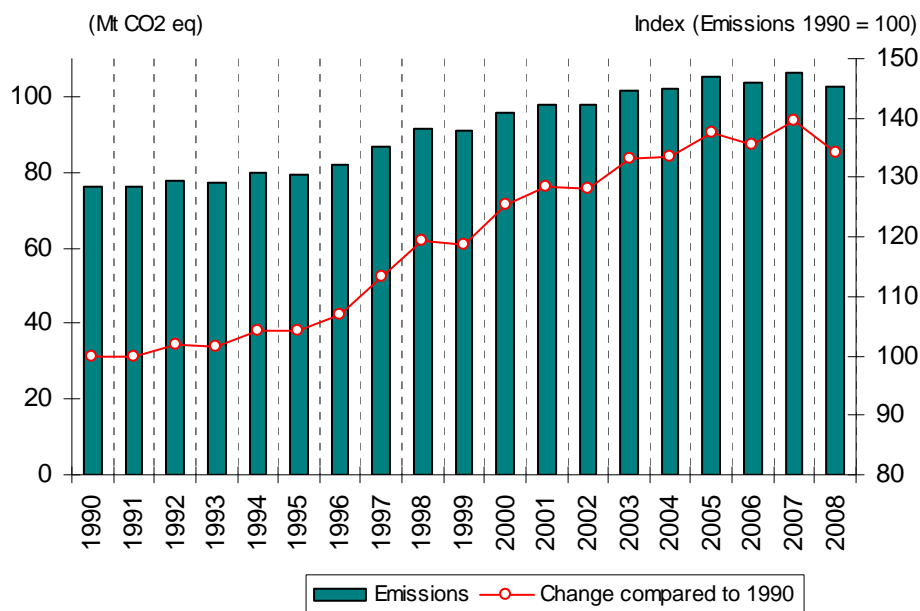


Figure 3.2 Total GHG emissions from Energy (in Mt CO₂ eq) for the period 1990 – 2008

The evolution of GHG emissions from *Energy* can be distinguished into three 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 0.85% 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 increase of GDP for the same period (3.4%). Finally, the average annual rate of emissions increase for the period 2000 – 2008 increased at 0.9% while GDP increased with higher rate (approximately 4%).

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 (55.5%) in 2008 derived from energy industries, while the contribution of transport, manufacturing industries and construction and other sectors is estimated at 21.8%, 9% and 12.2% 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 2.46%, followed by Other sectors (i.e. residential, tertiary and agriculture sectors) with a 2.44% average annual rate of increase. Emissions from energy industries increased with an average annual rate of 1.7%, while emissions from manufacturing industries and construction emissions had a mean annual rate of change of 0.0%. Finally, fugitive emissions from fuels increased with an average annual rate of 1.4% for the period 1990 – 2008.

Table 3.1 *GHG emissions from Energy by source category and gas for the period 1990 – 2008*

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	
CO2 emissions (in Mt)																			
A. Fuel Combustion																			
1. Energy Industries	42.99	41.85	44.13	44.03	46.01	44.77	43.95	47.39	49.90	50.20	54.63	55.15	54.57	55.81	57.13	57.96	55.31	59.25	57.52
2. Industry	9.73	9.62	8.97	8.62	8.45	9.21	9.77	10.03	10.10	9.01	9.72	9.89	9.42	9.13	8.49	10.17	10.39	10.09	9.31
3. Transport	14.51	15.24	15.65	15.86	16.17	16.53	17.00	17.76	19.52	19.94	19.07	19.88	20.10	21.25	21.62	21.71	22.57	23.37	22.34
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	12.29
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
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
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	0.83	0.90	0.89
2. Industry	0.43	0.43	0.43	0.42	0.40	0.41	0.44	0.45	0.44	0.42	0.48	0.47	0.48	0.41	0.42	0.48	0.45	0.45	0.49
3. Transport	5.45	5.76	6.13	6.36	6.51	6.76	7.16	7.30	7.59	7.65	7.61	7.20	6.70	6.37	5.65	5.00	4.78	4.89	4.77
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
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
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	7.10	7.12	7.37	7.53	7.38
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
2. Industry	0.14	0.15	0.15	0.15	0.15	0.16	0.16	0.17	0.17	0.16	0.17	0.17	0.16	0.15	0.14	0.15	0.15	0.15	0.15
3. Transport	0.54	0.56	0.57	0.58	0.60	0.66	0.74	0.83	0.96	1.05	1.09	1.22	1.13	1.07	0.98	0.93	0.90	0.88	0.79
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
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
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

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 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 ₂ O	
		Method	Emission factor	Method	Emission factor	Method	Emission factor
1A	Fuel combustion						
1A1	Energy industries						
1A1a	Public electricity and heat production	T2	CS, PS	T2	D	T2	D
1A1b	Petroleum refining	T2	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, CR	T2a	D, CR
1A3b	Road transport	T1	D	M, T1	M	M, T1	M
1A3c	Railways	T1	D	CR	CR	CR	CR
1A3d	Navigation	T1	D	CR	CR	CR	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	IE, NO	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 National Statistical Service 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 81% of total national GHG emissions in 2008 (without *LULUCF*).

Table 3.3 *Key categories from Energy*

IPCC source categories	Gas	Criteria
Stationary combustion – Solid fuels	CO ₂	Level, Trend
Stationary combustion – Liquid fuels	CO ₂	Level, Trend
Stationary combustion – Gas	CO ₂	Level, Trend
Mobile combustion – Road vehicles	CO ₂	Level, Trend
Mobile combustion - Navigation	CO ₂	Level, Trend
Mobile combustion – Aviation	CO ₂	Level, Trend
Coal mining and handling	CH ₄	Level

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 ₂ O	HFC	PFC	SF ₆	NO _x	CO	NM VOC	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	IE/NO	NA				NA	NA	NA	
Oil	☒	☒	☒				☒	☒	☒	☒
Natural gas	☒	☒	☒						NE	NE
International transport ¹⁾										
Aviation	☒	☒	☒				☒	☒	☒	☒
Marine	☒	☒	☒				☒	☒	☒	☒

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

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 CO₂ emissions, while the sectoral approach is based on a detailed disaggregation of energy consumption by sector, fuel and technology for the calculation of CO₂ 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 $\pm 2\%$) 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 *CO₂ emissions (in kt) according to the reference and the sectoral approach for the period 1990 – 2008*

Year	Reference approach	Sectoral approach	Deviation %
1990	76,009	75,350	0.87
1991	76,666	75,133	2.04
1992	78,358	76,812	2.01
1993	78,371	76,425	2.55
1994	80,598	78,600	2.54
1995	81,005	78,563	3.11
1996	81,984	80,673	1.63
1997	86,012	85,394	0.72
1998	90,485	90,097	0.43
1999	89,812	89,541	0.30
2000	94,636	94,412	0.24
2001	97,549	96,766	0.81
2002	97,666	96,480	1.23
2003	100,363	100,471	-0.11
2004	100,879	100,725	0.15
2005	103,450	103,967	-0.50
2006	102,485	102,294	0.19
2007	104,145	105,358	-1.15
2008	101,673	101,458	0.21

As shown in the table above, the estimated deviation (which ranges from –1.15% to 3.11%) is within the threshold defined by the IPCC Guidelines, with the exception of the deviation estimated for the years 1993-1995. 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, CO₂ 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 significant deviation in the consumption of gaseous fuels (for the period 1991 – 1997) is attributed to the consumption of city gas, which is taken into account only in the sectoral approach since it is a secondary fuel.

Table 3.6 *Deviations during the calculation of energy consumption (apparent and actual) for the period 1990 – 2008*

Year	Liquid fuels	Solid fuels	Gaseous fuels
1990	-0.61	-1.35	-72.88
1991	1.59	-1.09	-70.83
1992	2.89	1.13	-72.85
1993	1.16	1.05	-66.23
1994	3.03	1.12	-31.18
1995	-0.82	3.77	-31.21
1996	-1.01	1.04	-28.25
1997	-2.22	0.72	-26.28
1998	-2.88	0.62	-18.30
1999	-2.59	0.38	-1.78
2000	-2.73	-1.17	0.80
2001	-1.85	-0.40	1.37
2002	-1.19	-0.19	0.47
2003	-5.17	-1.36	0.15
2004	-2.66	-1.76	-0.14
2005	-3.53	-1.27	-0.17
2006	-2.85	-1.24	8.93
2007	-2.48	-0.21	-0.77
2008	-1.52	-0.55	-0.54

3.2.2 International bunker fuels

GHG emissions from international aviation and marine bunkers are calculated with the same methodologies mentioned above 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 Landing and Take-off cycles (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 22% since 1990 presenting an average annual rate of the order of 1% for the period 1990 – 2008.

A recalculation of the years 2005, 2006 and 2007 emissions of international aviation were carried out due to a transfer error of statistical input data.

Table 3.7 *Allocation of LTOs to domestic and international aviation for the period 1990-2008*

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	226550	226550

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	8108	7441	8548	9967	10575	11367	10000	10026	11170	9936

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 – 2008*

	Memo items 1) – International bunkers								
	Emissions (kt CO ₂ eq)								
	2000	2001	2002	2003	2004	2005	2006	2007	2008
International aviation	2527	2349	2349	3056	3142	2408	2887	2952	3071
International marine	11473	11140	9992	10230	10323	9170	9899	10112	9876

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, CO₂ 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 this 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 CO₂ emissions from the non-energy use of fuels is minor.

Table 3.9 *Non-energy fuel use (in PJ) for the period 1990 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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 ³	1.33 ¹⁵
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
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
Natural gas ⁴	4.05	3.87	3.68	2.37	0.24	0.16	0.15	1.68	4.95	0.78	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	1.62
Lignite	4.86	3.15																	
Petroleum coke	1.77	2.14	2.17	1.67	1.61	1.46	1.52	1.52	1.52	1.77	1.80	1.89	1.89	1.92	1.92	1.89	1.86	2.24	1.57
Paraffin waxes	0.12	0.12	0.16	0.16	0.12	0.08	0.08	0.04	0.04	0.04	0.04	0.04							
Other oil products	2.37	0.40	1.17	0.52	1.17	0.96	0.84	0.88	1.21	0.36	2.89	3.70	4.74	7.52	5.83	6.83	5.51	4.62	4.42

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%	33%	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 2008 decreased by 44% compared to 1990 levels, as the consumption of fuels used in chemical industry decreased due to the reduction of the relative production. It should be noted that the emissions presented in the following table are included (in the CRF tables) under the relevant source-categories.

³ Naptha quantities that are accounted in refineries sector for H₂ production are not included.

⁴ Natural gas allocated to industrial process sector is not included.

Table 3.11 *CO₂ emissions (in kt) from non-energy use and total amount of carbon stored (in kt) for the period 1990 - 2008*

Year	Carbon stored (kt)	CO ₂ emissions (kt)
1990	303.28	494.62
1991	286.84	356.58
1992	291.76	365.16
1993	288.84	286.95
1994	274.32	210.45
1995	329.30	212.22
1996	339.26	210.36
1997	329.73	255.41
1998	345.11	319.90
1999	333.76	157.43
2000	409.92	228.88
2001	427.73	286.11
2002	429.07	269.97
2003	436.51	418.57
2004	487.37	400.17
2005	367.64	399.23
2006	444.54	341.94
2007	342.18	241.38
2008	457.01	275.31

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 73% - 75% of total fossil fuel consumption in Greece for the period 1990 – 2008 (*Figure 3.3*).

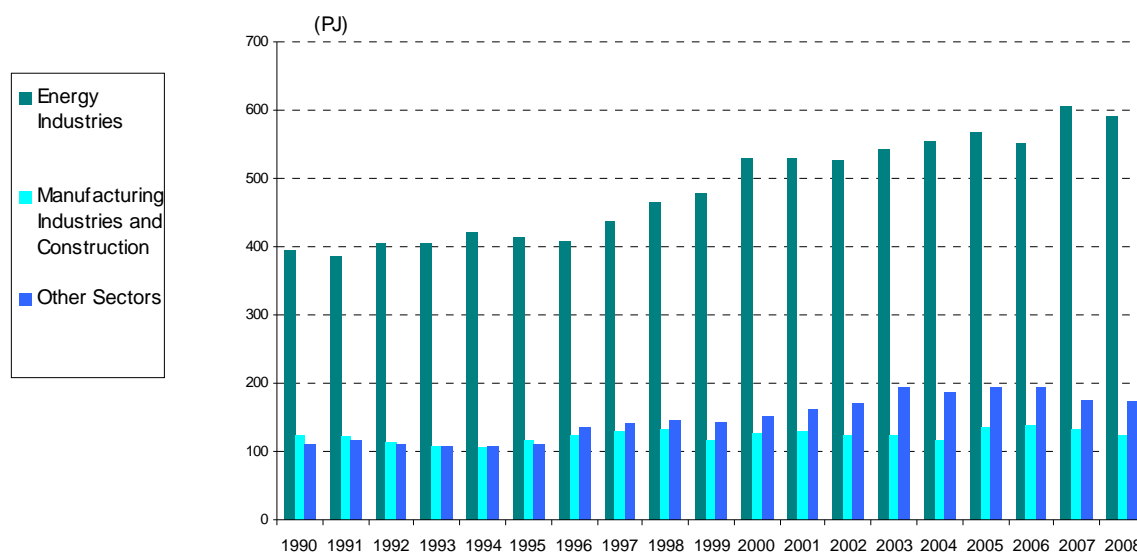


Figure 3.3 *Consumption of fossil fuels (in PJ) in stationary combustion for the period 1990 – 2008*

The consumption of fossil fuels in 2008 increased by approximately 45% compared to 1990, with an average annual rate of increase of 2.1% for the period 1990 – 2008.

- ↳ Fuel consumption in energy industries accounts for 64% (average value for the period 1990 – 2008) of fuel consumption in stationary combustion. The average annual rate of increase for the period 1990 – 2008 is estimated at 2.4%, resulting in an increase of 50% in 2008 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.
- ↳ 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 2008 increased by 1% compared to 1990 levels.
- ↳ Fossil fuels consumption in Other sectors increased by 54.9% from 1990 to 2008, as, according to the national energy balance, consumption of fossil fuels in 1996 increased by approximately 24% compared to 1995 and remained high since then.

GHG emissions from stationary combustion follow the trend of fossil fuels consumption, presenting however a lower annual rate of increase. Therefore, GHG emissions in 2008 (79.8 Mt CO₂ eq) increased by 29.7% compared to 1990 (61.5 Mt CO₂ eq), with an average annual rate of increase estimated at 1.5% for the period 1990 – 2008 (**Figure 3.4**). It is noted that emissions from stationary combustion account for around 60% of total national emissions (without *LULUCF*) for the period 1990 – 2008 (63% for 2008), while **three key categories** are included in this sector (**CO₂ emissions from solid, liquid and gaseous fuels combustion**).

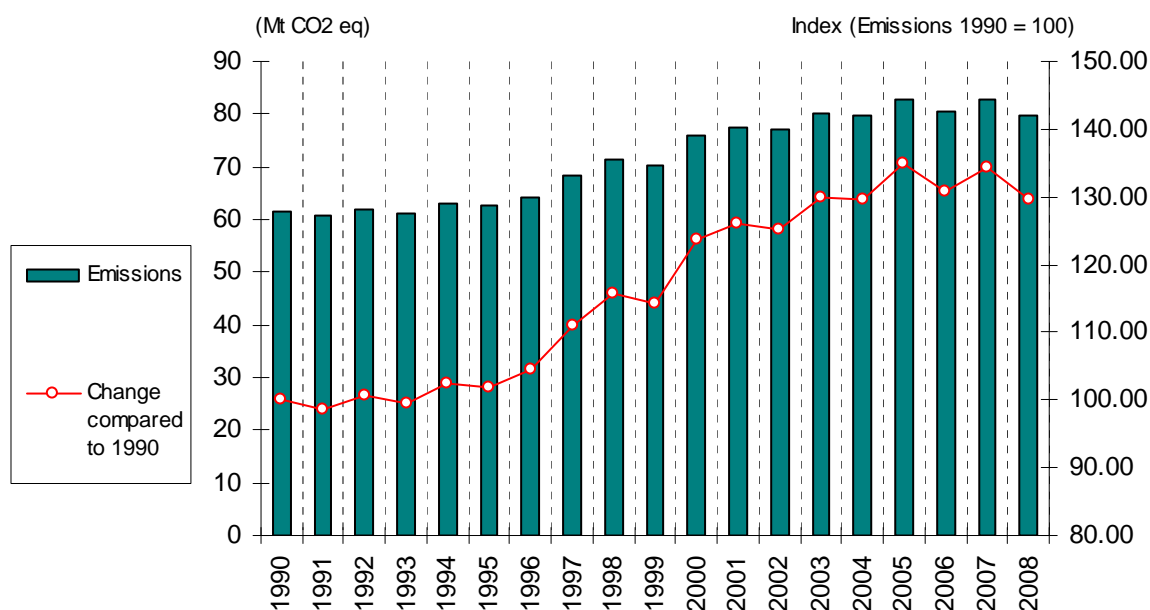


Figure 3.4 *GHG emissions (in Mt CO₂ eq) from stationary combustion for the period 1990 – 2008*

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 99.15% in 2008. Overall, CO₂ emissions in 2008 increased by 30% compared to 1990 levels with an average annual rate of increase estimated at 1.5%. N₂O emissions in 2008 account for 0.71% of emissions from stationary combustion, decreasing with an average annual rate of 0.05% during the period 1990 – 2008. CH₄ emissions account for the rest 0.14% of total emissions of the sector and increased by 0.2% from 1990 to 2008.

Table 3.12 *GHG emissions per gas and source category from stationary combustion for the period 1990 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
GHG emissions per gas																			
CO ₂ (in Mt)	60.84	59.89	61.16	60.57	62.43	62.03	63.67	67.63	70.57	69.60	75.34	76.89	76.38	79.22	79.11	82.26	79.72	81.99	79.12
CH ₄ (in kt)	5.03	5.05	5.86	5.43	5.02	4.97	5.10	4.91	4.81	5.36	6.05	5.62	4.70	4.74	5.18	4.78	5.16	5.14	5.04
N ₂ O (in kt)	1.87	1.90	1.87	1.83	1.85	1.77	1.79	1.84	1.86	1.86	1.93	1.94	2.00	2.11	1.95	1.97	1.99	1.89	1.83
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	47.57	50.10	50.39	54.83	55.36	54.77	56.02	57.34	58.17	55.51	59.46	57.72
Industry	9.78	9.67	9.03	8.68	8.50	9.27	9.83	10.09	10.17	9.07	9.78	9.96	9.49	9.19	8.54	10.23	10.44	10.14	9.36
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	12.70
TOTAL (Mt CO₂ eq)	61.53	60.59	61.87	61.25	63.11	62.69	64.33	68.30	71.25	70.29	76.07	77.61	77.10	79.98	79.82	82.97	80.45	82.69	79.79

Energy industries constitute the major contributor (72% in 2008) in the overall GHG emissions from stationary combustion, followed by manufacturing industry and construction from 1990 to 1995 and by other sectors since 1997 (emissions from other sectors increase with a mean annual rate of 2.4% for the period 1990 – 2008).

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. CH₄ and N₂O emission factors are differentiated by technology and fuel, while CO₂ 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.

CO₂ emissions from stationary combustion are estimated on the basis of fuel consumption and fuel characteristics, according to the following equation:

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

where, E_{CO_2} is CO₂ 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 CO₂ 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, 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 refinery gas, petcoke and steam coal 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 CO₂ emission factor is higher.

Table 3.13 *Carbon dioxide emission factors (in t CO₂ / TJ), net calorific value (in TJ / kt) and other parameters by fuel type*

Fuel type	Net calorific value (TJ/kt)	Carbon content. CC (tC/TJ)	Oxidation factor. OF (%)	EF (tCO ₂ /TJ)
Liquid fuels				
Refinery gas	48.68 ⁵	15.47 ⁵	99.0	56.16 ⁵
LPG	47.31	17.2	99.0	62.44 ⁶ , 63.01 ⁷
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 ⁸
Petroleum coke	32.28 ⁹ , 32.00 ¹⁰	27.5	99.0	99.99 ⁹ , 93.53 ¹⁰
Other oil products	40.19	20.0	99.0	72.60
Solid fuels				
Steam coal	25.87 ¹¹	26.22	98.0	94.22 ¹¹
Lignite				
Electricity generation	5.179	33.95	98.0	122.00
Other sectors	8.025	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		16.06 - 16.33 ¹²	99.5	56.76 ¹³
Natural gas – Imports		15.12 ¹⁴	99.5	55.16 ¹⁴ , 54.94 ¹⁵
Gas works gas		15.3	99.5	55.82

⁵ 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.

⁶ For use in sectors other than refineries.

⁷ 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.

⁸ Only for petroleum refining category – naphtha used as feedstock for hydrogen production.

⁹ Mean value. Petcoke consumed in refineries. It is derived from PS data contained in the verified EU ETS emission reports of refineries.

¹⁰ 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.

¹¹ Derived from PS data of verified EU ETS emission reports.

¹² Depends on the reservoir that the gas is extracted.

¹³ 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.

¹⁴ Mean value based on chemical composition data of NG provided by DESFA (Hellenic Gas Transmission System Operator S.A.).

¹⁵ Mean value for electricity production based on PS data derived from verified EU ETS emission reports.

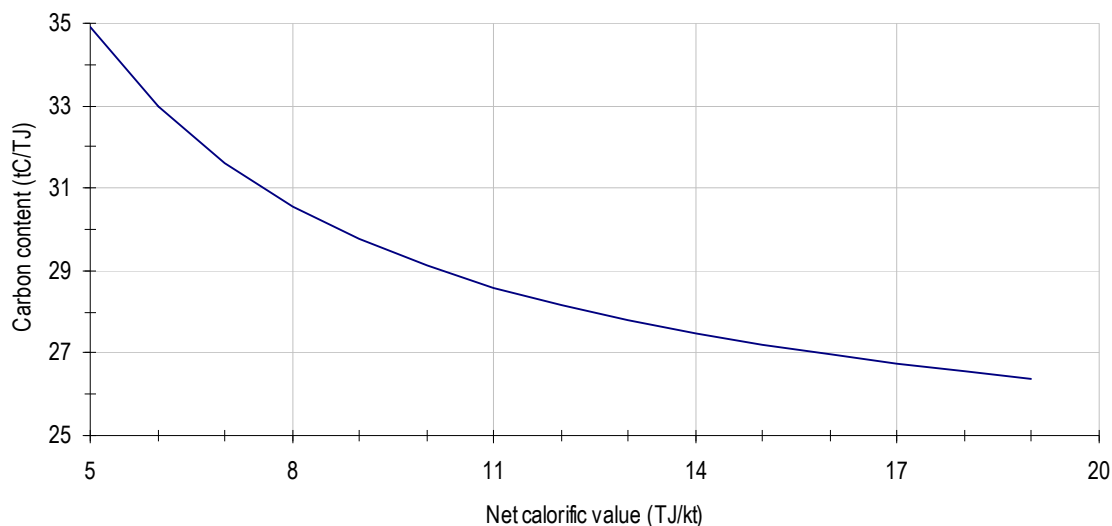
- ↪ Calorific values for gas works gas (in use until 1997) and natural gas do not appear in the table above, because the relative consumption in the energy balance is given directly in energy units (TJ).
- ↪ Domestic natural gas is produced from two reservoirs:
 1. the South Kavala reservoir, which has a NCV of 11328 kcal/Nm³ and a carbon content of 16.06 tC/TJ.
 2. the Prinos reservoir, which has a NCV of 12284 kcal/Nm³ and a carbon content of 16.33 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 - 2008*

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

- ↪ The carbon content in lignite used for electricity production is based on studies of the Public Power Corporation (PPC 1993). The value of 33.95 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).



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 CH₄ and N₂O 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. CH₄ and N₂O 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 2005-2008 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 - 2008. 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 88.5% of electricity production in 2008). Specifically, 52.3% 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 15.7% and 21.6% 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 – 2008 are presented in *Table 3.15*.

GHG emissions from electricity generation in 2008 increased by 31.2% compared to 1990 levels at an average annual rate of 1.6% for the period 1990 – 2008. 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.

CO₂ emissions in 2008 accounted for 99.64% of total emissions from public electricity and heat production, while emissions from solid fuels consumption accounted for 76% of total emissions in 2008. However, due to the penetration of natural gas, total emissions per electricity produced by fossil fuels has a decreasing trend.

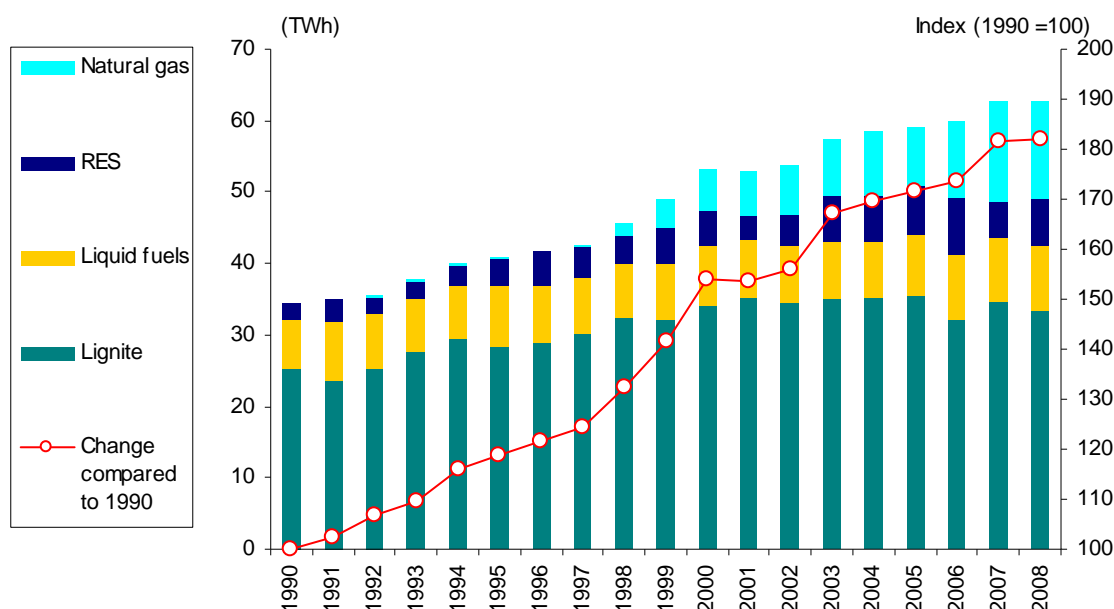


Figure 3.6 Electricity production (in TWh) by energy type for the period 1990 – 2008

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 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 CO₂ and N₂O emissions from catalytic cracking are included in this sub-source category, while CH₄ emissions are supposed to be included in Fugitive emissions from fuels.

The total increase of GHG emissions from refineries in 2008, compared to 1990 levels, is estimated at 80%, with an average annual rate of increase estimated at 3.6% for the period 1990 – 2008. 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 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
CO₂ 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
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
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	3.77	5.66	5.72
CH₄ 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
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
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	0.07	0.10	0.10
N₂O 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
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
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
TOTAL (Mt CO₂ 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	51.10	55.00	53.46

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 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
CO ₂ (kt)	2,308	2,350	2,283	2,262	2,433	2,459	2,694	2,744	2,821	2,558	3,072	3,117	3,222	3,075	3,225	3,639	4,303	4,355	4,155
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
N ₂ O (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
TOTAL (kt CO₂ eq)	2,317	2,359	2,292	2,270	2,442	2,468	2,704	2,754	2,832	2,568	3,084	3,128	3,234	3,087	3,237	3,652	4,318	4,370	4,169

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 - 2008) were used in this inventory. GHG emissions (**Table 3.17**) are calculated on the basis of the consumption of natural gas as it is presented in Annex II, the allocation of the consumption into gas turbines and boilers as described in ETS reports 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 2008 decreased by approximately 13% 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 CO₂ eq) from other energy industries for the period 1990 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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
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
N ₂ O	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
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

3.2.4.3.2 Recalculations

Differences that resulted from **recalculations / improvements** between the emissions estimates presented in the current submission and the estimates presented in the previous submission are attributed mainly to:

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

1. 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 2005-2008, a CO₂ EF of NG, based on plant specific data, was also calculated. Therefore, the emissions of CO₂ from natural gas combustion were recalculated for the years 1997 – 2007.
2. Activity data of natural gas combustion were updated for the years 2005-2007 based on plant specific data, derived from verified ETS reports. Therefore, the emissions of CO₂, CH₄ and N₂O from natural gas combustion were recalculated for the years 2005 – 2007.

Petroleum refining (CRF Source Category 1.A.1.b)

3. Based on plant specific data derived from verified EU ETS reports, a CO₂ EF from refinery gas combustion was calculated per year for the years 2005-2007. Therefore, the emissions of CO₂ were recalculated for the years 2005-2007. Moreover, following the recommendation of ERT which performed the centralised review from 21-26 September 2009 and concerning the issue of time series consistency when using data from verified EU ETS reports, the mean value of the above mentioned CO₂ EF was applied for the recalculation of the CO₂ emissions of the whole time series (years 1990-2004).
4. The activity data of liquid and gaseous fuels consumed in petroleum refineries were updated for the years 2005-2007, based on plant specific data, derived from verified ETS reports. Therefore, the emissions of CO₂, CH₄ and N₂O from liquid and gaseous fuels combustion were recalculated for the years 2005 – 2007.

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

5. The activity data of gaseous fuels consumed were updated for the years 2005-2007, based on plant specific data, derived from verified ETS reports. Therefore, the emissions of CO₂, CH₄ and N₂O from gaseous fuels combustion were recalculated for the years 2005 – 2007.
6. The CO₂ emissions for years 2005 to 2007 were recalculated by applying an EF derived from plant specific data (verified ETS reports) which includes CO₂ emissions from sour gas cleaning process among with the emissions from combustion.

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 - 2008 provided significant information regarding the structure of energy demand in industry per activity / technology. On the basis of those data (a) energy consumption per activity (e.g. steel production) as well as unit consumption indices were estimated, (b) the fuels used per activity were identified and (c) disaggregation of energy demand into different activities is performed (e.g. energy consumption in Iron & Steel as reported in the national energy balance is allocated between steel production and grey iron foundries). 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) and the results of the questionnaires analysis providing that the estimated total energy consumption is in accordance with the official figures provided by the 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 – 2008 (**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 - 2008. 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 - 2008 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 - 2008. 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 - 2008 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.

- ↳ 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 CH₄ and N₂O 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 - 2008.

- For years 1990-2004, it is assumed that steam coal and petroleum coke consumption refers only to cement production. For 2005 - 2008 data from verified ETS reports were used.
- Energy consumption in the rest activities is estimated on the basis of the calculated specific consumption (according to data collected during the formulation of the NAP for the period

2005 – 2007), production data, fuels used in each activity and information from the national energy balance. For 2005 - 2008 data from verified ETS reports were used.

- ✎ Non-energy fuels use and the relevant emissions (see Table 3.18) are reported under the corresponding source categories. The non-energy fuels use per energy balance sector is presented in Annex II.

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.

Non-ferrous metals and other industries (cement plants mainly) constitutes the only sub-source category in which emissions increased for the period 1990 – 2008. Overall, GHG emissions from industry in 2008 decreased by 4.2% compared to 1990.

3.2.4.4.2 Recalculations

Differences resulted from **recalculations / improvements** between the emissions estimates presented in the current submission and the estimates presented in the previous submission are attributed mainly to:

1.A.2a Iron and Steel

1. 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. Therefore, the emissions of CO₂ from natural gas combustion were recalculated for the years 1997 – 2007.

1.A.2b Non Ferrous Metals

2. 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. Therefore, the emissions of CO₂ from natural gas combustion were recalculated for the years 1997 – 2007.
3. Following the recommendation of ERT, which performed the centralised review from 21-26 September 2009, the emissions from the non-energy use of solid fuels for ferroalloys production were reallocated to the industrial processes sector (2.C.2) for the period 1990-2007.

1.A.2c Chemicals

4. 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. Therefore, the emissions of CO₂ from natural gas combustion were recalculated for the years 1997 – 2007.

5. The activity data of solid fuels were corrected for the year 1991 (error in CRF compilation during 2009 submission)
6. The activity data of gaseous and liquid fuels were updated for the years 2005-2007, based on plant specific data, derived from verified ETS reports. Moreover, according to plant specific data of refineries, the amounts of NG and naptha used for hydrogen production were reallocated to 1.A.1.b sector. Therefore, the emissions of CO₂, CH₄ and N₂O from gaseous and liquid fuels combustion were recalculated for the years 2005 – 2007.

1.A.2d Pulp, paper and Print

7. 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. Therefore, the emissions of CO₂ from natural gas combustion were recalculated for the years 1997 – 2007.

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

8. 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. Therefore, the emissions of CO₂ from natural gas combustion were recalculated for the years 1997 – 2007.
9. The activity data of solid fuels were updated for the years 2005-2006, 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 years 2005 – 2006.

1.A.2f Other

10. 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. Therefore, the emissions of CO₂ from natural gas combustion were recalculated for the years 1997 – 2007.
11. The activity data of solid and liquid fuels were updated for the years 2005-2006, based on plant specific data, derived from verified ETS reports. Moreover, a plant specific CO₂ EF for petcoke, coal and alternative solid fuels was recalculated per year. Therefore, the emissions of CO₂, CH₄ and N₂O from solid and liquid fuels combustion were recalculated for the years 2005 – 2006.
12. Following the suggestions of the last two ERTs, bitumen, a non energy fuel used in constructions that posses a carbon fraction stored to the end product of 100%, was excluded from AD of 1A2f sector. For that reason, the IEF of solid fuels has increased compared to previous submissions.

Table 3.18 *GHG emissions (in kt CO₂ eq) from manufacturing industries and construction for the period 1990 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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
CH ₄	0.40	0.36	0.36	0.32	0.31	0.30	0.22	0.24	0.20	0.22	0.19	0.20	0.21	0.20	0.13	0.08	0.07	0.08	0.08
N ₂ O	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
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
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
N ₂ O	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
Chemicals																			
CO ₂	1312.27	996.89	563.42	528.76	442.07	456.79	686.08	803.12	999.01	535.01	635.20	632.69	633.84	773.54	873.66	916.94	874.91	845.84	811.14
CH ₄	0.31	0.18	0.17	0.14	0.14	0.15	0.34	0.40	0.49	0.27	0.28	0.27	0.26	0.25	0.35	0.36	0.39	0.37	0.33
N ₂ O	2.42	2.39	2.40	2.90	3.06	3.02	3.06	3.59	3.82	3.61	3.53	3.51	3.29	3.52	3.75	4.07	3.82	3.55	3.55
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
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
N ₂ O	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
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	643.09
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
N ₂ O	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	15.28
Other industries																			
CO ₂	6126.41	6287.00	6070.10	5810.45	5814.33	6590.29	6839.81	6948.98	6700.54	5994.82	6411.02	6696.86	6109.80	5596.25	5290.17	7241.17	7397.91	7262.30	6683.43
CH ₄	6.93	7.09	7.09	6.92	6.71	7.00	3.15	3.16	2.84	2.54	2.73	2.76	2.50	2.05	2.08	2.99	2.72	2.76	2.62
N ₂ O	36.03	37.98	37.87	37.81	38.36	41.70	32.95	33.59	33.85	28.11	29.12	29.89	26.40	23.56	22.29	22.04	23.33	26.03	23.16
TOTAL	9777.85	9674.23	9028.15	8675.05	8502.29	9271.05	9826.61	10088.86	10166.41	9067.29	9780.98	9957.77	9485.08	9186.07	8541.89	10227.01	10440.83	10141.88	9364.27

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 CO₂ presented in Table 3.13 and default IPCC EF for CH₄ and N₂O 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 2008 increased substantially compared to 1990 levels (77% and 183% 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.

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 – 2008.

GHG emissions (*Table 3.21*) are estimated on the basis of fuel consumption as it is presented in Annex II, CO₂ emission factors presented in Table 3.13 and default IPCC EF for CH₄ and N₂O 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 95% for the period 1990 – 2008). Overall, in 2008 emissions from agriculture decreased by approximately 17% compared to 1990 emissions.

3.2.4.5.2 Recalculations

Differences resulted from **recalculations** / **improvements** between the emissions estimates presented in the current submission and the estimates presented in the previous submission for Residential, Tertiary and Agriculture sector are attributed mainly to:

1. 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. Therefore, the emissions of CO₂ from natural gas combustion were recalculated for the years 1997 – 2007.

Table 3.19 *GHG emissions (in kt CO₂ eq) from the residential sector for the period 1990 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
CO₂ emissions																			
Solid fuels	81.71	114.96	107.86	107.77	110.14	99.81	108.96	120.44	102.11	62.68	69.86	65.70	23.46	14.17	23.45	11.35	5.53	6.87	23.68
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
Gaseous fuels	4.92	5.68	8.29	7.64	4.52	6.28	6.28	6.53	10.68	8.93	11.15	12.05	19.74	43.15	79.99	166.49	316.75	407.48	479.18
CH₄ emissions																			
Solid fuels	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.01	0.02	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.01
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
Gaseous fuels	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.02	0.03	0.06	0.12	0.16	0.18
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
N₂O emissions																			
Solid fuels	0.40	0.56	0.53	0.52	0.54	0.49	0.53	0.59	0.50	0.31	0.35	0.32	0.12	0.07	0.12	0.06	0.03	0.03	0.11
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
Gaseous fuels	0.04	0.05	0.07	0.06	0.04	0.05	0.05	0.05	0.42	0.01	0.01	0.01	0.01	0.02	0.04	0.09	0.18	0.23	0.27
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

Table 3.20 *GHG emissions (in kt CO₂ eq) from the commercial / institutional sector for the period 1990 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
CO₂ emissions																			
Solid fuels	9.92	8.50	2.83	1.42	1.42	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	7.57	NO	NO	NO
Liquid fuels	505.09	649.71	610.00	581.80	599.67	646.72	786.18	759.26	767.34	743.71	757.34	982.41	987.27	1066.03	1119.55	1357.69	1392.15	1255.75	1196.56
Gaseous fuels	12.06	12.81	12.96	12.61	13.11	12.66	12.66	13.03	20.00	17.03	19.74	28.11	41.90	63.83	100.43	169.32	203.73	242.18	297.45
CH₄ emissions																			
Solid fuels	0.00	0.00	0.00	0.00	0.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00	NO	NO	NO
Liquid fuels	0.43	0.52	0.49	0.47	0.48	0.51	0.61	0.60	0.60	0.59	0.61	0.80	0.82	0.88	0.88	1.10	1.13	1.01	0.96
Gaseous fuels	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.04	0.06	0.08	0.09	0.11
N₂O emissions																			
Solid fuels	0.05	0.04	0.01	0.01	0.01	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.04	NO	NO	NO
Liquid fuels	1.27	1.52	1.42	1.35	1.39	1.46	1.76	1.72	1.72	1.71	1.77	2.33	2.39	2.57	2.54	3.18	3.27	2.93	2.79
Gaseous fuels	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.01	0.01	0.01	0.01	0.02	0.02	0.04	0.06	0.10	0.11	0.14	0.17

NO: Not Occurring

Table 3.21 *GHG emissions (in kt CO₂ eq) from agriculture for the period 1990 - 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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	2413.89
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
N ₂ O	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

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. Examples of such recalculations are the ones performed in this submission in sectors 1.A.1 a and b.

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 paragraphs. Summarizing, the recalculations performed in stationary combustion sector were as follows:

- ↳ Estimation of country specific emission factors: 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. Therefore, the emissions of CO₂ from natural gas combustion were recalculated for the years 1997 – 2007.
- ↳ Reallocation of emissions to more appropriate sector: The emissions from the non-energy use of solid fuels for ferroalloys production were reallocated to the industrial processes sector (2.C.2). Moreover, according to plant specific data of refineries, the amounts of NG and naphtha used for hydrogen production were reallocated from 1.A.1.c to 1.A.1.b sector
- ↳ Time-series consistency: Following the recommendation of ERT which performed the centralised review from 21-26 September 2009 and concerning the issue of time series consistency when using data from verified EU ETS reports, a consistent CO₂ EF from refinery gas combustion was calculated and applied for the recalculation of the CO₂ emissions of the whole time series (years 1990-2004), based on plant specific data available for 2005-2008 years.
- ↳ Application of improved emission factors resulted from ETS data.
- ↳ Application of plant specific activity data derived from verified EU ETS reports.
- ↳ Correction of errors.

The results of the recalculation of GHG emissions from stationary combustion, namely the difference (%) per gas, and the impact of them on total emissions excluding LULUCF, between present and previous emissions estimates, are presented in **Table 3.22**.

3.2.4.9 Planned improvements

In year 2009 an internal inventory review by an independent national expert took place. Based on the finding of this review improving actions were planned and executed that lead to the recalculations / improvements described above. Moreover, another independent audit is planned for 2010 and it is expected that its findings will be also valuable for the improvement of the inventory.

Table 3.22 *Recalculation of GHG emissions from stationary combustion*

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Recalculations of CO ₂ (%)																		
Energy Industries	-0.36	-0.39	-0.35	-0.38	-0.37	-0.40	-0.44	-0.43	-0.43	-0.42	-0.47	-0.47	-0.48	-0.49	-0.47	0.30	-0.32	0.70
Manufacturing Ind & Construction	-6.29	-5.99	-5.79	-7.06	-7.13	-6.53	-7.40	-5.85	-5.61	-4.52	-6.78	-6.14	-6.89	-7.83	-7.71	13.34	12.72	-3.81
Other Sectors								0.00	-0.01	0.00	-0.01	0.00	-0.01	-0.01	-0.02	-0.03	-0.05	-0.07
Recalculations of CH ₄ (%)																		
Energy Industries																0.50	-1.02	0.81
Manufacturing Ind & Construction	-1.57	-1.47	-1.32	-1.59	-1.65	-1.58	-1.79	-1.41	-1.38	-1.02	-1.49	-1.42	-1.51	-1.92	-1.74	9.29	1.29	-0.66
Other Sectors													-1.28					
Recalculations of N ₂ O (%)																		
Energy Industries																0.13	-0.15	0.22
Manufacturing Ind & Construction	-6.75	-6.11	-5.50	-6.38	-6.32	-5.88	-6.87	-5.36	-5.01	-3.87	-5.96	-5.57	-6.32	-7.50	-7.18	0.17	0.48	-5.01
Other Sectors																		
Impact of Recalculations on Total Emissions excl LULUCF of CO ₂ (%)																		
Energy Industries	-0.15	-0.16	-0.15	-0.16	-0.16	-0.17	-0.18	-0.18	-0.18	-0.17	-0.21	-0.21	-0.21	-0.21	-0.21	0.13	-0.14	0.31
Manufacturing Ind & Construction	-0.63	-0.60	-0.53	-0.63	-0.61	-0.60	-0.70	-0.54	-0.50	-0.35	-0.57	-0.51	-0.55	-0.60	-0.55	0.90	0.91	-0.30
Other Sectors								0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01
Impact of Recalculations on Total Emissions excl LULUCF of CH ₄ (%)																		
Energy Industries																0.00	0.00	0.00
Manufacturing Ind & Construction	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
Other Sectors													0.00					
Impact of Recalculations on Total Emissions excl LULUCF of N ₂ O (%)																		
Energy Industries																0.00	0.00	0.00
Manufacturing Ind & Construction	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
Other Sectors																		

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 item.

In total, GHG emissions from transport (*Table 3.23(a,b)*) in 2008 increased by approximately 53% compared to 1990 emissions (from 14.79 Mt CO₂ eq in 1990 to 22.66 Mt CO₂ eq in 2008). The average annual rate of emissions increase from transport for the period 1990 – 2007 was 3.4%, however, in 2008, an approximately 5% decrease of total emissions was observed compared to 2007 emissions. On an annual base, the highest increase of emissions (compared to the previous year) was observed in 1998 (approximately 10%) and the highest reduction in 2000 (4.2%) and 2008 (4.6%). These changes are due to the fluctuation of energy consumption (in navigation +54% for 1998 and –42% for 2000 and in all sectors in 2008) according to the information provided by the national energy balance account (Table 3.23 (a,b)).

In 2008, the majority of GHG emissions derived from road transport, the contribution of which increased from 81% in 1990 to 85% of total emissions of the sector, since the number of vehicles in the country has considerably increased between 1990 and 2008. It is to be mentioned that this contribution reached 91% in 2007.

The share of internal navigation in the emissions of the transport sector decreased from 12% in 1990 to 8.3% in 2008. Additionally, the contribution of internal aviation increased from 5% in 1990 to 5.7% in 2008, while the contribution of railways decreased from 1.4% in 1990 to less than 0.6% in 2007 and 2008. The contribution of other transport (pipeline transportation) is negligible.

During the period 1990 – 2007 GHG emissions from road transport present an average annual rate of increase of approximately 4%, whereas in 2008 road transport decreases by approximately 4%. Emissions from internal navigation increased with an average annual rate of less than 1% up to 2007 and a rather important decrease of 11% in 2008 leading to an increase of only 3% in comparison to 1990 emissions. Emissions from internal aviation increased by an average annual rate of 4.4% whereas emissions from railways presented a declining trend with an average annual rate of 2.3%.

Finally, emissions from international navigation and international aviation increased slightly with an average annual rate of the order of 1% for the period 1990 – 2008 (*Table 3.8(a,b)*).

Transport is also a major contributor of indirect greenhouse gases emissions (carbon monoxide, oxides of nitrogen and non-methane volatile organic compounds).

Table 3.23(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 ₂ O	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04
Road transport	CO ₂	11761	12612	12917	13217	13398	13829	14488	14819	15567	15841
	CH ₄	5.15	5.48	5.85	6.10	6.23	6.51	6.92	7.03	7.22	7.30
	N ₂ O	0.40	0.43	0.44	0.45	0.46	0.54	0.62	0.69	0.79	0.89
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 ₂ O	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	0.17	0.18	0.18	0.17	0.17	0.17	0.14	0.17	0.27	0.26
	N ₂ O	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 ₂ O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
kt CO₂eq	Total	14789	15538	15954	16169	16490	16878	17385	18173	19980	20429

Table 3.23(b) *GHG emissions in the transportation sector per category for the period 2000 – 2008*

Year		2000	2001	2002	2003	2004	2005	2006	2007	2008
		Emissions (kt)								
Aviation	CO ₂	1331	1227	1052	1185	1227	1213	1280	1348	1279
	CH ₄	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
	N ₂ O	0,05	0,04	0,04	0,04	0,04	0,04	0,04	0,05	0,04
Road transport	CO ₂	16029	16375	16974	18006	18108	18309	18895	19785	19030
	CH ₄	7,37	6,91	6,42	6,09	5,36	4,87	4,65	4,75	4,59
	N ₂ O	0,95	1,08	0,99	0,93	0,84	0,79	0,74	0,73	0,65
Railways	CO ₂	129	129	129	129	129	127	131	118	115
	CH ₄	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,06
	N ₂ O	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,04
Navigation	CO ₂	1580	2145	1937	1923	2153	2054	2260	2113	1885
	CH ₄	0,15	0,2	0,18	0,18	0,2	0,03	0,04	0,03	0,03
	N ₂ O	0,04	0,05	0,05	0,05	0,05	0,05	0,06	0,05	0,05
Other	CO ₂	NO	2,06	5,426	3,617	2,21	3,814	4,912	7,435	14,32
	CH ₄	NO	0	0	0	0	0	0	0	0
	N ₂ O	NO	0	0	0	0	0	0	0	0
kt CO₂eq	Total	19565	20408	20587	21713	22042	22101	22949	23746	22664

Table 3.24(a) Energy consumption (in TJ) in the transportation sector per category. for the period 1990 – 1999

Year	Energy consumption (in TJ)									
	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 3.24(b) Energy consumption (in TJ) in the transportation sector per category. for the period 2000 – 2008

	Energy consumption (in TJ)								
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Aviation	18846	17373	14901	16781	17394	17185	18143	19084	17876
Road transport	227903	232929	241641	256195	257910	260893	270979	285270	274546
Railways	1773	1773	1773	1773	1773	1758	1801	1630	1546
Navigation	21363	28895	26155	26024	28980	27674	30610	28405	25371
Other	NO	37	97	65	40	68	88	133	257
Total	269885	281007	284567	300838	306097	307579	321622	334522	319595
Energy consumption (in TJ)									
International aviation	35360	32863	32863	42776	43972	33762	40497	41389	37082
International marine	150495	145963	131216	134067	135395	119726	129215	132085	128662

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 CO₂, 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 N₂O/NH₃ 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 CO₂, N₂O, NH₃ and CH₄ calculations
- Effect of biodiesel blends on emissions from diesel cars and HDVs
- Split of NO_x emissions to NO and NO₂
- 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.

The different vehicle categories population along with the total annual kilometres driven by each category as well as other traffic characteristics are presented in **Table 3.25**. 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. All the updated data used, namely fleet composition and mileage, were based on up to date statistics and measurements from the Ministry of Transport and the Ministry for the Environment. It is to be noted that in 2008 a decrease of the annual kilometres driven was considered linked to the fuel consumption decrease.

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. In such cases, an effort was made, where possible, to recalculate values for the previous years of the time series. For this year submission (2010) the only recalculation performed was the update of biodiesel activity data for years 2006 and 2007. This correction led to minor recalculation of CO₂, CH₄ and N₂O emissions from biomass (i.e. biodiesel) consumption of road transportation sector.

Table 3.25 *Vehicle categories, vehicles population per category, total kilometres driven (mileage), average speed and mileage contribution by road vehicle category.*

Vehicle categories		Number of Vehicles	Total (10 ⁶ km)	Annual Mileage			Average speed		
				Urban (%)	Rural (%)	Highway (%)	Urban (km/h)	Rural (km/h)	Highway (km/h)
Passenger cars	Conventional	1262554	10108	44	42	14	19	60	90
	Euro I	528574	5233	44	42	14	19	60	90
	Euro II	911764	9066	44	42	14	19	60	90
	Euro III	1451770	14354	44	42	14	19	60	90
	Euro IV	913126	6068	44	42	14	19	60	90
Light duty vehicles	Conventional	255646	2391	44 ¹ /35 ²	42/35	14/30	19	60	90
	Euro I	153322	1533	44/35	42/35	14/30	19	60	90
	Euro II	144542	1590	44/35	42/35	14/30	19	60	90
	Euro III	171448	1800	44/35	42/35	14/30	19	60	90
	Euro IV	53395	280	44/35	42/35	14/30	19	60	90
Heavy duty vehicles	Conventional	101878	3099	35	35	30	19	50	70
	Euro I	17843	559	35	35	30	19	50	70
	Euro II	43192	1289	35	35	30	19	50	70
	Euro III	64880	1815	35	35	30	19	50	70
	Euro IV	17488	456	35	35	30	19	50	70
Buses & Coaches	Urban buses	5045	253	100			19		
	Coaches	20418	842	5	45	50	19	60	90
Mopeds & motorcycles	Mopeds	88000	606	90	10		20	40	
	Motorcycles	1407304	9123	65	20	15	30	60	90

¹ Gasoline vehicles ² Diesel vehicles

In the last years, the vehicle fleet has doubled compared to 1990 levels, while a remarkable increase of the share of medium and larger size passenger vehicles is observed (from 15% in 1990, to 35% in 2008).

Road transport is a key category of CO₂ emissions. CO₂ emissions in 2008 increased by approximately 62% compared to 1990 emissions, CH₄ emissions decreased slightly (about 11%), while N₂O emissions increased by 63% (**Table 3.26(a,b)**). During this period, energy consumption augmented by 64%.

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, NO_x and NMVOC emissions decrease. Finally, after the considerable reduction of SO₂ 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 SO₂ 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 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 CO₂, are incorporated in the total emissions amount for each gas and are not reported separately.

Table 3.26(a) GHG emissions (in kt CO₂ 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 Mt CO₂ eq)										
CO ₂ (kt)	11,761	12,612	12,917	13,217	13,398	13,829	14,488	14,819	15,567	15,841
CH ₄ (kt)	5.15	5.48	5.85	6.10	6.23	6.51	6.92	7.03	7.22	7.30
N ₂ O (kt)	0.40	0.43	0.44	0.45	0.46	0.54	0.62	0.69	0.79	0.89
TOTAL	11,992	12,862	13,177	13,486	13,671	14,133	14,825	15,181	15,965	16,269
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 3.26(b) *GHG emissions (in kt CO₂ eq) and energy consumption (in TJ) from road transportation for the period 2000 – 2008*

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions (in Mt CO₂ eq)									
CO ₂ (kt)	16,029	16,375	16,974	18,006	18,108	18,309	18,895	19,785	19,030
CH ₄ (kt)	7.37	6.91	6.42	6.09	5.36	4.87	4.65	4.75	4.59
N ₂ O (kt)	0.95	1.08	0.99	0.93	0.84	0.79	0.74	0.73	0.65
TOTAL	16,479	16,854	17,416	18,424	18,48	18,655	19,223	20,111	19,328
Energy consumption (in TJ)									
Gasoline	144,704	149,453	156,486	163,52	167,1	170,92	172,813	180,593	177,208
Diesel	81,894	82,11	83,41	90,993	89,173	88,272	94,459	99,187	95,793
LPG	709.65	756.96	709.65	567.72	520.41	520.41	520.41	567.72	567.73
Natural Gas			404.00	446.00	444.00	489.80	516.42	600.30	534.60
Other liquids	595.51	608.64	630.35	668.27	672.77	690.97	712.36	734.46	716.71
TOTAL	227,903	232,929	241,641	256,195	257,910	260,893	269,021	281,682	274.820

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). 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 (CO₂ emissions) is a key category. GHG emissions from navigation in 2008 were slightly higher (2%) than the emissions in 1990, on the basis of fuel consumption data from this sector (*Table 3.27*).

Table 3.27 *GHG emissions (in kt CO₂ eq) and energy consumption (in TJ) from internal navigation for the period 1990 – 2008*

	Emissions (in kt CO ₂)				Energy consumption (in TJ)			
	CO ₂	CH ₄	N ₂ O	ktCO ₂ eq	Diesel	Fuel Oil	Lubricants	Total
1990	1,825	0.17	0.05	1,843	14,559	9,525	764	24,848
1991	1,851	0.18	0.05	1,869	15,469	9,284	161	24,913
1992	1,899	0.18	0.05	1,918	15,079	10,248	241	25,568
1993	1,738	0.17	0.04	1,755	15,166	8,078	201	23,445
1994	1,831	0.17	0.05	1,849	14,082	10,289	281	24,652
1995	1,744	0.17	0.04	1,761	12,349	10,771	362	23,482
1996	1,493	0.14	0.04	1,508	9,923	9,847	322	20,091
1997	1,812	0.17	0.05	1,830	10,226	13,665	442	24,333
1998	2,793	0.27	0.07	2,821	15,252	21,622	522	37,397
1999	2,761	0.26	0.07	2,788	12,522	23,752	643	36,918
2000	1,580	0.15	0.04	1,595	11,396	9,485	482	21,363
2001	2,145	0.20	0.05	2,166	14,949	13,464	482	28,895
2002	1,937	0.18	0.05	1,956	14,299	11,374	482	26,155
2003	1,923	0.18	0.05	1,942	13,042	12,298	683	26,024
2004	2,153	0.20	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	2,260	0.04	0.06	2,279	15,378	14,428	804	30,610
2007	2,113	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

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 3.28(a,b)*).

GHG emissions from internal aviation increased by 78% since 1990 with an average annual increase rate of 4.4% (*Table 3.28(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 3.29(a,b)*) decreased by 45% from 1990 to 2008.

Table 3.28(a) *GHG emissions (in kt CO₂ 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 ₂ O	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04
TOTAL (in kt CO ₂ eq)	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 3.28(b) *GHG emissions (in kt CO₂ eq). energy consumption (in TJ) and air movement (in thousands LTOs) for the period 2000 – 2008*

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
	Emissions (in kt CO₂)								
CO ₂	1.331	1.227	1.052	1.185	1.227	1.213	1.280	1.348	1.279
CH ₄	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
N ₂ O	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04
TOTAL (in kt CO ₂ eq)	1.345	1.240	1.064	1.198	1.241	1.226	1.294	1.363	1.292
Energy Consumption (TJ)	18.846	17.373	14.901	16.781	17.394	17.185	18.143	19.084	18.358
LTOs (1000s)	220.07	202.87	174.00	195.95	203.11	200.67	211.85	222.85	214.36

Table 3.29(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 ₂ O (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 3.29(b) *GHG emissions from railways for the period 2000 – 2008*

Year	2000	2001	2002	2003	2004	2005	2006	2007	1990
CO ₂ (kt)	128.55	128.55	128.55	128.55	128.55	127.45	130.60	118.00	113.40
CH ₄ (kt)	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06
N ₂ O (kt)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04
Total (in kt CO ₂ eq)	145.44	145.44	145.44	145.44	145.44	144.34	147.91	133.62	127.06

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: Biodiesel consumption

A recalculation of the years 2006 and 2007 emissions were carried out due to a correction of NCV of biodiesel and consequently of biodiesel activity data.

3.2.5.6 Planned improvements

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

Road Transport

- A detailed and updated fleet population and composition database has already been accomplished but the effort continues for further improvement in next year's fleet.
- The problem with emissions calculation cross-check using statistical data for energy consumption due to fuel smuggling and other illegal uses, is expected to be reconsidered in the following years, as since last year legal measures have been applied. As a matter of fact, concerning gasoline consumption the calculated amount is only 3% lower than the statistical amount. On the contrary, the respective deviation between calculated and statistically determined diesel consumption reaches 12% with the calculated amount being larger. This finding shows that the problem still persists.

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.

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 (CH₄), 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 (CH₄ emissions) are a key category. CH₄ emissions (**Table 3.30**) from the mining of lignite in 2008 account for 1.33% of total GHG emissions from *Energy* and 1.1% of total national emissions (without *LULUCF*). Moreover, lignite mining is the third more important source of CH₄ emissions (following enteric fermentation and solid waste disposal on land) and is responsible for 17.6% of total methane emissions in 2008 (without *LULUCF*). The average annual rate of emissions increase for the period 1990 – 2008, is estimated at 1.4% (a total increase of 26.6% in 2008 compared to 1990 levels).

Table 3.30 *CH₄ emissions from lignite mining (in Mt) and primary production of lignite (in kt) for the period 1990 – 2008*

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

3.3.1.2 Methodological issues

CH₄ 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 3.30) used for the calculation of emissions.
- ↳ The typical emission factor (1.5 m³ / 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 / m³.

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 SO₂ scrubbing technology is used in conjunction with combustion of coal, the process, which removes sulphur dioxide from the flue gas, also releases CO₂ from the chemical reactions during the process. Typically, calcium carbonate reacts with sulphur oxides in flue gas to produce calcium sulphate and carbon dioxide.

3.3.2.2 Recalculations

The emissions of this category have been reallocated to the Industrial Processes sector (2.A.3).

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 700 km, (b) the terminal of the liquefied natural gas which includes two storage tanks with a total capacity of 130,000 m³ 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 3.31**) from oil and natural gas in 2008 accounted for 0.15% of total GHG emissions from *Energy* and for 0.13% of total national emissions (without *LULUCF*). Overall, emissions in 2008 decreased by 1% 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 3.32a** and **Table 3.32b** respectively) present a continuous decreasing trend and as a result emissions from venting and flaring are decreasing. Since venting and flaring constitute a significant sub-source within oil and natural gas GHG emissions trends are clearly affected.

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 3.31 *GHG emissions (in kt CO₂ eq) from oil and natural gas for the period 1990 – 2008*

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	159.85
1992	35.83	8.71	92.37	0.01	136.92
1993	29.44	5.70	75.45	0.01	110.59
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	151.91
1997	31.55	42.71	79.29	0.01	153.56
1998	26.29	61.84	67.98	0.01	156.13
1999	13.28	66.23	29.41	0.01	108.94
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	155.77
2003	20.31	86.35	49.17	0.01	155.85
2004	19.74	91.78	49.16	0.01	160.69
2005	18.83	94.94	45.29	0.01	159.07
2006	18.88	99.51	45.47	0.01	163.86
2007	18.17	104.35	42.66	0.01	165.19
2008	16.46	104.21	39.63	0.01	160.31

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 3.32a) used for the calculation of emissions.
- ↳ Emissions are estimated for the following activities:
 - Primary production of crude oil (CO₂ and CH₄),
 - Crude oil transport by tankers (CO₂ and CH₄),
 - Refining and storage of oil products (CH₄, NO_x, CO, NMVOC and SO₂),
 - Distribution of oil products (NMVOC) and
 - LPG transport (CO₂ and N₂O).
- ↳ Emissions from crude oil transport are reported under Venting, while emissions from LPG transport are reported under Other (1.B.2d - Other).
- ↳ The CH₄ emission factor used for refining and storage derives from IPCC Guidelines (Table 1.58 – Western Europe, IPCC 1997). The CO₂ and CH₄ 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 3.32a *Key activity data for the estimation of GHG emissions from oil systems for the period 1990 - 2008*

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	10.5	18699	520
2006	94	11.5	19836	520
2007	74	7	20330	568
2008	59	3	19286	568

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

- ↳ Activity data for the estimation of emissions (Table 3.32b) derive from the national energy balance, the Public Gas Corporation (length of transmission pipeline) and international institutes and databases (e.g. European Union of the Natural Gas Industry for the length of the distribution pipelines).
- ↳ Emissions are estimated for the following activities
 - Production and processing of natural gas (CO₂ and CH₄) and
 - Transmission and distribution of natural gas (CH₄).
- ↳ 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 CO₂ and CH₄ emissions for the period 1996 – 2007 derive from the IPCC Good Practice Guidance (Table 2.16, IPCC 2000).

Table 3.32b *Key activity data for the estimation of GHG emissions from natural gas systems for the period 1990 - 2008*

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%	3081	960
2005	16	25%	3411	960
2006 ¹⁶	23	17%	3756	960
2007 ¹⁴	21	14%	4136	960
2008 ¹⁴	14	21%	4136	960

In relation to emissions from venting and flaring (CO₂, CH₄ and N₂O) it should be mentioned that in most cases more than one variable is used as activity data (see **Table 3.33** 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.

3.3.3.3 Recalculations

No recalculations were performed.

¹⁶ Provisional data

Table 3.33 GHG emissions (in t) from venting and flaring for the period 1990 – 2008

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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
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
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
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
N.G. – Production																			
CO ₂	2556.00	3053.00	2556.00	1917.00	2130.00	1775.00	1846.00	1349.00	1420.00	71.00	1207.00	1136.0	1917.00	150.16	363.16	292.16	292.16	221.16	221.16
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	15.36	15.36	15.36
CH ₄							1608	2019	2931	3153	3376	3667	3650	4103	4362	4515	4731	4962	4957
Flaring																			
Oil – Production																			
CO ₂	66944.6	67103.5	54999.4	44904.4	42657.8	36566.9	41323.1	37413.5	25418.1	1287.4	22622.9	15620.17	15588.	11286.8	10910.4	9006.85	8640.70	6578.01	4961.42
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
N ₂ O	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
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
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
N ₂ O	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	124.2	9.20	23.00	18.40	18.40	13.80	13.80
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
N ₂ O	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 SF₆
- ↳ Consumption of halocarbons and SF₆

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 2008, GHG emissions from *Industrial processes* account for 8.61% of total emissions (including LULUCF) and have decreased by 9.51% compared to base year emissions and increased by 10.69% compared to the emissions of 1990 (**Figure 4.1**), while the average annual rate of increase is estimated at 0.76% for the period 1990 – 2008.

Emissions from *Industrial processes* are characterized by intense fluctuations during the period 1990 – 2008, reaching a minimum value of 9.52 Mt CO₂ eq in 1992 and a maximum value of 14.19 Mt CO₂ eq in 1999, that are mainly attributed to changes in industrial production and especially in HCFC-22 production.

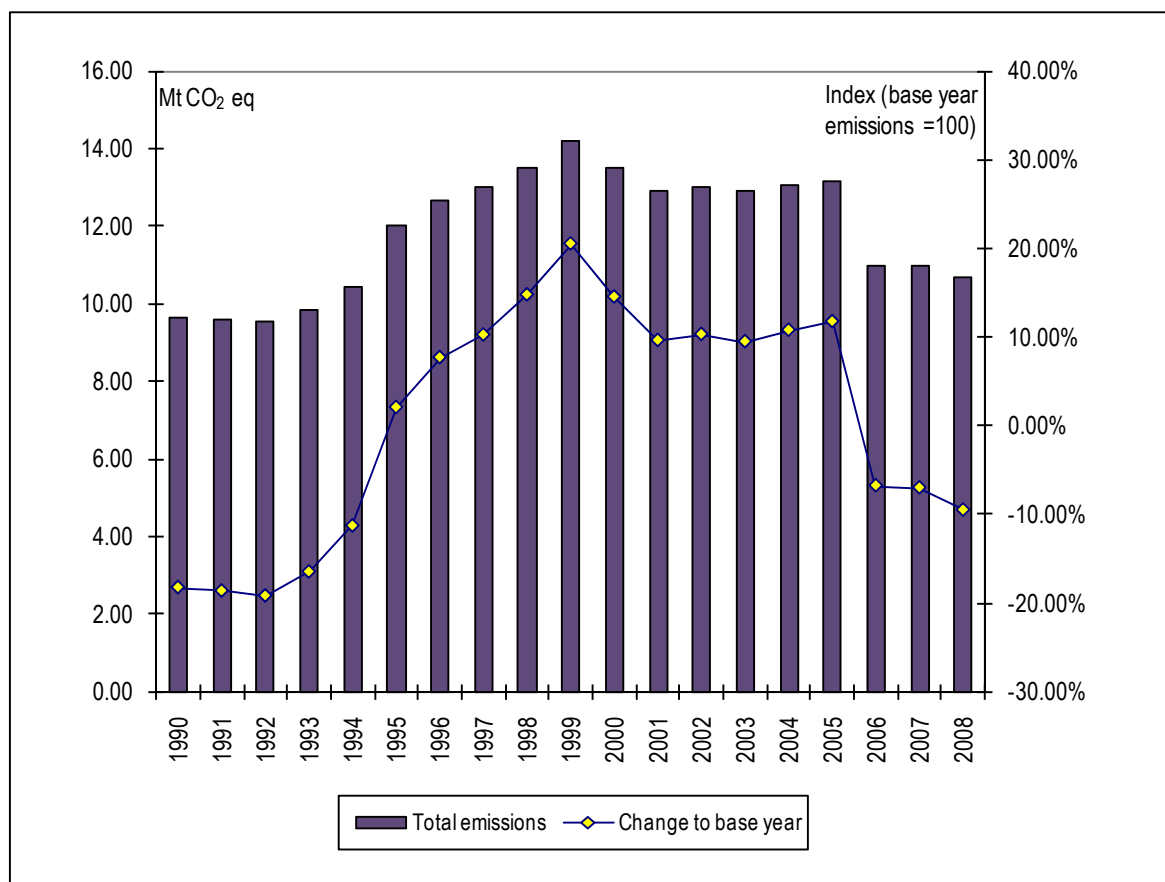


Figure 4.1 *Total GHG emissions (in Mt CO₂ eq) from Industrial Processes for the period 1990 - 2008*

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 56.42% to 80.25%. Overall, CO₂ emissions in 2008 increased by 11.03% from 1990, with an average annual rate of increase estimated at 0.63%. CO₂ 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 12.23% in 1990 to 38.27% in 1999 (peak). The contribution continues to be important until 2006 where an abrupt decrease is observed (from 27.70% in 2005 to 15.71% 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 58.74% in 2005). In the recent years (2006-2008) 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 – 2008, with an average annual rate of change of -5.52%. The reduction of N₂O emissions in 2008 compared to 1990 levels is -66.87%, and is attributed to the reduction in the nitric acid production.

The contribution of CH₄ 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. The average rate of decrease is 0.67% for the period 1990-2008.

Table 4.1 *GHG emissions (in kt CO₂ eq) per gas from industrial processes for the period 1990 – 2008*

Year	CO ₂	CH ₄	N ₂ O	HFC	PFC	SF ₆	TOTAL
1990	7,325.55	0.73	1,109.04	935.06	257.62	3.07	9,631.06
1991	7,303.69	0.76	914.40	1,106.82	257.56	3.16	9,586.39
1992	7,399.28	0.71	956.20	908.39	252.30	3.26	9,520.14
1993	7,168.29	0.76	908.04	1,606.64	152.59	3.35	9,839.67
1994	7,325.30	0.75	882.84	2,143.91	93.62	3.45	10,449.86
1995	7,798.04	0.80	878.50	3,259.05	82.97	3.59	12,022.94
1996	7,841.64	0.80	1,003.21	3,764.20	71.74	3.68	12,685.18
1997	7,915.29	0.84	881.10	4,019.62	165.34	3.73	12,985.91
1998	8,081.27	0.82	725.06	4,503.28	203.75	3.78	13,517.96
1999	8,009.35	0.53	752.96	5,296.54	131.72	3.87	14,194.97
2000	8,417.62	0.47	771.07	4,149.68	148.38	3.99	13,491.21
2001	8,413.07	0.27	648.08	3,756.59	91.38	4.06	12,913.45
2002	8,329.51	0.39	623.93	3,947.36	88.33	4.25	12,993.76
2003	8,506.66	0.36	575.90	3,732.36	77.30	4.25	12,896.83
2004	8,535.80	0.41	547.53	3,889.62	71.38	4.47	13,049.21
2005	9,041.64	0.48	545.80	3,595.15	71.31	6.45	13,260.83
2006	8,815.14	0.51	442.70	1,646.48	71.16	8.37	10,984.35
2007	8,746.52	0.54	439.53	1,700.82	58.66	9.92	10,955.99
2008	8,133.53	0.46	367.42	2,077.34	74.17	7.53	10,660.45

Throughout the inventory years, the main sources of emissions from *Industrial processes* are mineral products and production of halocarbons and SF₆ (**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. As a result the contribution of GHG emissions from the above mentioned sources to the total sector emissions decreases from 75.94% in 1990 to 63.55% in 2008. The contribution of halocarbons consumption to total emissions from the sector has increased considerably in the recent years (19.56% in 2008 against 0.08% in 1995) due to the replacement of Ozone Depleting Substances (ODS), from halocarbons. The average annual rate of increase is 53.54% for the period

1995 – 2008. Finally, the contribution of emissions from the chemical production decreases from 11.52% in 1990 to 5.74% in 2008, whereas metal industry in general remains stable (12.51% in 1990 versus 11.15% in 2008).

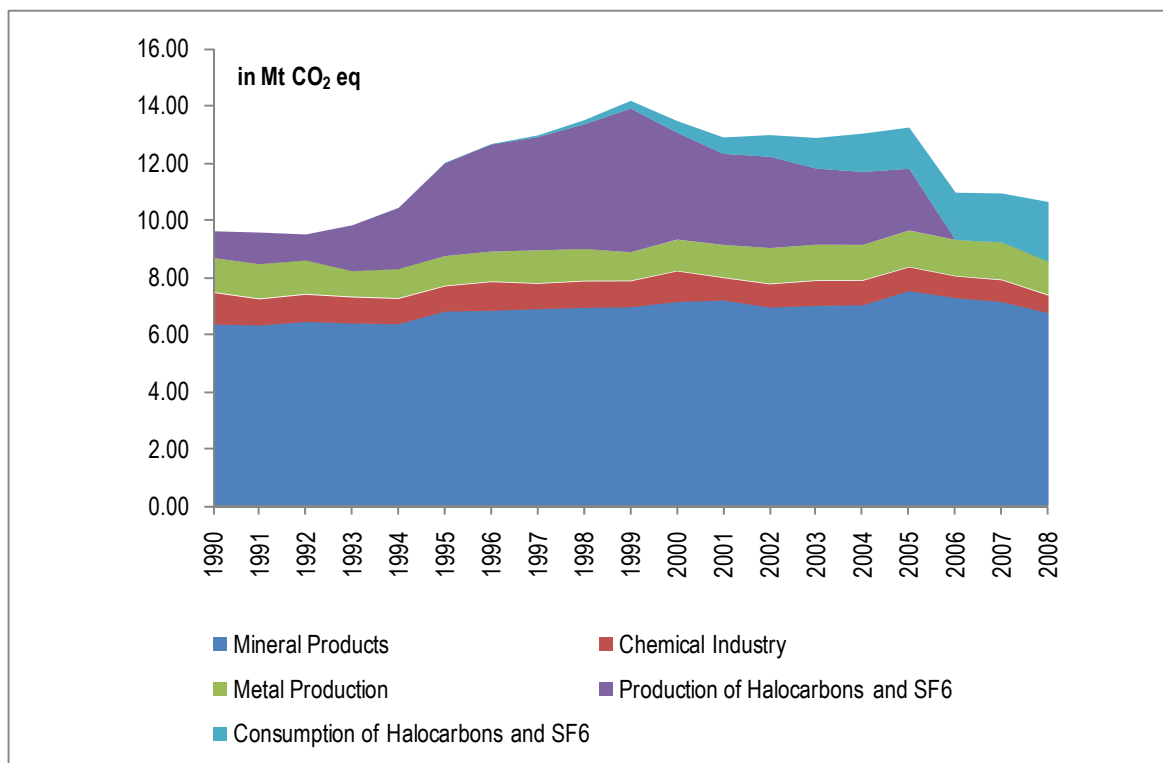


Figure 4.2 *GHG emissions (in Mt CO₂ eq) from Industrial processes, per main source category for the period 1990 – 2008*

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 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.

- ✎ CO₂ 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. All the information received is archived in the Input File, according to the Greek QA/QC system. For the *Consumption of Halocarbons and SF₆* subcategory, emission factors have been estimated by the National Association of Refrigerating and Cooling Technicians. 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 National Statistical Service of Greece (NSSG). 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 NSSG, which has been achieved through various meetings between the inventory team and the Production Statistics Section of the NSSG. 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 (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 SF₆*, data have been provided by market surveys, NSSG (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 NSSG, 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 ₂ O		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, CS	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 2008 (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).

Table 4.3 *Key categories from industrial processes in the year 2008*

Source category	Gas	Level assessment	Trend assessment
Cement production	CO ₂	☒	☒
Nitric acid production	N ₂ O		☒
Ammonia production	CO ₂		☒
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 IV. 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:

- ↪ CO₂ emissions from SO₂ scrubbing have been reallocated from category 1.B.1.C to the *Limestone and Dolomite Use* category.
- ↪ N₂O from ammonia production are reported as Not Applicable (NA).
- ↪ The possibility of any fugitive CH₄ emissions during Ammonia Production is considered as non existing by the sole operating Greek plant. Emissions are therefore reported as NA.
- ↪ CO₂ emissions from *Ferroalloys Production* have been reallocated from the energy sector using information received by the corresponding plant.
- ↪ CH₄ emissions from *Iron and Steel Production* have been estimated for the first time in the current inventory. The emissions are calculated using the default emission factor suggested in the SNAP Code 040207 of the CORINAIR (Electric Furnace Steel Plants).
- ↪ CH₄ emissions from *Ferroalloys Production* and *Aluminium Production* are reported as Not Applicable (NA) according to information received by each of the respective manufacturing plants, as it is also the case in other EU countries.
- ↪ HFCs emissions from *Foam Blowing* are estimated for the first time, using information received by the four companies in Greece. According to the information received by the above mentioned companies, only three of them are making use of HFC-134a and HFC-152a, while no use has been reported before 2001.
- ↪ HFCs emissions from the *Aerosols* category have been calculated making use of the information received by the plants that are involved in this activity. Moreover, the collected data have been crosschecked with information received by the Hellenic Aerosols Association. According to the information received, there is only one plant that uses HFC-134a for the production of aerosol products (apart from the manufacture companies that are involved in the production and importation of MDIs).
- ↪ Finally, emissions from *Fire Extinguishers* are estimated for the first time in the current inventory. In absence of any data on the respective category, emissions have been estimated on the basis of emissions from other countries that are similar to Greece (Portugal, Spain and Italy), using the population as a driver.

The main reasons for the non estimation of GHG emissions refer to the lack of emission factors in the IPCC Guidelines (e.g. CO₂ emissions from *organic chemicals production* and *asphalt roofing-road paving with asphalt*). In one case (*Solvents*) emissions have not been estimated due to the absence of any activity data.

As concerns to the *Potential Emissions from the Consumption of Halocarbons and Sf₆*, imports and exports data of the relative compounds (in bulk) have been provided by the NSSG. However, these compounds are not reported separately and the estimation of potential emissions is not possible. To resolve this issue, Greece follows the plan already described in previous submissions (NIR 2009):

1. The raise of confidentiality regarding the importers/exporters of f-gases has been requested by the NSSG. This is a time-consuming procedure as the request will have to be examined by the relative Committee of the NSSG.

2. Using the data received by the NSSG, a questionnaire will be prepared and distributed to the importers/exporters in order to collect data concerning the consumption of the above mentioned compounds.

Although the first step has not been concluded yet, due to some internal organizational issues of the NSSG, according to information received by members of the service, the preparation of the list of importers/exporters is underway.

Table 4.4 Industrial processes – Completeness

	CO ₂	CH ₄	N ₂ O	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
F. Consumption of halocarbons and SF ₆							
1. Refrigerating and air conditioning equipment				☒	NA	NA	
2. Foam blowing				☒	NO	NO	
3. Fire extinguishers				☒	NE	NO	
4. Aerosols/metered dose inhalers				☒	NO	NO	
5. Solvents				☒	NO	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 CO₂ occur during the production of clinker, which is an intermediate component in the cement manufacturing process. CO₂ emissions are attributed to the calcination of limestone (mainly CaCO₃), to produce lime (CaO) and carbon dioxide as a by-product.

Cement production (CO₂ emissions) is a key category. CO₂ emissions from cement production in 2008 (**Table 4.5**) accounted for 56.78% of total GHG emissions from industrial processes and for 4.77% of total national emissions including LULUCF (4.89% of total national emissions excluding LULUCF). The average annual rate of increase of CO₂ emissions from cement production during the period 1990 – 2008 was 0.44% (emissions increased by 7.32% from 1990 to 2008).

Table 4.5 *CO₂ emissions from cement production (in kt) and clinker production (in kt) for the period 1990 - 2008*

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

4.2.2 Methodological Issues

During the inventory preparation the calculation of CO₂ emissions from cement production is very important, as this is a key category by both trend and level assessment.

For the years 2005-2008 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:

$$\text{CO}_2 \text{ Emissions} = \sum_i (\text{EF}_i \cdot \text{M}_i \cdot \text{F}_i) - \text{M}_d \cdot \text{C}_d \cdot (1 - \text{F}_d) \cdot \text{EF}_d$$

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 2008 the average content of the raw materials in CaCO_3 and MgCO_3 has been estimated at 76.80% and 2.62%, whereas the emission factor used is 44% and 52.2%, respectively, deriving from the stoichiometry of the reaction. Also, the raw material used throughout 2008 was 17,428.56 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 $\text{F}_d=1$ has been used to avoid double counting.

In 2008 the plants have reported for the first time the emissions from non-carbonate carbon (organic carbon). The percentage of organic carbon to the raw material has been low (average content of 0.18%) and the respective emissions constitute the 2.03% of total emissions from cement production.

For reasons of consistency between both the previous years and the other countries, the activity data of the more recent years (2005-2008) 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 as regards to 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 centralised review. It should be noted that emissions in 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 one year 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.

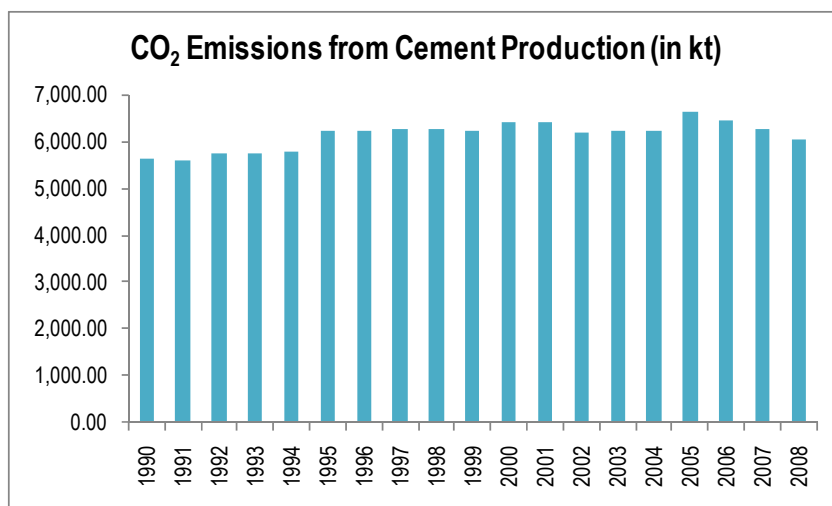


Figure 4.3 *CO₂ emissions (in kt) from Cement Production for the period 1990 – 2008*

Table 4.6 *Country specific CO₂ emission factor (in t / t) for clinker (cement) production for the period 1990 - 2008*

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

During the years 1990-2005, emissions show some fluctuations (*Figure 4.3*). In general, annual variations of clinker production and, as a result, of CO₂ 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, 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.

It should be also noted that the 2008 IEF is higher than the one used in the previous years (*Table 4.6*). This is due to the fact that the reported percentage of carbonates in the raw material is higher for 2008 than the one of 2007 (CaCO₃ 76.0% and MgCO₃ 2.53% for 2007 versus CaCO₃ 76.8% and MgCO₃ 2.62% for 2008 respectively). The average CaO and MgO content of clinker for the years 2005-2007, 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

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 NSSG. 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.

4.2.5 Recalculations

No recalculation has been performed in the 2010 submission. This is in line with the results of the 2009 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 for the first time in the inventory year 2008, 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 ($\text{CaCO}_3 \cdot \text{MgCO}_3$) to produce lime or dolomitic lime. Lime production in Greece is mainly based on limestone.

Lime production (CO_2 emissions) is not a key category, although it has been considered as a key category under the trend analysis during 1993-1995, 1997 and 2005. CO_2 emissions from lime production in 2008 (**Table 4.8**) account for 3.21% of total GHG emissions from Industrial processes and for 0.28% of total national emissions (including LULUCF) and are characterized by fluctuations, mainly because of the difference between plant-specific data and NSSG data. The average annual rate of decrease of CO_2 emissions from lime production, for the period 1990 – 2008, is estimated at 0.84%.

Table 4.8 *CO_2 emissions (in kt) from lime production and production of lime (in kt) for the period 1990 - 2008*

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	0.854	549.45
2008	341.76	0.853	400.41

4.3.2 Methodology

For years 2005 – 2008, 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:

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

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 966.127 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 NSSG 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. For 2008 the production data that have been provided were reported as ‘provisional’ and their use has led to a significant change of the IEF. According to the Tier 2 QC procedures, the inventory team has decided not to use this piece of information until it is finalized by the NSSG. For this reason the same IEF has been used in order to report production.

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%.

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 NSSG 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 CO₂ 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 review 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 level, as well as to the EF, 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, an important decrease has been observed, depicting the economical crisis of the 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 NSSG production data. For 2008 emissions on the basis of the provisional data provided by the NSSG did not match very well with the emissions reported by the plants. After coming into communication with the NSSG, the inventory team has been informed that the service is also re-checking the data in order to make sure that the corrected values have been used. It has jointly been decided, therefore, that the inventory team shall wait for the finalization of the data to use this kind of information in the inventory. For the time being the estimation of the production levels is being performed using the previous IEF.

4.3.5 Recalculations

No recalculations have been performed. Also, no such suggestion has been made by the ERT in the 2009 centralized review.

4.3.6 Planned improvements

The current submission can be considered satisfactory, with the exemption of accurate production levels for 2008. 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 ($\text{CaCO}_3\cdot\text{MgCO}_3$) 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 not a key category, according to the results of the analysis carried out in the present inventory. Emissions in 2008 (**Table 4.9**) accounted for 3.40% of total GHG emissions from *Industrial processes* and for 0.29% of total national emissions (without *LULUCF*).

Table 4.9 Limestone use (in kt) and CO_2 emissions (in kt) for the period 1990 – 2008

Year	Limestone (kt)	CO_2 emissions (kt)
1990	649.10	285.60
1991	704.32	309.90
1992	698.52	307.35
1993	583.07	256.55
1994	463.94	204.13
1995	446.91	196.64
1996	452.83	199.24
1997	489.26	215.27
1998	552.01	242.89
1999	553.16	243.39
2000	685.91	301.80
2001	767.94	337.90
2002	736.87	324.22
2003	883.04	388.54
2004	929.99	409.19
2005	1,128.13	506.95
2006	908.58	416.31
2007	886.36	403.77
2008	811.64	632.73

4.4.2 Methodology

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

CO₂ emissions are estimated according to the following general equation:

$$CO_2Emissions = \sum_i (M_i \cdot EF_i \cdot F_i)$$

where, CO₂ 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 CO₂ 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 2005-2008) and the reporting performed for the NAP formulation in the previous years. For 2008, the total CaCO₃ equivalent amounts to 17.68 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 CaCO₃. Plant specific data on limestone consumption cover the years 1990 and 1998 – 2008. The specific limestone consumption has been estimated on the basis of the available information (for the years 1990 and 1998 – 2007) and has been used for filling in missing data.
- ✎ **Ceramics production:** Carbonates consumption data (in the context of the ETS reports) have been used to estimate emissions in the years 2005-2008. Activity data refer to CaCO₃ and MgCO₃ consumption (emission factors 0.44 and 0.522 respectively). The total CaCO₃ equivalent amounts to 479.87 kt. 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 NSSG for the same period.
- ✎ **SO₂ 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 2005-2008 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.
- ✎ 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 CO₂ 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 to the emission factor used in the most recent years (2005-2008) (it is higher than the default (0.44)) is attributed to the fact that in the ceramics industry two of the plants also report on the pet coke used in the manufacturing process

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 NSSG (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.

4.4.5 Recalculations

Emissions from SO₂ scrubbing have been reallocated from the energy sector. As it has been already mentioned, these data correspond to the years 2000-2008. Also ceramics production of 2005 has been recalculated using updated activity data. The difference between the previous and the current estimates and the impact on total emissions is presented in *Table 4.10*. It should be noted that the impact on total emissions is counter-balanced from the energy sector, since the CO₂ emissions have been reallocated from CRF category 1.B.1.C (Other/SO₂ scrubbing).

Table 4.10 *Recalculations of CO₂ emissions from limestone and dolomite use (2000-2007)*

Year	2000	2001	2002	2003	2004	2005	2006	2007
Difference (%)	26.60	35.97	25.49	29.24	35.45	67.37	32.08	35.96
Impact on total emissions (excl LULUCF) (%)	-0.05	-0.07	-0.05	-0.07	-0.08	-0.15	-0.08	-0.08

4.4.6 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.

4.5 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.

CO₂ emissions from glass production are not a key source. CO₂ emissions from glass production in 2008 have decreased by 15.07% compared to 1990 levels (*Table 4.11*), represent 0.16% of GHG emissions from *Industrial processes* and 0.01% of total GHG emissions (including LULUCF).

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:

$$CO_2Emissions = \sum_i (M_i \cdot EF_i \cdot F_i)$$

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 Na₂CO₃, Ca₂CO₃ and K₂CO₃ with emission factors 0.415, 0.44 and 0.522 respectively. The implied emission factor for 2008 is 0.15 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 2007-2008. Also for the years 2005-2008 the reports in the EU ETS context have been extensively used.

- ↗ Activity data (glass production) for the period 1990 – 1992 are provided by the NSSG, 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.

Table 4.11 ***Glass production (in kt) and CO₂ emissions (in kt) for the period 1990 - 2008***

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	116.26	17.15

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.

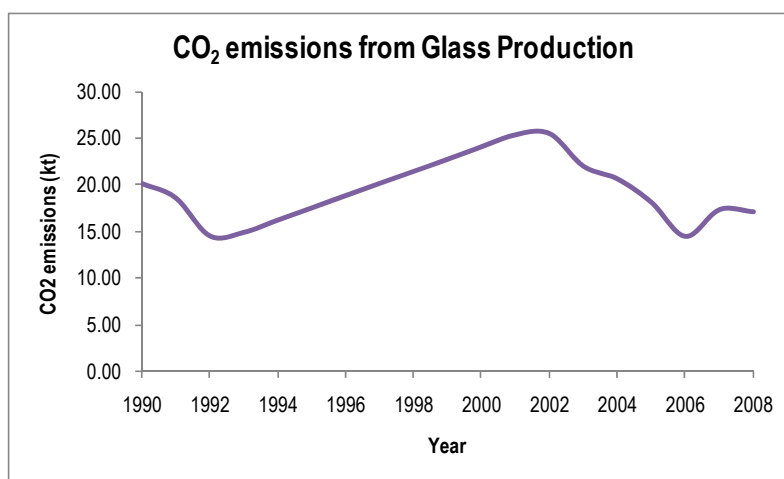


Figure 4.4 *CO₂ emissions (in kt) from Glass Production for the period 1990 – 2008*

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 CO₂/kg glass produced for the case of container glass, leading to emissions that are very close 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 2010 submission. This is in line with the conclusions made by the ERTs in the 2009 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 CO₂ emissions.

Up to 1999 there were two ammonia plants in Greece. Since 1998 (and up to today) the one plant still operating is using natural gas. The other plant closed in 2000. According to expert information, it used lignite as feedstock until 1991, and liquid fuels until its closure. In absence of gas consumption data, for the years 1998-1999 only CO₂ emissions from the first plant have been estimated. CO₂ emissions in IP refer to emissions from natural gas (years 1998-2007), whereas emissions from the other fuels used (years 1990-1999) are included in the energy sector.

CO₂ emissions from ammonia production are a key category by trend assessment. This is probably because emissions of 1990 are estimated in the energy sector, and therefore, they are misleadingly accounted for non-existing in the base year. CO₂ emissions have increased by 25% since 1998 and represent 2.29% 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):

$$E = \text{TFR} \cdot \text{CCF} \cdot 44/12,$$

where E stands for CO₂ emissions, TRF is the total fuel requirement (GJ of natural gas), CCF is the carbon oxidation factor (15.3 kg/kJ for natural gas) and 44/12 is the stoichiometric ratio of carbon dioxide to carbon.

Activity data concerning fuel consumption for the years 1998-2008 have been provided by the plant using natural gas. Ammonia production for the whole time-series has been made available by the NSSG and for the years 1998-2008 by the one plant still operating in Greece. All the activity data are presented in **Table 4.12**.

Table 4.12 *Ammonia production and natural gas consumption (in kt) for the period 1990 - 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Ammonia production (kt)	313.03	255.61	167.94	69.78	0.00	96.98	133.91	122.16	244.76	233.33	147.48
Natural gas consumption (TJ)									3,480.94	2,827.66	5,247.31
Year	2001	2002	2003	2004	2005	2006	2007	2008			
Ammonia production (kt)	68.70	94.14	150.18	159.92	143.90	160.90	165.77	125.91			
Natural gas consumption (TJ)	2,444.34	3,349.36	5,223.31	5,546.84	5,084.43	5,613.09	5,729.97	4,354.66			

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 than 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.

Apart from the time-series inconsistency of the first years, data are generally in line. The difference in the estimated emissions and IEF are presented in **Table 4.13**. As it can be seen, there is a important difference in the IEF of years 1999 and 2000 is due to the fact that for years 1998-1999 part of the CO₂ emissions have been included in the energy sector (emissions regarding the use of lignite as a fuel). The EF generally depends on the fuel requirement, and therefore its oscillation should be attributed to the natural gas consumption data. It should be mentioned that the IEF of years 2007-2008 is practically stable.

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 not very close to the estimated IEF, however according to other sources the country specific emission factor is in the range of reported emission factors.

Additional QC checks include the gathering of data from different sources. In that way, apart from the plant-specific data, information from alternative sources such as the NSSG (Prodcom

department, confidential data) and the Ministry of Economy, Competitiveness and Shipping have been used, whenever available.

Table 4.13 *CO₂ emissions (in kt) from ammonia production and IEF (for the period 1998- 2008*

Year	CO ₂ emissions (kt)	IEF
1998	195.28	0.798
1999	158.63	0.680
2000	294.37	1.996
2001	137.13	1.996
2002	187.90	1.996
2003	293.03	1.951
2004	311.18	1.946
2005	285.24	1.982
2006	314.89	1.957
2007	321.45	1.939
2008	244.30	1.940

4.6.5 Recalculations

During the 2009 centralised review the Expert Review Team has recommended to Greece to improve the time-series consistency of the reported emissions. However, this has not been performed, since it has not been possible to find the required data concerning the liquid and solid fuel consumption of the closed unit for the years 1990-1998. An alternative solution would be to estimate emissions using the available data of the more recent years (2000-2008). This methodology has been rejected for the current submission, as (a) the respective fuels remain unknown and cannot be removed from the energy sector, leading, therefore, to the double-counting of the respective emissions and (b) the IEF of the years 2000-2007 has been considered quite unstable and the 2008 data are considered to contribute to the evaluation of a more representative value. In order to make the decision of not performing any recalculations in 2010, the inventory team has also taken into account that the specific emissions are considered a key category (by trend) in the Greek system, and any recalculation should be performed with caution. As regards to CH₄ emissions, these are reported as NA in the current submission, according to information received by the plant.

4.6.6 Planned improvements

Since it is quite clear that consumption data will not be easy to find and collect, planned improvements include the attempt to define the liquid fuel used during the years 1992-1999. Then, using the default methodology (ammonia production data) an estimation of the emissions could be

performed. The respective fuel requirement quantities should be additionally estimated using default values.

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 (N₂O emissions) is a key category by trend assessment. Nitrous oxide emissions from nitric acid production in 2008 (**Table 4.14**), account for 3.45% of total GHG emissions from *Industrial Processes* and for 0.29% of total national emissions (without *LULUCF*). Emissions have decreased by 66.87% from 1990 to 2008.

4.7.2 Methodology

N₂O emissions from nitric acid production are estimated according to the following equation (IPCC 2000):

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

where, E is N₂O emissions, P is nitric acid production, EF is the emission factor, D is the N₂O 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 N₂O / t HNO₃).
- ✎ Nitric acid production data derive from NSSG and the individual industrial units for 1990-2008. 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 N₂O emissions (IPCC 2000), and for this reason D and U parameters in the above mentioned equation are not considered.
- ✎ 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 N₂O 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 controlled 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 4.5**. 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 more intense in 2008, indicating the effects of the economical crisis (decrease by 16.41 % from 2007 level of emissions).

Table 4.14 *Nitric acid production (in kt) and N₂O emissions (in kt) for the period 1990 – 2008*

Year	HNO ₃ production (kt)	N ₂ O 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	169.32	1.19

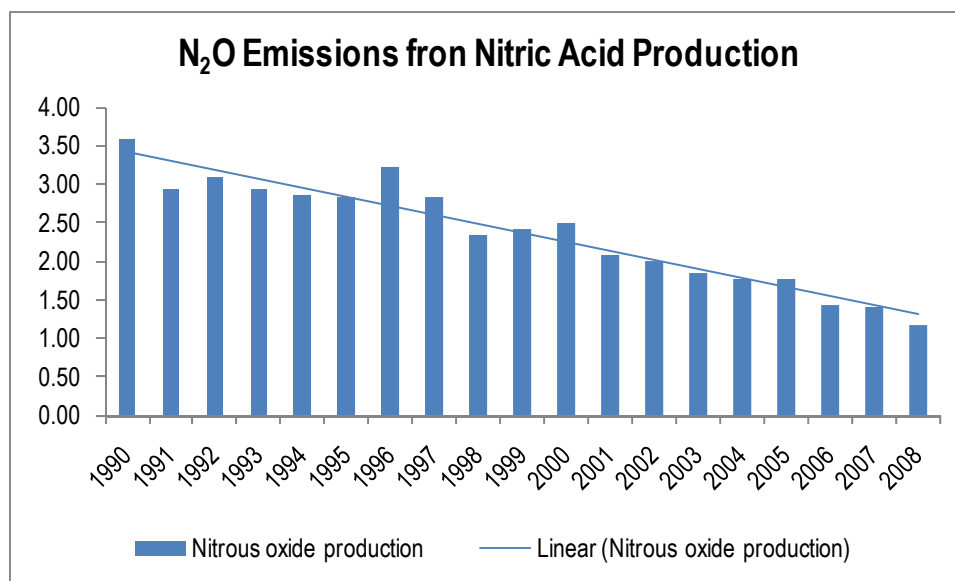


Figure 4.5 *N₂O emissions (in kt) from Nitric Acid Production for the period 1990 – 2008*

4.7.3 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, and has been provided to the independent review of the system in July 2009. 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 NSSG and the Ministry of Economy, Competitiveness and Shipping, depending on data availability.

4.7.4 Recalculations

According to the results of the 2009 Centralised Expert Review, Greece has been recommended to explore the possibility of obtaining measurement data. The inventory team has come into communication with the plant and has been informed that such measurements are still not implemented by the plant. In addition, it is probable that this will continue to happen in the future, since the nitric oxide production is continuously decreasing. As a result, no recalculations have been performed in the current submission.

4.7.5 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.

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

4.8.1 Description

CH₄ 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 – 2008).

4.8.2 Methodology

CH₄ emissions from the production of ethylene and 1,2 dichloro-ethane are estimated according to the equation:

$$(\text{Emissions}) = (\text{Production}) * (\text{Emission factor})$$

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 NSSG. 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 NSSG. 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 to 1999 due to the cease of the ethylene production. After 2000 CH₄ 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 2008 (*Table 4.15*) accounted for 1.95% of total GHG emissions from *Industrial production* and for 0.16% of total national emissions (without *LULUCF*). Emissions have increased by more than 100% (123.83%) from 1990 to 2008, following the increasing trend of the production.

Methane emissions are considered negligible and account for 0.004% of emissions from *Industrial Processes* in 2008.

Table 4.15 *Steel production, CO₂ emissions and CH₄ emissions (in kt) for the period 1990 – 2008*

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	2,175.02	207.49	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:

$$E_{\text{CO}_2} = (\text{SC} + \text{AN} + \text{C} + \text{GR} + \text{EL} - \text{SLB} - \text{SLG} - \text{D} - \text{CL}) \cdot \frac{44}{12},$$

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 CO₂ emissions from iron and steel production, it should be noted that:

- ↳ Activity data for 2005-2008 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 NSSG for the years 2004-2008 (in the previous years the relevant Prodcom code did not exist).
- ✎ According to information received by the NSSG, all the iron and steel plants of the country are included in the EU ETS.
- ✎ In 2008 the average carbon content of the scrap and steel produced has been estimated at 0.52% and 0.19% respectively.
- ✎ Electrodes consumption is estimated at 2.06 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 CO₂ 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 CH₄ emissions, the uncertainty values are at the same level, in absence of any other data.

The methodology used for the CO₂ 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. All the information regarding the procedure has been provided in the 2009 NIR. Moreover, in the 2009 centralised review, the ERT have concluded that the recalculation methodologies used are in line with the IPCC good practice guidance.

CO₂ emissions from steel production follow an increasing trend, reaching a maximum value of 229.71 kt in 2007. Then in 2008 emissions are decreased by 9.67%, as result of the decreased production.

On the basis of the completed and detailed data of 2005-2007 a country specific CO₂ emission factor is estimated (0.093 t/t). This emission factor has been calculated a little higher in 2008 (0.095 t/t), due to the higher carbon content of anthracite and of dust in the dust filter.

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.

Also, any fuels used in the current category are removed from the energy sector in order to avoid double-counting of the emissions.

4.9.5 Recalculations

Emissions from methane have been estimated for the first time in the current inventory for the whole time-series, following the results of the interior review and the recommendation of the Expert Review Team. The impact on total emissions is negligible and is presented in *Table 4.16*.

Table 4.16 *Recalculations of CH₄ emissions from iron and steel production [1990-2007]*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Impact on total emissions, % (excl LULUCF)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Year	2001	2002	2003	2004	2005	2006	2007				
Impact on total emissions, % (excl LULUCF)	0.00	0.00	0.00	0.00	0.00	0.00	0.00				

4.9.6 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.

4.10 Ferroalloys production (CRF Source Category 2.C.2)

4.10.1 Description

Ferroalloy production involves a metallurgical reduction process that results in CO₂ emissions. The carbon in the electrodes captures the oxygen from the metal oxide to form CO₂. In addition, the calcination of carbonates fluxes such as limestone or dolomite contributes to these emissions.

The CO₂ emissions in 2008 account for the 6.12% of total emissions from *Industrial Processes*, and for the 0.51% 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.

4.10.2 Methodology

The estimation of CO₂ 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 2005-2008 derive of the verified report 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 2000-2008 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 2000-2008 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) has been considered, therefore 7%.

As regards to the time-series consistency, as it has been already mentioned, years 1998-2000 have been estimated using the Ni production as a driver, in absence of any other available data by the industry, whereas years 2000-2008 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.

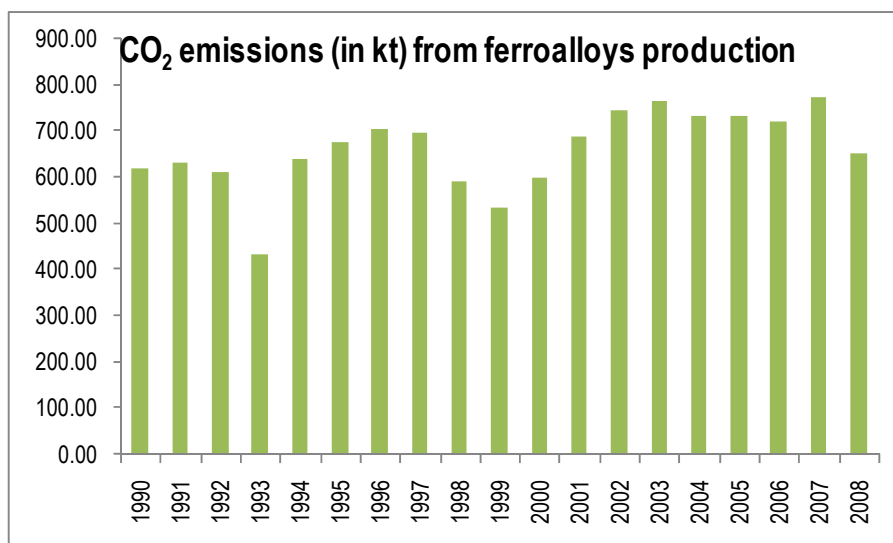


Figure 4.6 *CO₂ emissions (in kt) from Ferroalloys Production for the period 1990 – 2008*

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.

4.10.5 Recalculations

It should be noted that, in the current submission, CO₂ emissions from the use of fuels as reducing agents have been reallocated from the energy sector (1.A.2b), according to the information received by the plant, following the recommendation made by previous Expert Review Teams. The difference between the previous and the currents and estimates and their impact on total emissions can be viewed in **Table 4.17**. Although the values are high, it should be stressed out that the respective emissions have been removed from the energy sector in order to avoid double counting, in a way that the change is counterbalanced.

Table 4.17 *Recalculations of CO₂ emissions from ferroalloys production [1990-2007]*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Difference (%)	1,213.91	1,164.01	1,099.29	961.14	1,163.69	1,163.62	1,163.62	1,163.54	1,110.05	1,045.01	864.39
Impact on total emissions (excl LULUCF) (%)	0.56	0.57	0.54	0.38	0.56	0.58	0.58	0.55	0.45	0.40	0.43
Year	2001	2002	2003	2004	2005	2006	2007				
Difference (%)	916.64	914.91	955.65	915.31	1,020.49	1,225.56	1,152.89				
Impact on total emissions (excl LULUCF) (%)	0.49	0.53	0.53	0.51	0.50	0.52	0.54				

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 CO₂ and PFC. Carbon dioxide is produced when, during electrolysis, the carbon of the anode reacts with alumina (Al₂O₃). Two PFC (CF₄ and C₂F₆) are formed during the phenomenon known as the anode effect, when the aluminium oxide concentration in the reduction cell electrolyte is low.

Emissions of CO₂ and PFC from aluminium production in 2008 (**Table 4.18**) accounted for 2.38% and 0.70%, respectively, of total GHG emissions from *Industrial processes*. The average annual rate of increase of CO₂ emissions during the period 1990 – 2008 was 0.59 %. The average annual rate of decrease of PFC emissions is estimated at -1.53%, while emissions have decreased by 10.6%, compared to base year emissions (1995).

Emissions of CO₂ depend directly on aluminium production, while PFC emissions are influenced as well from actions on the restriction of the anode effect.

Table 4.18 *CO₂ emissions (in kt) and PFC emissions (in kt CO₂ eq) from primary aluminium production for the period 1990 – 2008*

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	257.62	257.56	252.30	152.59	93.62	82.97	71.74	165.34	203.75	131.72

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
CO ₂	251.99	251.16	254.05	257.84	258.29	256.26	255.70	257.32	254.14
PFC	148.38	91.38	88.33	77.30	71.38	71.31	71.16	58.66	74.17

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). It should be noticed that data on aluminium production are confidential and therefore are not presented in the current report.

PFC emissions estimates are based on measurements data made by the aluminium industry according to the PESHINEY methodology (Tier 3b methodology, IPCC 2000). The results of the estimation are directly provided to the inventory team.

4.11.3 Uncertainties and time-series consistency

The uncertainties regarding the CO₂ 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 CO₂ 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 Pechiney 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 4.7**. 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.

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 1993-1996, 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 1997-1998, 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.

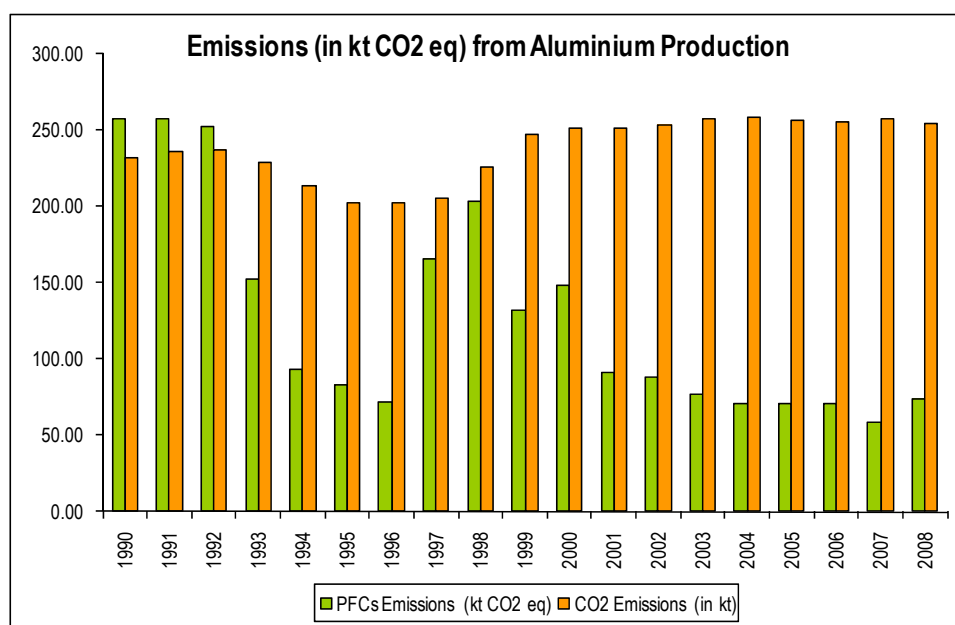


Figure 4.7 *CO₂ and PFCs emissions (in kt CO₂ eq) from aluminium production for the period 1990 – 2008*

4.11.4 Source-specific QA/QC procedures and verification

In the recent years, 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.

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*).

4.11.5 Recalculations

No recalculation of CO₂ and PFCs emissions has been performed in the current submission. The plant-specific data concern the total of the time-series.

4.11.6 Planned improvements

The possibility to collect plant-specific data on net carbon anode consumption as a reducing agent is under investigation. 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 SF₆ (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 4.19*.

Table 4.19 *HFC-23 emissions (in kt CO₂ eq) from HCFC-22 production for the period 1990 – 2006*

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	1998	
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	

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, the estimations presented hereafter cover only a part of the materials/equipments mentioned above.

In the current submission an attempt has been made to improve the accuracy and completeness of the respective sector. Towards this direction, some emissions have been reported for the first time, using all available information. Examples of these new inclusions are emissions from foam blowing, fire extinguishers and from aerosols (apart from MDIs that have also been estimated in the previous years). However, the general lack of activity data has prevented the Greek inventory team from estimating emissions from Solvent uses and other applications using ODS substitutes.

Emissions from ODS substitutes constitute a key category in the Greek inventory system. Emissions in 2008 (**Table 4.20**) accounted for 19.49% of total GHG emissions from *Industrial processes* and for 1.64% of total national emissions (without *LULUCF*). The average annual rate of emissions' increase for the period 1995 – 2008 is estimated at 69.18%. The significant increase of emissions is attributed to the increased 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. However, emissions from large commercial applications of refrigeration are also important, mostly due to the high value of the equipment's charge. Apart from emissions due to refrigeration and air conditioning equipment, emissions from aerosols and metered dose inhalers are also significant (7.21% contribution to the emissions from ODS substitutes in the 2008 inventory). **Figure 4.8** 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.

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).

Table 4.20 *HFC emissions (in kt CO₂ eq) per gas from the consumption of F-gases for the period 1990 - 2008*

Year	HFC-32	HFC-125	HFC-134a	HFC-227ea	TOTAL
1990					
1991					
1992					
1993					
1994					
1995			5.98		5.98
1996			17.76		17.76
1997			59.41		59.41
1998			143.39		143.39
1999			269.32	4.18	273.50
2000	2.37	11.05	395.18	5.97	414.57
2001	4.16	19.44	542.09	7.75	575.13
2002	8.46	39.49	664.26	10.17	752.79
2003	14.08	65.74	937.49	13.09	1,071.31
2004	19.60	91.46	1,174.97	17.81	1,339.02
2005	26.08	121.67	1,229.79	22.44	1,437.67
2006	36.66	171.07	1,365.52	26.50	1,646.48
2007	41.84	195.09	1,390.51	32.15	1,700.82
2008	52.91	246.60	1,701.55	35.37	2,077.34

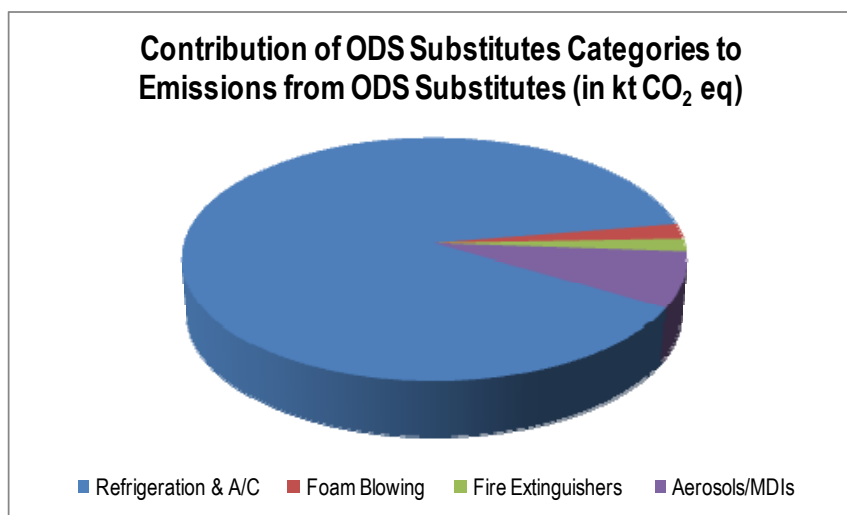


Figure 4.8 *HFCs emissions from ODS substitutes in 2008 (in kt CO₂ eq)*

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. It 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 4.21**) the following should be mentioned:

- ↳ Data on the air conditioning equipment stock for the period 1993 – 2007 are provided by market surveys (ICAP 2000, 2002, 2003, 2005, 2008, 2009).
- ↳ Data residential refrigeration equipment stock for the period 1993 – 2007 are provided by market surveys (ICAP 2000, 2002, 2006, 2008). For 2008 emissions are estimated using the trend of the more recent years 2005-2007, as the respective survey has been made publicly available in March 2010 by ICAP and could not be used.
- ↳ Data on the commercial refrigeration equipment stock are provided from the elaboration of NSSG 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 for the years prior 1995 are not presented in table 4.18 as the use of F-gases for mobile air-conditioning started in 1995.
- ↳ Data on the number of transport refrigeration for 2000-2008 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 4.22**. 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.

HFC emissions from the above mentioned applications are presented in **Table 4.23** for the period 1993-2008.

Table 4.21 Refrigeration and air conditioning equipment for the years 1993 – 2008

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Refrigeration																
Residential	311000	320000	335000	350000	355000	365000	360000	387000	376000	375000	390000	406000	402000	410000	421000	430000
Domestic production	80000	82000	90000	120000	185000	235000	260000	327000	324000	335000	368000	408000	431000	507200	390700	402667
Imports	283000	315000	325000	350000	340000	340000	335000	340000	342000	340000	342000	320000	340000	313400	338000	328467
Exports	52000	77000	80000	120000	170000	210000	235000	280000	290000	300000	320000	322000	369000	410600	307700	301133
Large commercial applications			31550	25832	24480	20284	26665	22852	15151	567	25825	4738	4738	12312	2045	3677
Domestic production			20820	14800	20520	17680	20200	16080	13050	7254	20310	23004	23004	17117	16383	12214
Imports			14908	17410	13519	9532	18634	14795	17568	26114	21357	30000	30000	23306	17712	11385
Exports			4172	6378	9559	6928	12169	8023	15467	32801	15842	48266	48266	28111	32046	19921
Small commercial applications			73642	74179	79243	67761	79885	73586	79347	48352	64395	51667	51781	62596	87362	102827
Domestic production			58640	71680	63730	57140	69090	61900	67168	51759	56461	54886	55000	57862	85689	96873
Imports			16195	11062	24111	21231	19160	19868	20218	16835	18000	15000	15000	17487	12500	12496
Exports			1193	8563	8598	10610	8365	8182	8039	20242	10066	18219	18219	12753	10827	6541
Transport Refrigeration								517	479	633	649	826	460	731	817	747
In circulation								517	479	633	649	826	460	731	817	747
Stationary air-conditioning																
Split unit systems and semi-central systems	89570	126730	154200	150880	188900	229550	330650	431380	617800	305750	503950	493100	430800	489520	574310	574090
Domestic production	12320	17550	22000	21200	2800	2250	1750	1750	1400	1250	500	700	300	220	210	190
Imports	82250	115180	141200	137380	189700	240000	342205	445035	647000	341000	626350	644500	522000	611000	726000	726100
Exports	5000	6000	9000	7700	3600	12700	13300	15400	30600	36500	122900	152100	91500	121700	151900	152200
Chillers	1100	1080	1120	1180	1140	1240	1315	1585	2350	2850	2400	1950	1770	1580	1860	1800
Domestic production	350	380	400	430	420	500	600	950	1600	1800	1100	700	520	480	560	530
Imports	750	700	740	770	780	840	835	945	1500	1450	1650	1450	1400	1300	1600	1650

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Exports	0	0	20	20	60	100	120	310	750	400	350	200	150	200	300	380
Other applications of air conditioning	28800	31500	32000	35700	39850	43250	44830	48300	53800	67400	73200	48250	42100	44100	45950	45400
Domestic production	32900	33500	35200	34300	34500	37730	37900	39300	40100	37900	34500	26000	19350	16700	17100	16600
Imports	4900	5300	6300	9300	9600	12120	12130	14200	18900	37300	48350	29600	25400	32000	36600	37000
Exports	9000	7300	9500	7900	4250	6600	5200	5200	5200	7800	9650	7350	2650	4600	7750	8200
Mobile air-conditioning			133757	141589	166778	183857	268716	302620	289943	277567	273870	317508	344339	346551	316721	296201
Domestic production																
Imports			133757	141589	166778	183857	268716	302620	289943	277567	273870	317508	344339	346551	316721	296201
Exports																

Table 4.22 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	12.5	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	0.55	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 4.23 HFC emissions (in k t CO₂ eq) from refrigeration and air conditioning equipment for the period 1993 – 2008

Year	Residential Refrigeration	Refrigeration - Large commercial applications	Refrigeration - Small commercial applications	Transport Refrigeration	Stationary air-conditioning	Mobile air-conditioning
1993	0.00					
1994	0.00					
1995	0.01	5.46	0.34			0.14
1996	0.02	16.36	0.94			0.40
1997	0.05	55.88	2.65			0.80
1998	0.10	135.67	6.24			1.36
1999	0.17	255.13	11.67			2.26
2000	0.33	361.18	17.00	0.14	23.79	6.05
2001	0.46	484.32	24.58	0.33	41.75	10.74
2002	0.54	570.48	30.97	0.57	84.66	12.75
2003	0.61	816.96	41.89	0.82	141.05	14.72
2004	0.68	992.83	53.15	1.14	196.11	40.83
2005	0.73	973.63	58.14	1.32	260.48	52.49
2006	0.86	957.00	61.20	1.60	366.37	70.31
2007	0.71	897.28	68.32	1.92	416.10	87.89
2008	0.75	1,100.15	86.08	2.07	525.02	136.12

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:

$$\begin{aligned} \text{Emissions from closed-cell foam} = & [(\text{Total HFCs and PFCs used in manufacturing of new closed-cell foam in year } t) \cdot (\text{first-year Loss emission factor})] \\ & + [(\text{Original HFC or PFC charged blown into closed-cell foam manufacturing between year } t \text{ and year } t-n) \cdot (\text{annual loss emission factor})] \\ & + [(\text{Decommissioning losses in year } n) \cdot (\text{HFC or PFC destroyed})] \end{aligned}$$

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 4.24*.

Fire extinguishers

According to the IPCC Good Practice Guidance, emissions should be estimated using the following equation:

$$\begin{aligned} \text{Emissions} = & \text{Annual sales of HFCs/PFCs for Fire Protection} \\ & - (\text{HFCs/PFCs used to Charge new fire protection equipment} \\ & - \text{HFCs or PFCs originally used to charge retiring fire protection equipment}) \end{aligned}$$

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 4.25**.

Table 4.24 *HFCs emissions (in kt CO₂ eq) from foam blowing for the period 1995 – 2008*

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

Table 4.25 *HFC-227ea emissions (in kt) from fire protection equipment for the period 1999 – 2008*

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
HFC-227ea	1.44	2.06	2.67	3.51	4.51	6.14	7.74	9.14	11.09	12.20

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:

$$\begin{aligned} \text{Emissions in year } t = & [\text{Quantity of HFC and PFC contained in aerosol products sold in year } t) \cdot \\ & (\text{EF})] \\ & + [(\text{Quantity of HFC and PFC contained in aerosol products in year } (t-1)) \cdot (1 - \text{EF})] \end{aligned}$$

Data derive from 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, 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 2005-2008. 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 4.26**.

Table 4.26 *HFC-134a emissions from aerosols (in kt CO₂ eq) for the period 1995 - 2008*

Year	Emissions (t 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	114.77
2007	154.08
2008	149.73

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 suggested by the Greek experts (National Association of Refrigerating and Cooling Technicians) are not always in the range suggested by the IPCC GPG. The uncertainty associated with the fire protection equipment (2.F.4) is also high, mainly due to the absence of official data on the respective area.

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 2008 values for the refrigeration stock equipment.

In **Figures 4.9** and **4.10**, 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 the emissions of 2008 do not represent actual data but have been estimated using the linear extrapolation method, and the increase observed with respect to 2007 levels should be viewed with caution until new data are made available.

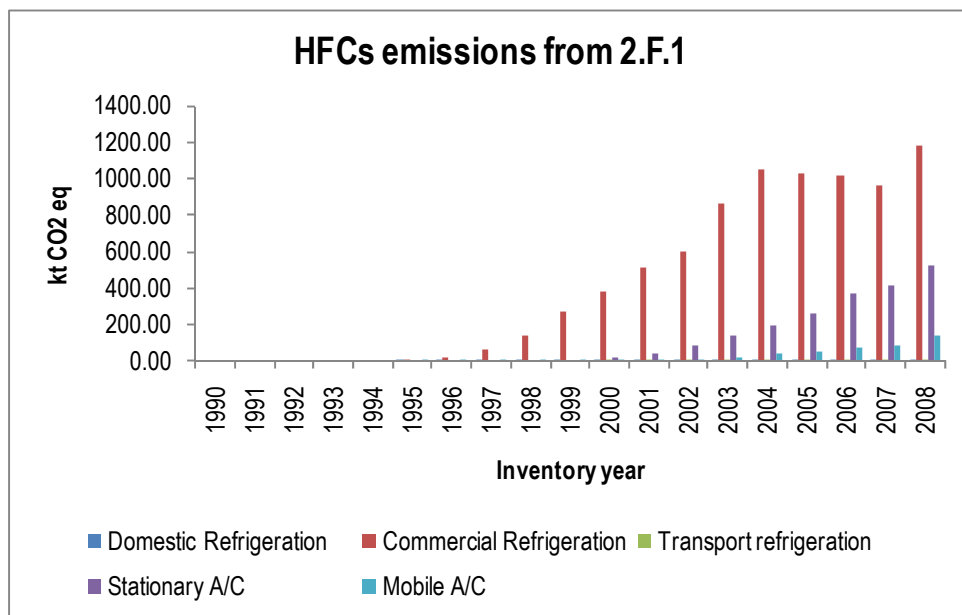


Figure 4.9 *HFCs emissions from Refrigeration and A/C equipment for the period 1990-2008 (in kt CO₂ eq)*

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.

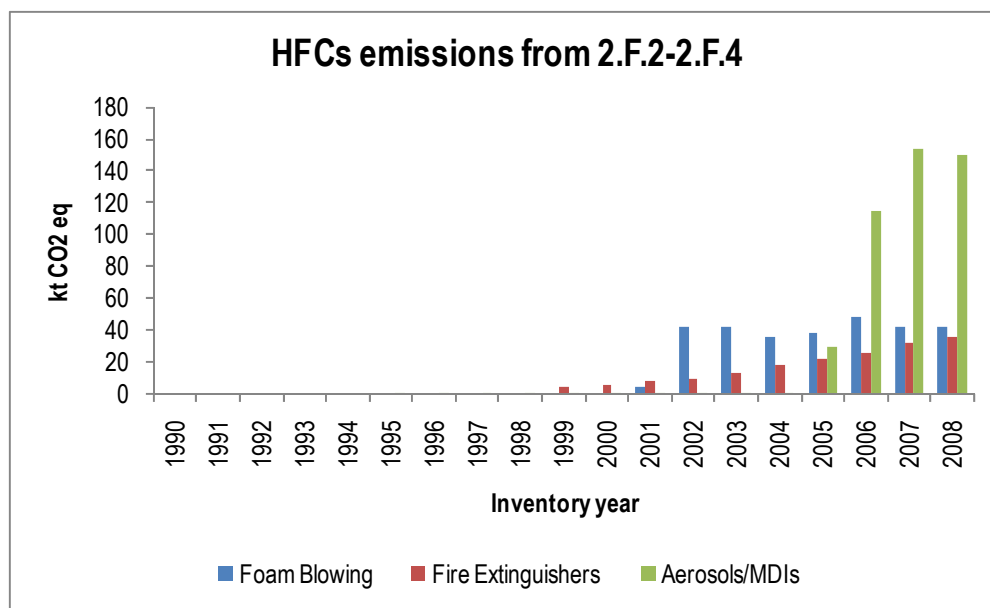


Figure 4.10 *HFCs emissions from Foam blowing, Fire extinguishers and Aerosols/MDIs for the period 1990-2008 (in kt CO₂ eq)*

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 quite 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. In order to resolve this issue and to lower the uncertainty from the main subcategory of the sector (Refrigeration and A/C Equipment, CRF 2.F.1), the inventory team plans to implement a series of activities that are described in the Planned Improvements paragraph (4.13.7) of the current NIR.

4.13.5 Recalculations

In the current submission various recalculations have been performed. The reasons of the recalculations include the following:

- ✎ Correction of an error in the working files (Domestic refrigeration, year 2007)

- ↪ Use of a higher charge value for large commercial refrigeration equipment. The value has changed from 10 kg (that was the value suggested by the Greek experts of the National Association of Refrigerating and Cooling Technicians in 2008) to 100 kg that belongs into the default range suggested in the IPCC GPG. The recalculation has been suggested by the ERT in the centralized review of 2009. However, due to the large contribution of emissions from the specific sector, Greece plans to implement a new procedure in order to collect more accurate data and use a value that is in line with the real situation in the Greek market.
- ↪ Update of the activity data in transport refrigeration, due to the acquisition of data from the Ministry of Transport.
- ↪ Inclusion of new sources in the categories 2.F.2 and 2.F.3, as well as in the 'Other' subcategory of the aerosol products for the whole inventory time series.
- ↪ Update of the activity data regarding MDIs, on the basis of the newly collected information.

The difference between the previous and the current estimates and the impact on total emissions is presented in **Table 4.27**.

Table 4.27 *Recalculations of HFCs emissions from ODS substitutes [1990-2007]*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Difference (%)						421.69	467.01	542.84	567.60	286.45	395.83
Impact on total emissions (excl LULUCF) (%)						0.00	0.01	0.04	0.10	0.19	0.27
Year	2001	2002	2003	2004	2005	2006	2007				
Difference (%)	354.68	303.41	281.32	242.00	205.27	175.96	155.54				
Impact on total emissions (excl LULUCF) (%)	0.36	0.45	0.61	0.72	0.73	0.82	0.79				

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. Recently 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.

- ↳ The approach in order to obtain information on the potential emissions activity data has already been mentioned in the previous NIR submission. By now the official raise of confidentiality has not yet been granted by the NSSG.
- ↳ 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.

4.14 Electrical equipment (CRF Source Category 2.F.8)

4.14.1 Description

The use of SF₆ as dielectric, in the transmission and distribution system of electricity, is considered as the main source of SF₆ 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

The available information is not sufficient in order to apply the methodologies suggested by the IPCC Good Practice Guidance.

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 – 2008. Emissions estimates are being performed on the basis of the quantity of SF₆ consumed during the year, by the Directorate of Strategy and Planning of the PPC. Emissions for the period 1990 – 1994 are estimated (by the inventory team) by mean of a linear extrapolation.

SF₆ emissions from electrical equipment are presented in **Table 4.28**. Emissions in 2008 have been increased by 145% from 1990, whereas they have decreased by 24.09% from 2007. The contribution of emissions from electrical equipment is insignificant (lower than 0.00 % for the whole time-series).

Table 4.28 *SF6 emissions (in kg) from electrical equipment for the period 1990 - 2008*

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
Transmission	130	132	140	140	148	230	310	375	280
Distribution	37	38	38	38	39	40	40	40	35
Total	167	170	178	178	187	270	350	415	315

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.

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. 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

Given the data availability and the contribution of the sector to the total emissions, no specific improvements have been planned for future submissions. 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 CO₂. This sector also includes evaporative emissions of greenhouse gases arising from other types of product use (e.g. N₂O 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 CO₂ and NMVOC emissions from the sector *Solvents and other products use*. Carbon dioxide emissions in 2008 were 160.68kt (0.1% of the total GHG emissions in Greece, without *LULUCF*), while NMVOC emissions have been estimated at 54.0 kt, accounting for approximately 26% of the total NMVOC emissions in the country.

CO₂ and NMVOC emissions in 2008 decreased by 5.3% and 4.7% respectively compared to 1990 levels, due to a decrease in the amount of products processed with solvents (e.g. fat, edible and non edible oil extraction, wood preservation).

Table 5.1 *NMVOC and CO₂ emissions (in kt) from Solvents and other products use for the period 1990 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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
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

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 ₂ O	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 ₂ O in medicine ¹⁾				☒			
6. N ₂ O from fire extinguishers				NO			
7. N ₂ O from aerosol cans ¹⁾				☒			
8. Other use of N ₂ O				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. N₂O 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 National Statistical Service of Greece, 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).

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 21.42% between 1990 and 2008 (**Figure 6.1**), with an average annual rate of decrease of 1.19%. 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 N₂O emissions from agricultural soils are characterized by intense fluctuations during the period 1990 – 2008. 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 National Statistical Service of Greece (NSSG), 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 are reduced by 20 % compared to the previous submission due to modification in the value of nitrogen excretion (Nex) for goats from 40 kg N/head/yr to 12 kg N/head/yr. The change was realized after the 2008 in-country and 2009 centralized ERT review recommendations. The value for the similar-sized sheep was used until a more appropriate value is determined.

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 CO₂ eq) per gas from Agriculture, for the period 1990 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N ₂ O	7878	7731	7522	6718	6533	6824	6904	6759	6763	6635	6436
CH ₄	3470	3436	3424	3455	3479	3504	3522	3530	3532	3538	3553
Year	2001	2002	2003	2004	2005	2006	2007	2008			
N ₂ O	6354	6274	6180	6237	5923	5775	6049	5388			
CH ₄	3577	3589	3557	3527	3518	3523	3527	3530			

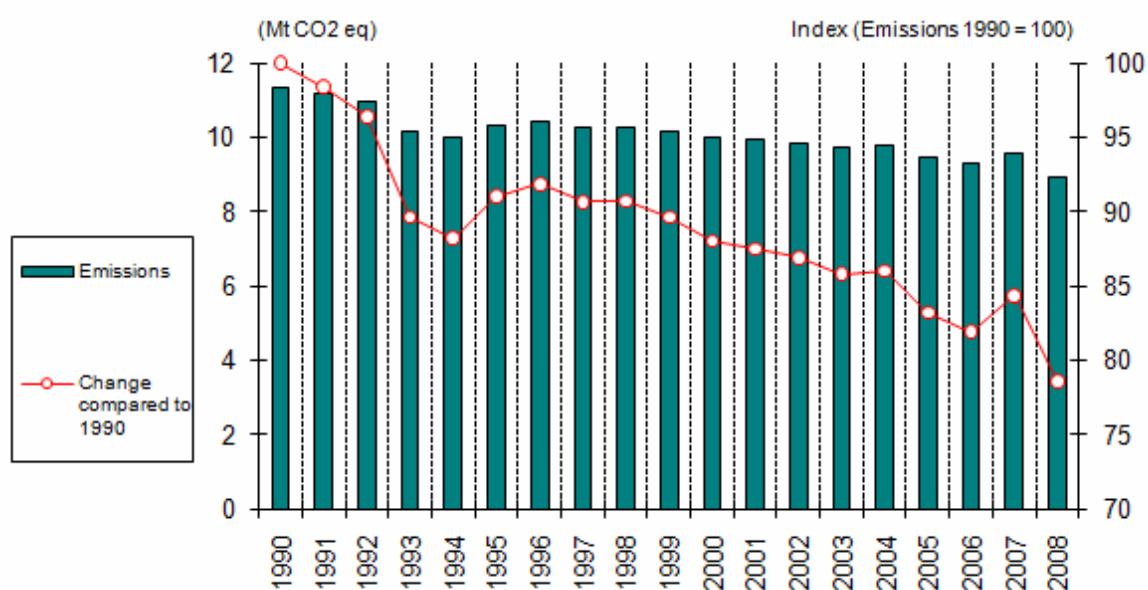


Figure 6.1 *Total GHG emissions (in kt CO₂ eq) from Agriculture for the period 1990 – 2008*

Nitrous oxide represents the main GHG from *Agriculture*, with a contribution ranging from 69.4% to 60.4%. Nitrous oxide emissions in 2008 decreased by 31.61% compared to 1990 levels with an average annual rate of decrease estimated at 1.72%.

Agricultural soils are the main source of emissions from *Agriculture* (**Figure 6.2**), accounting for 57.0% - 66.7% of the total emissions from the sector.

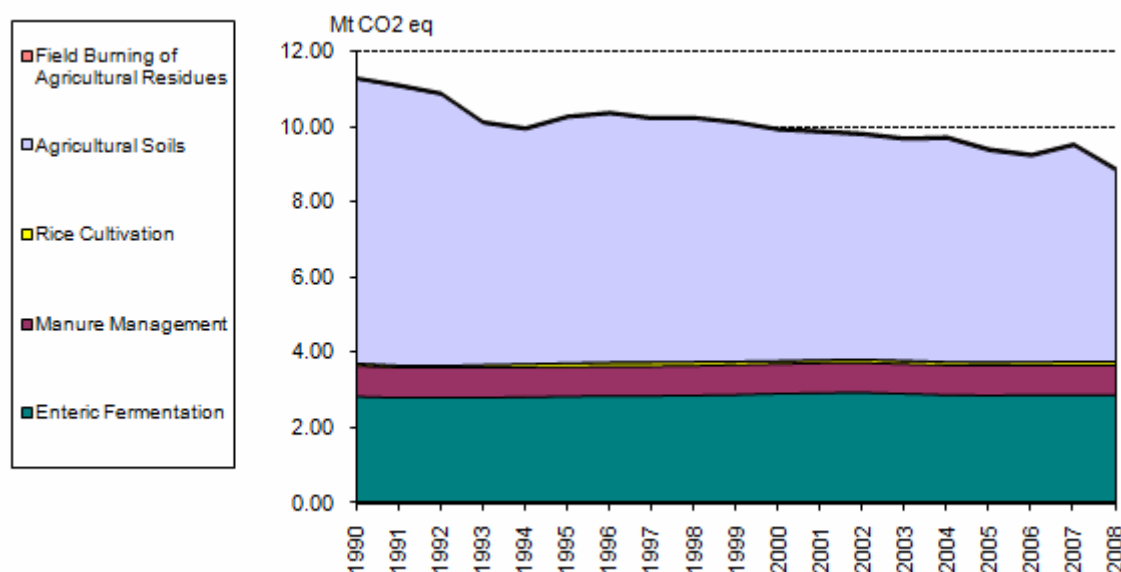


Figure 6.2 GHG emissions (in kt CO₂ eq) from Agriculture per source category, for the period 1990 – 2008

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 NSSG, 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 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

Enteric fermentation, agricultural soils and animal production are the key categories identified in the sector of *Agriculture* (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 6.2 *Methodologies for the estimation of emissions from Agriculture*

	CH ₄		N ₂ O	
	Method	Emission factor	Method	Emission factor
Enteric fermentation	T2,T1	CS, D		
Manure management	T1	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

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, the Tier 2 methodology is applied at least for the animal species that account for a significant part of the emissions from this source category. In Greece, enteric fermentation of sheep is responsible for 39% of methane emissions from this source and therefore the Tier 2 methodology is used in this case. Concerning agricultural soils both simple and detailed methodologies (Tier 1a and Tier 1b) as well as their combination are proposed, depending on data availability.

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 6.3 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 6.3 *Agriculture – Inventory completeness*

	CO ₂	CH ₄	N ₂ O
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 (CH₄ emissions) is a key category. As already mentioned, the Tier 2 methodology is applied for the estimation of methane emissions from enteric fermentation of 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 animal species.

Methane emissions from enteric fermentation in 2008 account for 32.62% of total GHG emissions from *Agriculture* and for 2.29% of total national emissions (excluding *LULUCF*). The average annual rate of increase of emissions from enteric fermentation for the period 1990 – 2008, is estimated at 0.07% (increase by 1.11% in 2008 compared to 1990). Emissions from enteric fermentation are presented in *Table 6.4*.

Table 6.4 CH₄ emissions (kt) from enteric fermentation. for the period 1990 – 2008

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CH ₄ emissions (kt)	137.02	135.54	135.47	135.94	136.32	137.19	137.59	137.80	138.44	139.22	140.57
Year	2001	2002	2003	2004	2005	2006	2007	2008			
CH ₄ emissions (kt)	141.41	141.89	140.45	138.90	138.39	138.85	138.62	138.54			

6.2.2 Methodology

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.

The first step is the "enhanced" livestock characterization, which intends to define livestock sub-categories based on the age of animals, their sex, weight, feeding situation and the various management systems used. Additionally, the estimation of feed intake in terms of energy (MJ/day) is required for each sub-category and each activity animals perform, such as growth, lactation and pregnancy. 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 CH₄ (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 CH₄. In certain cases the emission factor was not calculated for a full year period, but rather for the period that actually corresponds to the given activity.

The calculation of gross energy for sheep is based on the following equation:

$$GE_i = \begin{cases} \frac{\frac{NE_i}{NE_{ma}} \cdot \frac{DE}{100}}{\frac{DE}{100}}, \text{ maintenance} \\ \frac{\frac{NE_i}{NE_{ga}} \cdot \frac{DE}{100}}{\frac{DE}{100}}, \text{ growth} \end{cases}$$

where, NE_i is the net energy for each activity, DE is the digestible energy expressed as a percentage of gross energy, NE_{ma}/DE is the ratio of net energy available in a diet for maintenance to digestible energy consumed and NE_{ga}/DE is the similar ratio for growth. The first equation concerns activities related to animal maintenance, activity, lactation, milk production and pregnancy. The second equation concerns animal growth and wool production.

The characterization and classification of sheep was based on data from NSSG 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 6.5**. It should be noted that there is not always a one-to-one correspondence between the sub-categories presented in the following table and the activities mentioned above. The data for 2007 were updated with confirmed data from NSSG because in the previous submission provisional data were used.

The average bodyweight of sheep at weaning is estimated at 15 kg. The average weight of lambs at one year of age or at slaughter is estimated at 35 kg. The average weights of milking ewes and the rest of mature sheep are estimated at 53 kg and 70 kg respectively. The average milk production for domestic and in flock and for nomadic sheep is 0.48 kg/day and 0.43 kg/day respectively. Wool production is estimated at 4 kg/sheep/year, while, due to lack of data, all births are assumed singles. 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 6.6** information regarding gross energy (GE_i), CH₄ conversion rate (Ym) values and emissions factors (EFs) for each subcategory of sheep (such as grazing, lactation and growth) are shown for 2008.

The duration of lamb's growth is estimated at 315 days, which correspond to the period between effective weaning and one year of age, lactation lasts 50 days, while pregnancy lasts 147 days.

The average feed intake, which is calculated by dividing the total gross energy with the total sheep population, is more or less 23.54 MJ/day while average conversion rate is 6.69%. The number of animals is a three-year average centred at the year of reference.

Table 6.5 *Number of sheep (in 1000s) for each sub-category (three-year average), for the period 1990 – 2008*

Sub-categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Milking ewes	5650	5637	5647	5671	5715	5756	5774	5787	5799	5822	5865
Other female sheep > 1 year old	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
Grazing flat pasture	2148	2155	2159	2164	2175	2188	2187	2180	2171	2176	2190
Grazing hilly pasture	5623	5594	5604	5634	5686	5721	5750	5780	5820	5849	5894
Housed fattening lambs	921	924	925	927	932	938	937	934	930	933	939
Domestic / in flock sheep milked	7647	7708	7711	7780	7904	8000	8056	8073	8148	8198	8267
Nomadic sheep milked	1013	984	955	927	898	869	840	811	782	753	724
For wool production	2408	2418	2627	2677	2399	2395	2371	2348	2348	2353	2412
Births	8490	8487	8590	8664	8728	8787	8841	8855	8882	8910	8966
Total population (at the end of each year)	8660	8692	8666	8706	8802	8869	8896	8884	8930	8951	8991
Sub-categories	2001	2002	2003	2004	2005	2006	2007	2008†			
Milking ewes	5888	5891	5826	5768	5731	5731	5734	5725			
Other female sheep > 1 year old	765	766	757	750	745	745	745	744			
Males > 1 year old	412	412	408	404	401	401	401	401			
Female lambs	1594	1595	1577	1562	1552	1552	1553	1550			
Male lambs	399	399	394	390	388	388	388	388			
Grazing flat pasture	2209	2218	2220	2217	2221	2226	2233	2236			
Grazing hilly pasture	5904	5894	5791	5706	5644	5638	5632	5613			
Housed fattening lambs	947	951	951	950	952	954	957	958			
Domestic / in flock sheep milked	8432	8401	8343	8227	8214	8281	8282	8195			
Nomadic sheep milked	695	657	657	600	577	549	549	608			
For wool production	2382	2393	2306	2269	2246	2217	2161	2205			
Births	9005	9039	9038	9024	9008	8998	8995	8988			
Total population (at the end of each year)	9127	9058	9002	8827	8792	8830	8831	8803			

† Provisional data

Table 6.6 *Gross energy (Gei), CH₄ conversion rate (Ym) value and emissions factor (EFs) for each subcategory of sheep for 2008*

	Gross Energy (Gei) MJ/day/head	Conversion rate (Ym)	Emissions factors (EF) KgCH ₄ /head/yr
Female lamb maintenance	7.9	0.05	2.6
Female sheep maintenance - milking ewes	12.6	0.07	5.8
Female sheep maintenance	15.7	0.07	7.2
Male lamb maintenance	9.1	0.05	3.0
Male sheep maintenance	18.1	0.07	8.3
Grazing flat pasture	1.3	0.07	0.6
Grazing hilly pasture	3.0	0.07	1.4
Fattening lambs	0.5	0.05	0.2
Male lamb growth	3.6	0.05	1.0
Female lamb growth	4.2	0.05	1.2
Lactation dom+flock	6.6	0.07	0.4
Lactation nomadic	5.9	0.07	0.4
Wool prod	1.3	0.07	0.6
Pregnancy	1.2	0.07	0.2

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.

The application of this methodology requires livestock population data and emission factors per animal species. Population data were obtained from the NSSG. The provisional data for the period 2007 used in previous submissions were updated with confirmed data from NSSG. Emission factors used were the ones suggested by IPCC Guidelines (*for non dairy cattle*: Eastern European countries, Table 4-4, IPCC 1997 - for the rest animal categories: Developed countries, Table 4-3, IPCC 1997). For dairy cattle, the emission factor used was an interpolation between Eastern Europe and West Europe respective factors, based on average annual milk production. According to Table 4-4, IPCC 1997, the emission factor is about 81 and 100 kg/head/yr for milk production 2550 kg/head/yr (Eastern Europe) and 4200 kg/head/yr (Western Europe), respectively. Thus, the emission factor was calculated according to the following equation:

$$\text{Emission Factor} \left(\frac{\text{kg CH}_4}{\text{head} \cdot \text{yr}} \right) = \text{Milk Production} \left(\frac{\text{kg Milk}}{\text{head} \cdot \text{yr}} \right) \cdot 0.0115 + 51.64$$

The number of animals used for the calculation of methane emissions (**Table 6.7**) is a three-year average centred at the year of reference.

Table 6.7 *Number of animals (in 1000s) by category (three-year average), for the period 1990 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Dairy cows	246	242	238	235	233	230	229	227	226	226	225
Other cattle	380	363	351	346	347	350	351	354	362	374	387
Buffalo	1	1	1	1	1	1	1	1	1	1	1
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
Year	2001	2002	2003	2004	2005	2006	2007	2008†			
Dairy cows	226	227	225	221	218	216	215	213			
Other cattle	394	396	392	393	399	409	412	413			
Buffalo	1	1	1	1	1	1	1	1			
Goats	5658	5652	5600	5517	5444	5409	5372	5325			
Horses	29	28	28	27	27	27	27	27			
Mules and ashes	90	84	79	74	69	66	62	58			
Swine	946	937	939	942	930	918	906	907			

† Provisional data

6.2.3 Uncertainties and time-series consistency

The combined uncertainty of CH₄ emissions of enteric fermentation sector as % of total emissions is estimated by 0.7%. 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 plant-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 are followed in the enteric fermentation source are:

1. Cross checking information provided by the National Statistical Service of Greece and by the Ministry of Rural Development regarding the animal population and the agricultural crop production.
2. Animal population is also checked by comparison with two different works provided by the NSSG. The first one is a census of livestock population while the second one is an annual statistical survey. The results of the first one was used while its trend is compared with this of second one.
3. Comparison of information regarding animal population, agricultural crop production and emissions factors with this of other neighbour countries.
4. Estimations were checked with several calculation tools such as emissions trends and sum deviations.

6.2.5 Recalculations

CH₄ emissions from enteric fermentation have been recalculated for 2006 and 2007 because of the availability of updated population activity data for 2007. Emissions for 2006 was recalculated because, as mentioned above, a three-year average centred at the year of reference is used as the number of animals, i.e. for 2006 the mean value of 2005, 2006 and 2007 is used. 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 6.8*.

Table 6.8 *Recalculations of CH₄ emissions from enteric fermentation (%)*

Year	2006	2007
Difference	-0.086	-0.665
Impact on total emissions (excl LULUCF)	-0.002	-0.015

6.2.6 Planned improvements

The possibility of applying Tier 2 methodology for the estimation of methane emissions from the enteric fermentation in cattle is under examination.

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.

CH₄ and N₂O from manure management in 2008 accounted for 5.42% and 3.26% of total GHG emissions from *Agriculture* respectively, and for 0.38% and 0.23% of total national emissions respectively (without *LULUCF*). CH₄ emissions in 2008 decreased by 2.67% compared to 1990 levels, with an average annual rate of decrease estimated at 0.15% for the period 1990 - 2008. N₂O emissions in 2008 decreased by 3.68% compared to 1990 levels, with an average annual rate of decrease estimated at 0.20%. CH₄ and N₂O emissions from manure management for the period 1990 – 2008 are presented in *Table 6.9*.

Table 6.9 CH₄ and N₂O emissions (in kt) from manure management, for the period 1990 – 2008

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CH ₄ (kt)	23.66	23.30	23.15	23.11	23.07	23.01	23.00	23.03	23.15	23.27	23.25
N ₂ O (kt)	0.97	0.95	0.93	0.92	0.91	0.91	0.91	0.91	0.92	0.93	0.94
Year	2001	2002	2003	2004	2005	2006	2007	2008			
CH ₄ (kt)	23.27	23.16	23.12	23.10	23.09	23.13	23.05	23.02			
N ₂ O (kt)	0.94	0.95	0.94	0.93	0.93	0.94	0.94	0.94			

6.3.2 Methodology

CH₄ emissions from manure management were estimated according to the IPCC Tier 1 methodology, which is similar to the one used for the enteric fermentation. Livestock population has been already presented in *Table 6.6*, while poultry and sheep population are presented in *Table 6.10*. The choice of emission factors follows the same criteria as for the case of enteric fermentation (IPCC 1997, Tables 4-5 and 4-6).

Table 6.10 Livestock population (in 1000) for poultry and sheep (three-year average), for the period 1990 – 2008

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Poultry	28747	28648	28972	29151	29231	29198	29266	29482	30005	30480	30150
Sheep	8692	8673	8688	8725	8792	8856	8883	8904	8922	8958	9023
Year	2001	2002	2003	2004	2005	2006	2007	2008†			
Poultry	29937	29312	29936	30429	31251	31592	31572	31592			
Sheep	9059	9062	8962	8874	8816	8818	8821	8808			

† Provisional data

In order to calculate N₂O emissions from manure management, the default IPCC methodology was used, according to the following equation.

$$E = \sum_S \left(\sum_T (N_T \cdot Nex_T \cdot MS_{(T,S)}) \right) \cdot EF_S$$

where E is N₂O 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 N₂O emission factor for system S .

The emission factors for N excretion and N₂O-N/N are those suggested by the IPCC Guidelines. Especially for N excretion, the values referring to Mediterranean countries were chosen (IPCC 1997, Table 4-20). The shares of manure management systems per animal species (**Table 6.11**), 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 – 2008.

Country-specific data for the allocation of manure to animal waste management systems per animal species was estimated 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 Agriculture 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 6.11 *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%

6.3.3 Uncertainties and time-series consistency

The combined uncertainty of CH₄ emissions of manure management sector as % of total emissions is estimated at 0.2%. 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 N₂O 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 plant-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

CH₄ and N₂O emissions from manure management have been recalculated because of the availability of updated activity data as far as the population of the animals for 2007 is concerned. 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 6.12** for CH₄ and for N₂O.

Table 6.12 *Recalculations of CH₄ and N₂O emissions from manure management (%)*

Year		2006	2007
Difference		-0.347	-0.597
Impact on total emissions (excl LULUCF)	CH ₄	-0.001	-0.002
Difference		-0.552	-1.027
Impact on total emissions (excl LULUCF)	N ₂ O	-0.001	-0.002

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.

CH₄ emissions from rice cultivation in 2008 account for 1.18% of total GHG emissions from *Agriculture* and for 0.08% of total national emissions (without *LULUCF*). CH₄ emissions increased by 51.99 % in 2008 compared to 1990, with an average annual rate of increase of 2.89% for the period 1990 - 2008. CH₄ emissions from rice cultivation for the period 1990 – 2008 are presented in *Table 6.13*.

Table 6.13 CH₄ emissions (in kt) from rice cultivation for the period 1990 – 2008

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			
CH ₄	4.22	4.48	4.52	4.55	4.62	4.46	5.00	5.00			

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 CH₄ / m²) 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 CH₄ emissions of rice cultivation sector as % of total emissions is estimated by 0.03%. 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 plant-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. N₂O is produced naturally in soils through the microbial processes of nitrification and denitrification. Agricultural activities add nitrogen to soils, increasing the amount of N₂O released in the atmosphere. Anthropogenic N₂O emissions from agriculture are produced either directly from nitrogen inputs to soils or indirectly, after the removal of nitrogen from soils. The N₂O emissions sources examined are the following:

- ↳ Pasture, range and paddock (animal production)
- ↳ Direct N₂O emissions
- ↳ Indirect N₂O emissions

Emissions from animal manure deposited to soils during pasture, range and paddock accounted for 21.27% of total GHG emissions from *Agriculture* and for 1.49% of total national emissions (without *LULUCF*) in 2008. Emissions decreased in 2008 by 25.3% compared to 1990 levels, with an average annual rate of decrease of 1.40% for the period 1990 – 2008. Direct N₂O emissions from agricultural soils in 2008 accounted for 15.30% of total GHG emissions from *Agriculture* and for 1.07% of total national emissions (without *LULUCF*). Direct emissions in 2008 decreased by 50.21% compared to 1990 levels, with an average annual rate of decrease of 2.79% for the period 1990 - 2008. Finally, indirect N₂O emissions in 2008 accounted for 20.46% of total GHG emissions from agriculture and for 1.44% of total national emissions (without *LULUCF*). Indirect emissions in 2008 decreased by 37.08% compared to 1990 levels, with an average annual rate of decrease estimated at 2.06% for the period 1990 – 2008. Emissions from agricultural soils for the period 1990 – 2008 are presented in **Table 6.14**.

Table 6.14 N₂O emissions (in kt) from agricultural soils for the period 1990 – 2008

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Animal production	6.22	6.18	6.17	6.18	6.21	6.24	6.26	6.28	6.29	6.31	6.34
Direct emissions	8.84	8.66	8.27	6.79	6.43	6.93	7.06	6.79	6.76	6.51	6.12
Indirect emissions	9.35	9.11	8.86	7.75	7.48	7.90	8.00	7.79	7.81	7.63	7.33
Year	2001	2002	2003	2004	2005	2006	2007	2008			
Animal production	6.35	6.33	6.28	6.21	6.17	6.16	6.15	6.12			
Direct emissions	5.96	5.82	5.69	5.87	5.34	5.05	5.56	4.40			
Indirect emissions	7.21	7.10	6.99	7.07	6.63	6.44	6.83	5.88			

GHG emissions estimated from *Agriculture* in the current submission are reduced by 20 % compared to the previous submission due to modification in the value of nitrogen excretion (Nex) for goats. The value used in previous submission, 40 kg N/head/yr, was replaced by 12 kg N/head/yr. The value used in the previous submissions was the default value in the Revised 1996 IPCC Guidelines defaults for other animals for Mediterranean countries. However, after the recommendation of ERTs of 2008 in-country and 2009 centralized reviews the value for the similar-sized sheep was used. Moreover, Greece is working on a country-specific Nex value for goats to develop a country-specific value.

The reduction of N₂O 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 – 2008.

6.5.2 Methodology

Animal production

The estimation of N₂O emissions from pasture, range and paddock was based on the methodology used for the calculation of N₂O from manure management, using the default factors suggested by IPCC Guidelines (see Paragraph 6.3). Nitrogen input from pasture, range and paddock and N₂O emissions for the period 1990 – 2008 are presented in **Table 6.15**.

Table 6.15 *Nitrogen input (in kt) and N₂O emissions (in kt) from pasture, range and paddock, for the period 1990 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N input	197.77	196.58	196.29	196.61	197.61	198.70	199.32	199.69	200.13	200.82	201.63
N ₂ O emissions	6.22	6.18	6.17	6.18	6.21	6.24	6.26	6.28	6.29	6.31	6.34
Year	2001	2002	2003	2004	2005	2006	2007	2008			
N input	202.05	201.55	199.67	197.61	196.28	196.06	195.54	194.66			
N ₂ O emissions	6.35	6.33	6.28	6.21	6.17	6.16	6.15	6.12			

Direct N₂O emissions from agricultural soils

Direct N₂O 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

For the estimation of N₂O 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 volatilised 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 N₂O emissions for the period 1990 – 2008 are presented in **Table 6.16**.

Table 6.16 *Synthetic nitrogen applied (in kt) and N₂O emissions (in kt) from synthetic fertilizers, for the period 1990 – 2008*

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 ₂ O 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			
N input	234.00	227.70	222.30	229.50	201.60	189.00	216.00	153.00			
N ₂ O emissions	4.60	4.47	4.37	4.51	3.96	3.71	4.24	3.01			

The basic methodology was also applied for the estimation of N₂O 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 volatilises 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 6.17** nitrogen input to soils from animal manure and subsequent N₂O emissions are presented, for the period 1990 – 2008.

Table 6.17 *Nitrogen input to soils from animal manure (in kt) and N₂O emissions (in kt) from animal manure used as fertilizers, for the period 1990 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N input	39.49	38.76	38.40	38.24	38.11	37.94	37.87	37.90	38.08	38.30	38.29
N ₂ O emissions	0.78	0.76	0.75	0.75	0.75	0.75	0.74	0.74	0.75	0.75	0.75
Year	2001	2002	2003	2004	2005	2006	2007	2008			
N input	38.37	38.25	38.17	38.11	38.07	38.13	37.98	37.94			
N ₂ O emissions	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75			

For the estimation of N₂O 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_{NCR0}) 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_{NCR0} is significantly 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.

N₂O emissions from N-fixing crops and crop residues for the period 1990 – 2008 are presented in **Table 6.18**.

Table 6.18 *N₂O emissions (in kt) from N-fixing crops and crop residues, for the period 1990 – 2008*

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			
N-fixing crops	0.021	0.021	0.020	0.019	0.019	0.019	0.020	0.016			
Crop residues	0.506	0.493	0.474	0.512	0.525	0.485	0.470	0.552			

Estimation of N₂O emissions from the organic soils (0.084 kt) was based on the cultivated area (6.7 kHa. constant for the entire period examined) 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 N₂O emissions from agricultural soils

Indirect N₂O emissions from agricultural soils derive from:

- ↳ Volatilisation of nitrogen included in synthetic fertilizers and animal manure (used as fertilizers) as NO_x and NH₃, followed by atmospheric deposition as NO_x, HNO₃ and NH₄ on soils and surface waters and subsequent N₂O formation.
- ↳ Leaching and runoff of nitrogen contained in applied fertilizers (synthetic and animal manure).

For both sources of N₂O 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 and animal manure 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 N₂O emissions for the period 1990 – 2008 are presented in **Table 6.19**.

Table 6.19 *Deposited nitrogen (in kt) and indirect N₂O emissions (in kt) from agricultural soils, for the period 1990 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Atmospheric deposition											
N deposited	91.83	89.81	87.86	79.58	77.65	80.83	81.63	80.11	80.35	79.04	76.90
N ₂ O emissions	1.44	1.41	1.38	1.25	1.22	1.27	1.28	1.26	1.26	1.24	1.21
Leaching/Runoff											
N deposited	201.34	195.91	190.29	165.42	159.37	168.64	170.90	166.22	166.72	162.51	155.85
N ₂ O emissions	7.91	7.70	7.48	6.50	6.26	6.63	6.71	6.53	6.55	6.38	6.12
Year	2001	2002	2003	2004	2005	2006	2007	2008			
Atmospheric deposition											
N deposited	76.00	75.17	74.18	74.55	71.17	69.74	72.60	65.42			
N ₂ O emissions	1.19	1.18	1.17	1.17	1.12	1.10	1.14	1.03			
Leaching/Runoff											
N deposited	153.01	150.71	148.32	150.08	140.36	136.12	144.91	123.62			
N ₂ O emissions	6.01	5.92	5.83	5.90	5.51	5.35	5.69	4.86			

6.5.3 Uncertainties and time-series consistency

The combined uncertainty of N₂O emissions of direct emissions as % of total emissions is estimated by 4.3%. 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 N₂O 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 N₂O emissions of animal production as % of total emissions is estimated by 1.7%. 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 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 plant-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 National Statistical Service of Greece 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

N₂O emissions from agricultural soils have been recalculated for the period 1990-2007 because of the updating of nitrogen excretion (Nex) value for goats from 40 kg N/head/year to 12 kg N/head/year and because of the availability of updated activity data concerning the population of the animals and the quantities of synthetic fertilizers consumed for 2007. 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 6.20*.

Table 6.20 Recalculations of N₂O emissions from agricultural soils (%)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Difference	-22.114	-22.462	-22.994	-25.263	-26.008	-25.354	-25.303	-25.826	-25.869	-26.306	-27.003
Impact on total emissions (excl LULUCF)	-2.080	-2.090	-2.069	-2.101	-2.068	-2.056	-2.019	-1.944	-1.863	-1.870	-1.818
Year	2001	2002	2003	2004	2005	2006	2007				
Animal production	-27.342	-27.587	-27.710	-27.218	-28.039	-28.418	-22.786				
Indirect emissions	-1.804	-1.807	-1.739	-1.710	-1.649	-1.688	-1.286				

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 CH₄, N₂O, CO and NO_x.

CH₄ and N₂O emissions from field burning of agricultural residues in 2008 accounted for 0.50% of total GHG emissions from *Agriculture* and for 0.035% of total national emissions (without LULUCF). Emissions in 2008 increased by 20.90% compared to 1990 levels with an average annual rate of increase estimated at 1.16%. CH₄ and N₂O emissions from field burning of agricultural residues for the period 1990 – 2008 are presented in *Table 6.21*.

Table 6.21 GHG emissions (in kt) from field burning of agricultural residues, for the period 1990 – 2008

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 ₂ O 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			
CH ₄ emissions	1.42	1.38	1.27	1.42	1.43	1.32	1.28	1.54			
N ₂ O emissions	0.04	0.03	0.03	0.04	0.04	0.03	0.03	0.04			

6.6.2 Methodology

For the estimation of CH₄ and N₂O 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 CH₄ emissions of field burning of agricultural sector as % of total emissions is estimated by 0.01%. The combined uncertainty of N₂O 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 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 plant-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 CO₂ and other greenhouse gases, based on six top-level land-use¹⁷ 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-CO₂ 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. However, GHG emissions and removals for several land use and land use change categories were not estimated until the 2009 submission.

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

¹⁷ 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.

sources of specific methodologies, assumptions, emission factors and activity data used and the rational for their selection) on each category is presented.

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 – 2008. During this period, the LULUCF sector offset about 2.3-3.1% of the total national emissions (without LULUCF). The magnitude of this sink increased from approximately 2.5 Mt CO₂ eq in 1990, to 3.2 Mt CO₂ eq in 2008 (**Figure 7.1**), i.e. an increase of 28%. 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.

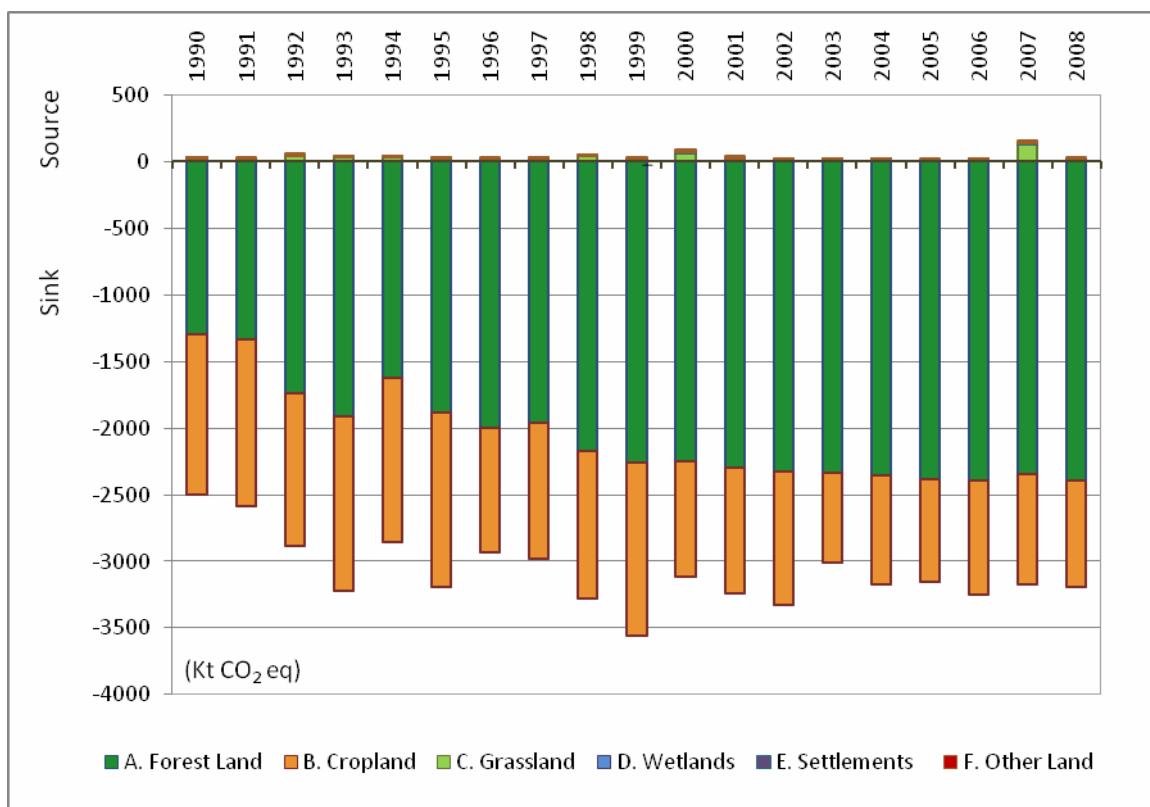


Figure 7.1 *Net GHG emissions / removals (in kt CO₂ eq) from the Land Use, Land Use Change and Forestry sector by category for the period 1990 – 2008*

CO₂ is the main greenhouse gas emitted and removed to / from the atmosphere following carbon stocks changes in different carbon pools. Non-CO₂ greenhouse gases (CH₄ and N₂O) 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 – 2008. 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 CO₂ eq in 1990 to 2.4 Mt CO₂ eq in 2008, i.e. an increase of about 85%.

Removals from Cropland, caused by changes in management practices and crop type, fluctuate between 0.67 - 1.3 Mt CO₂ eq yr⁻¹. Grassland category appears as a small source of CO₂ due to conversion of Forest land to Grassland, as well as, source of CH₄ and N₂O due to emissions during wildfires. Wetlands, Settlements and Other Land categories are small sources of CO₂ 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 – 2008*

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Net CO ₂ emissions / removals (in kt)																			
A. Forest Land	-1,308	-1,341	-1,759	-1,934	-1,639	-1,892	-2,004	-1,972	-2,207	-2,266	-2,290	-2,303	-2,327	-2,343	-2,362	-2,386	-2,400	-2,399	-2,403
B. Cropland	-1,205	-1,251	-1,146	-1,311	-1,230	-1,315	-936	-1,025	-1,104	-1,297	-864	-946	-1,006	-668	-822	-776	-857	-831	-801
C. Grassland	0.01	0.21	NO	NO	0.49	3.00	NO	0.08	NO	0.31	NO	NO	0.02	2.03	0.37	NO	0.04	0.06	0.05
D. Wetlands	0.00	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.06	NE,NO	NE,NO	NE,NO	NE,NO	0.13	1.89	0.76	0.94	0.18	0.58	0.20	NE,NO
E. Settlements	2.30	1.35	1.92	1.52	2.00	2.21	5.38	1.63	1.26	4.54	4.61	1.98	1.95	1.55	1.50	3.45	5.91	8.43	1.05
F. Other Land	6.77	3.67	13.10	4.50	5.36	2.21	8.76	8.46	6.19	16.62	16.79	25.28	8.45	7.65	8.13	4.62	8.32	19.02	5.96
CH ₄ emissions (in kt)																			
A. Forest Land	0.52	0.20	0.57	0.60	0.52	0.34	0.14	0.42	1.30	0.08	1.61	0.17	0.02	0.02	0.06	0.05	0.16	2.12	0.33
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
C. Grassland	0.67	0.57	1.71	1.20	1.25	0.53	0.57	0.86	1.69	0.19	2.64	0.53	0.10	0.13	0.33	0.17	0.27	5.47	0.58
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
E. Settlements	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
N ₂ O emissions (in kt)																			
A. Forest Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
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
C. Grassland	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
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
E. Settlements	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
TOTAL LULUCF (kt CO₂ eq)	-2,477	-2,570	-2,837	-3,197	-2,820	-3,180	-2,910	-2,957	-3,234	-3,534	-3,034	-3,205	-3,318	-2,995	-3,163	-3,149	-3,232	-3,027	-3,176

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 ₂ O	
	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	T1	D	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 ₂ O
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 Recalculations and improvements

Greece has undertaken a major effort in order to improve accuracy and completeness of the reported estimates in this sector and to be compliant with the reporting requirements under the KP art. 3.3 and 3.4. Two are the main novelties introduced in the present submission:

- A new methodology for estimating carbon stock changes in 5.A.1 category Forest land remaining Forest land, followed by a change in the forest management definition, and
- The estimation, for first time, of emissions and removals from the land use change of Forest land, Grassland and Other land to Cropland, Grassland, Wetlands, Settlements and Other land.

The main recalculations and improvements, as well as their implications to emissions / removals levels in relation to previous submission are presented in **Table 7.5**. Detailed information on the new methods, activity data and emission factors is given in the following chapters.

Table 7.5 *Recalculations and improvements in the 2010 LULUCF Inventory and their implications to the reported estimates*

Recalculations and improvements in 2010 LULUCF Inventory	Implication
<ul style="list-style-type: none"> • Change in forest and forest management definition, in order to increase accuracy of estimates and consistency with KP inventory 	Smaller area is defined as Forest land and as managed forest. Net CO ₂ removals in Forest land are smaller. Larger area is defined as Grassland. Non- CO ₂ emissions from wildfires in Grassland are larger.
<ul style="list-style-type: none"> • Change from the Default method (flux approach) to the 'C stock change' approach for the estimation of CO₂ emissions and removals from Forest land remaining Forest land 	Uncertainties are smaller. Estimated net removals of CO ₂ are smaller. Inter annual variation of CO ₂ emissions/ removals is smaller.
<ul style="list-style-type: none"> • Development of a land use change database concerning 10 types of land use changes and estimation of emissions and removals from these categories 	Enhancement of completeness of estimations. Minor emissions of CO ₂ are reported from these categories
<ul style="list-style-type: none"> • Revised activity data on the areas of Cropland that have been converted to Forest Land after 2001 	Lower CO ₂ removals from this category.
<ul style="list-style-type: none"> • Revised activity data on the areas of Cropland remaining Cropland for the years 2004-2007 	Minor modifications in CO ₂ emissions and removals in these years

The net GHG emissions / removals from the sector estimated in 2010 are approximately 1 Mt of CO₂ eq higher than these reported in the previous inventory (**Figure 7.2**). Another main feature of the new submission is the lower annual variation in estimations. This variation, which is mainly attributed to the variation of areas burnt by wildfires each year, is not observed in the 2010 submission because of the new approach used for the estimation of carbon stock changes in Forest land.

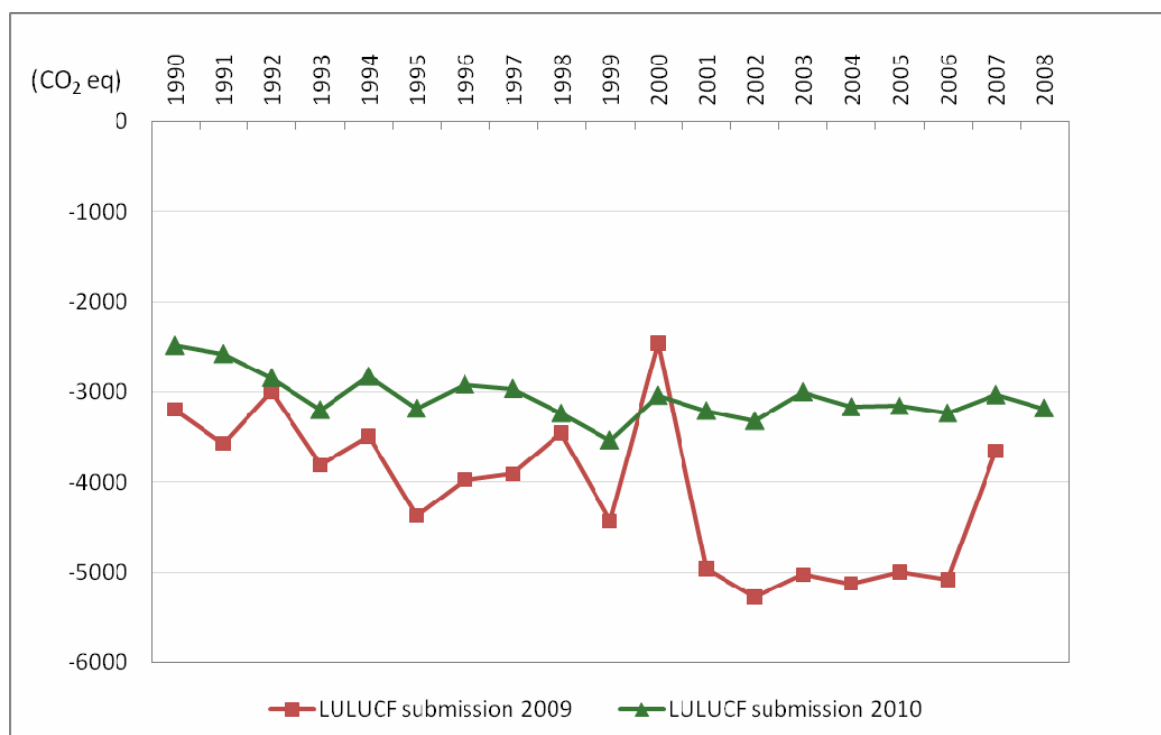


Figure 7.2 *Net emissions / removals of GHG from the LULUCF sector for the period 1990 – 2007 according to the inventories submitted in 2009 and 2010*

The results of the recalculation of GHG emissions and removals in each category and the difference (%) between present and previous emissions /removal estimates are presented in **Table 7.6**.

Table 7.6 *Comparison of the 2010 inventory results with the results of the previous inventory (in kt CO₂ eq) for the LULUCF sector*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Forest Land																		
2009 submission	-1,989.83	-2,318.91	-1,849.82	-2,498.20	-2,261.27	-3,054.37	-3,035.99	-2,889.38	-2,357.28	-3,130.12	-1,597.18	-4,015.01	-4,268.86	-4,356.73	-4,253.79	-4,242.71	-4,206.74	-2,826.76
2010 submission	-1,296.32	-1,336.92	-1,745.66	-1,919.86	-1,626.97	-1,884.13	-2,001.12	-1,962.48	-2,176.94	-2,263.59	-2,253.18	-2,298.68	-2,326.27	-2,342.2	-2,360.38	-2,384.89	-2,396.2	-2,350.4
Change (%)	-34.85	-42.35	-5.63	-23.15	-28.05	-38.31	-34.09	-32.08	-7.65	-27.68	41.07	-42.75	-45.51	-46.24	-44.51	-43.79	-43.04	-16.85
Cropland																		
2009 submission	-1,205.41	-1,251.23	-1,146.04	-1,310.96	-1,229.90	-1,315.50	-936.2	-1,025.06	-1,103.81	-1,296.61	-863.76	-945.94	-1,005.91	-668.05	-874.38	-751.07	-867.98	-832.57
2010 submission	-1,205.38	-1,251.07	-1,145.93	-1,310.66	-1,229.87	-1,315.41	-936.33	-1,025.04	-1,103.77	-1,296.58	-863.73	-945.94	-1,005.88	-667.94	-821.65	-776.16	-857.33	-830.68
Change (%)	0.00	-0.01	-0.01	-0.02	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-6.03	3.34	-0.23
Grassland																		
2009 submission	1.98	2.17	3.93	2.49	6.31	1.18	3.15	8.83	8.08	0.99	7.82	2.25	0.26	0.63	5.59	0.04	0.19	8.55
2010 submission	15.47	13.30	39.63	27.78	29.45	15.27	13.21	19.96	39.06	4.72	61.12	12.30	2.32	5.11	8.02	3.93	6.28	126.48
Change (%)	682.05	512.38	908.06	1,014.74	366.46	1,190.14	319.96	126.18	383.45	374.73	681.93	446.71	793.97	706.35	43.45	10,130.3	3,123.57	1,379.71
Wetlands																		
2009 submission	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2010 submission	0.00	NO	NO	NO	NO	NO	0.06	NO	NO	NO	NO	0.13	1.89	0.76	0.94	0.18	0.58	0.20
Change (%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Settlements																		
2009 submission	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2010 submission	2.30	1.35	1.92	1.52	2.00	2.21	5.38	1.63	1.26	4.54	4.61	1.98	1.95	1.55	1.50	3.45	5.91	8.43
Change (%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Land																		
2009 submission	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2010 submission	6.77	3.67	13.10	4.50	5.36	2.21	8.76	8.46	6.19	16.62	16.79	25.28	8.45	7.65	8.13	4.62	8.32	19.02
Change (%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LULUCF																		
2009 submission	-3,193.27	-3,567.97	-2,991.93	-3,806.66	-3,484.86	-4,368.69	-3,969.27	-3,905.62	-3,453.02	-4,425.74	-2,453.13	-4,958.70	-5,274.51	-5,024.15	-5,122.58	-4,993.74	-5,074.53	-3,650.78
2010 submission	-2,477.16	-2,569.67	-2,836.94	-3,196.71	-2,820.03	-3,179.85	-2,910.04	-2,957.47	-3,234.2	-3,534.28	-3,034.38	-3,204.92	-3,317.54	-2,995.06	-3,163.45	-3,148.87	-3,232.45	-3,026.95
Change (%)	-22.43	-27.98	-5.18	-16.02	-19.08	-27.21	-26.69	-24.28	-6.34	-20.14	23.69	-35.37	-37.10	-40.39	-38.25	-36.94	-36.30	-17.09

7.1.5 Representation of land areas

The various forms of land uses in 2008 are presented in *Figure 7.3*.

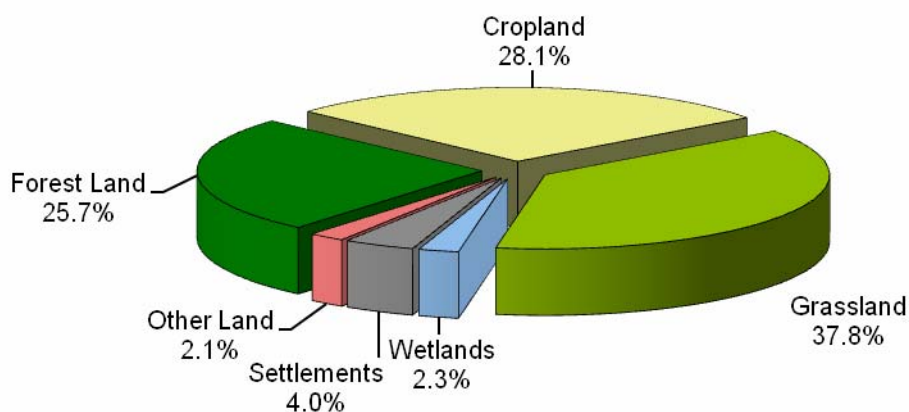


Figure 7.3 Distribution of the area of Greece in 2008 by land-use category

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 National Statistical Service of Greece (NSSG, annual census)
- the ‘Distribution of the Country’s Area by Basic Categories of Land Use’ of the National Statistical Service of Greece (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 7.7* is the land-use matrix of year 2008.

Table 7.7 *Land-Use Matrix of Year 2008 (areas in kha).*

2007 2008	Forest Land	Cropland	Grassland	Wetlands	Settlements	Other Land	Total in 2008
Forest Land	3,356.05	33.27					3,389.32
Cropland	0.01	3,709.15	0.05				3,709.21
Grassland	0.18	201.78	4,791.62				4,993.57
Wetlands	0.07		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
Total in 2007	3,359.19	3,948.02	4,793.33	299.60	530.32	265.28	13,195.74

 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-CO₂ 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 – 2008 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-CO₂ greenhouse gases released to the atmosphere during biomass burning. Estimates of emissions / removals in this category are presented in **Table 7.8**.

The sink capacity of Forest Land has increased from 1.3 Mt CO₂ eq in 1990 to 2.4 Mt CO₂ eq in 2008, i.e. an increase of about 85%. This rising trend is attributed mainly is attributed mainly to the reduction in fellings and the afforestation programmes started in 1994.

Table 7.8 *Net GHG emissions / removals (in kt) from Forest Land by subcategory and gas for the period 1990 - 2008*

IPCC categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Forest land remaining forest land										
CO ₂	-1,308.36	-1,341.49	-1,758.9	-1,933.67	-1,613.99	-1,833.58	-1,914.59	-1,819.62	-2,035.78	-2,052.47
CH ₄	0.52	0.20	0.57	0.60	0.52	0.34	0.14	0.42	1.30	0.08
N ₂ O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
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 ₂ O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (kt CO₂ eq)	-1,296.32	-1,336.92	-1,745.66	-1,919.86	-1,626.97	-1,884.13	-2,001.12	-1,962.48	-2,176.94	-2,263.59

IPCC categories	2000	2001	2002	2003	2004	2005	2006	2007	2008
Forest land remaining forest land									
CO ₂	-2,052.47	-2,052.47	-2,052.47	-2,052.47	-2,052.46	-2,052.47	-2,052.47	-2,052.47	-2,052.47
CH ₄	1.61	0.17	0.02	0.02	0.06	0.05	0.16	2.12	0.33
N ₂ O	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Land converted to forest land									
CO ₂	-237.86	-250.14	-274.17	-290.29	-309.38	-333.67	-347.45	-347.00	-350.62
CH ₄	NO	NO	NO	NO	NO	NO	NO	NO	NO
N ₂ O	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (kt CO₂ eq)	-2,253.18	-2,298.68	-2,326.27	-2,342.2	-2,360.38	-2,384.89	-2,396.2	-2,350.4	-2,395.45

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-CO₂ 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-CO₂ 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, 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} , 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, $t C (t d.m.)^{-1}$

CO₂ 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 7.9 *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. CO₂ 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 CO₂ 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 CO₂ from wildfires are reported. The implication of the use of this method on the inventory is the normalisation of the net emissions/removals of CO₂ 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- CO₂ GHG emissions. According to IPCC Guidelines, CH₄ and CO emissions from wildfires were estimated as ratios to carbon released during burning ($L_{W_{oxid}}$), and N₂O 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).

$$CH_4 \text{ emissions} = L_{W_{oxid}} \cdot 0.012 \cdot 16/12$$

$$CO \text{ emissions} = L_{W_{oxid}} \cdot 0.06 \cdot 28/12$$

$$N_2O \text{ emissions} = L_{W_{oxid}} \cdot (N/C \text{ ratio}) \cdot 0.007 \cdot 44/28$$

$$NO_x \text{ emissions} = L_{W_{oxid}} \cdot (N/C \text{ ratio}) \cdot 0.121 \cdot 46/14$$

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:

$$L_{W_{oxid}} = \sum_i A_{disturbance_i} \cdot Bw_i \cdot (1 - f_{BL_i}) \cdot CF$$

where, $L_{W_{oxid}}$ 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:

$$Bw = (V \cdot D \cdot BEF_2 + B_{W_{understorey}}) \cdot CF$$

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.

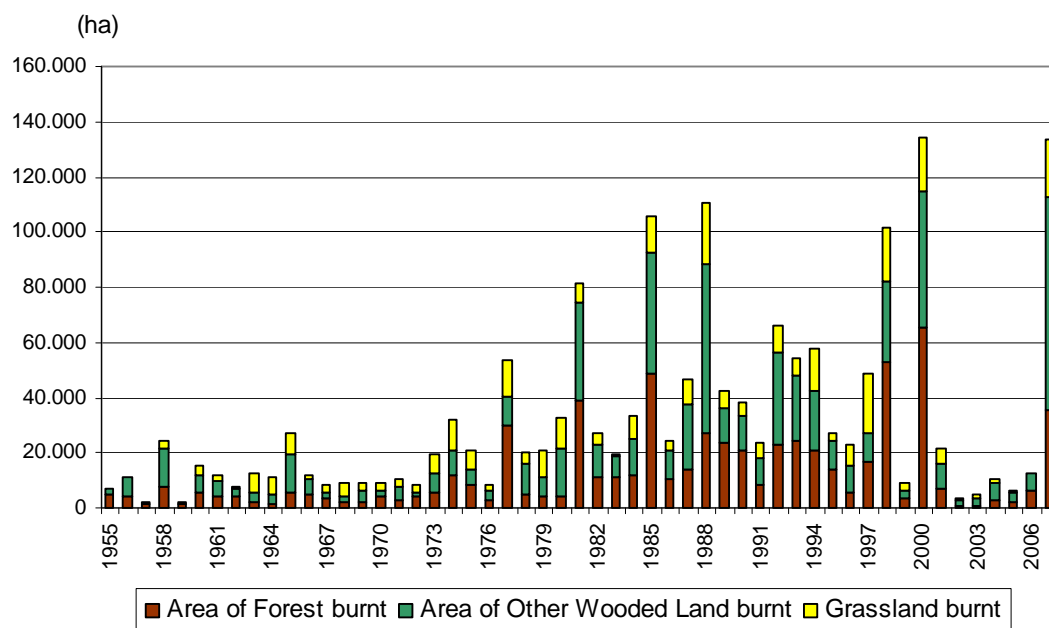


Figure 7.4 *Areas of Forest, Other Wooded Land and Grassland burnt since 1955*

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.

$$\Delta C_{LF} = (\Delta C_{LFLB} + \Delta C_{LFDOM} + \Delta C_{LFSoils})$$

where, ΔC_{LF} is the annual change in carbon stocks in land converted to forest land, t C yr⁻¹, ΔC_{LFLB} 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, ΔC_{LFDOM} 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 $\Delta C_{LFSoils}$ 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:

$$\Delta C_{LFLB} = (\Delta C_{LFGROWTH} + \Delta C_{LFCONVERSION} - \Delta C_{LFLOSS})$$

where, $\Delta C_{LFGROWTH}$ is the annual increase in carbon stocks in living biomass due to biomass growth in land converted to forest, t C yr⁻¹, $\Delta C_{LFCONVERSION}$ is the annual change in carbon stocks in living biomass due to actual conversion to forest land, t C yr⁻¹ and ΔC_{LFLOSS} 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 ($\Delta C_{LFCONVERSION}$) 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 (ΔC_{LFLOSS}) 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.

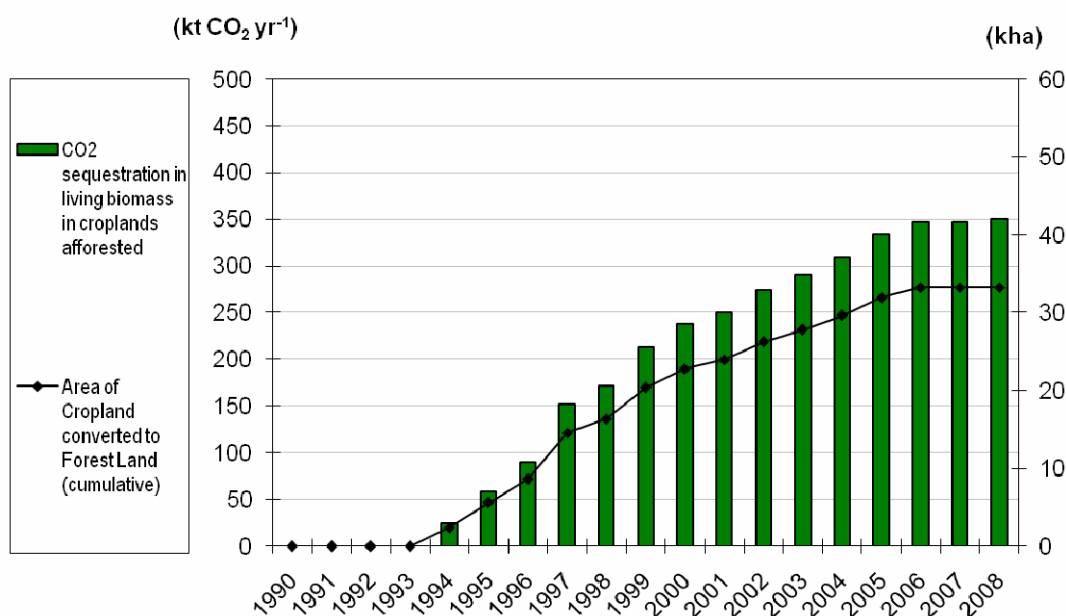


Figure 7.5 *Carbon sequestration in living biomass and area of Croplands converted to Forest land during 1990-2008*

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:

$$\Delta C_{LF_{Soils}} = \Delta C_{LF_{Mineral}} = \left[\sum_i (SOC_{REF} - SOC_{Cropland_i}) \cdot A_{aff_i} \right] / T_{aff}$$

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 CH₄ and N₂O from these lands were estimated as part of *Agriculture* (Chapter 6). The net CO₂ emissions / removals from each subcategory are presented in **Table 7.10**.

Table 7.10 Net CO₂ emissions / removals (kt CO₂) from Cropland by subcategory for the period 1990 - 2008

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
Cropland remaining Cropland	-946	-1006	-668	-822	-776	-857	-831	-801
Biomass	-966	-1027	-689	-842	-797	-878	-852	-822
Dead Organic matter	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
Land converted to Cropland	0.00	0.03	0.12	0.18	0.00	0.00	0.24	0.01
Biomass	NO	0.03	0.12	0.18	0.00	NO	0.24	0.01
Dead Organic matter	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
Cropland	-946	-1006	-668	-822	-776	-857	-831	-801

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 National Statistical Service of Greece, 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 CO₂ yr⁻¹ during the period 1990 – 2008. 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 CO₂ per year during the period 1990 – 2008. Cultivation of organic soils resulted in net emissions of 244 kt CO₂ yr⁻¹ during the same period, and therefore soils accounted for net emissions of 20 kt CO₂ 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 7.6*.

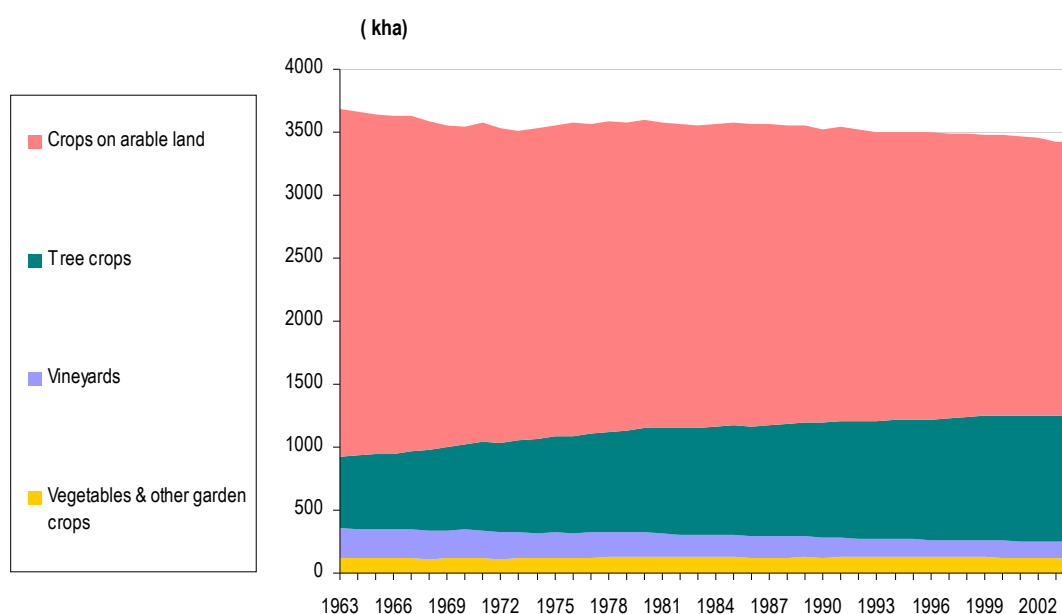


Figure 7.6 Areas of cropland in Greece since 1963 (fallow land excluded)

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 or 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 7.7**). 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:

$$\Delta C_{CC_G} = \sum_i \sum_{j=k-(\lambda_i/2)-1}^k \frac{1}{\lambda_i/2} \cdot A_{planted_{ij}} \cdot G_{w_i} \cdot CF, \quad G_{w,i} = \frac{B_{M,i}}{(\lambda_i/2)}$$

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 .

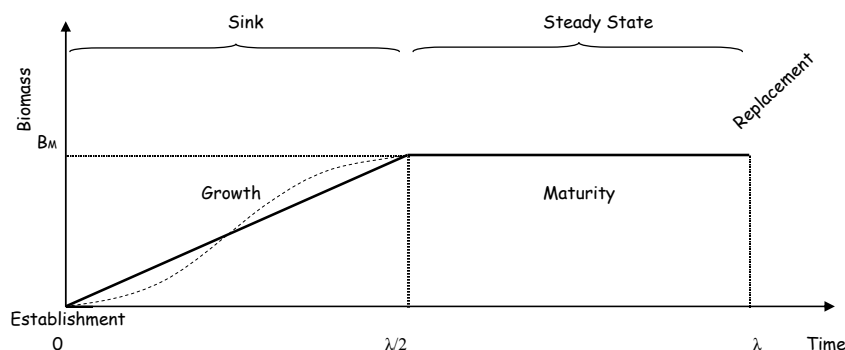


Figure 7.7 Assumed biomass accumulation in new plantations

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:

$$\Delta C_{CC_L} = \sum_i A_{\text{eradicated}_i} \cdot B_{M_i}$$

where, $A_{\text{eradicated}_i}$ 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 National Statistical Service of Greece, 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 7.11**.

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 ($\Delta C_{CC_{\text{Soils}}}$, tonnes C yr⁻¹) was estimated as the difference in the annual emissions from cultivated organic soils ($\Delta C_{CC_{\text{Organic}}}$, tonnes C yr⁻¹) from the annual change in organic carbon stocks in mineral soils ($\Delta C_{CC_{\text{Mineral}}}$, tonnes C yr⁻¹).

$$\Delta C_{CC_{\text{Soils}}} = \Delta C_{CC_{\text{Mineral}}} - \Delta C_{CC_{\text{Organic}}}$$

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 CO₂ when applied to soil. These materials are proved to be more efficient, since limestone (CaCO₃) has large diameter that result in small / slow dissolubility under the Greek dry conditions. CO₂ 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 7.11 *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, bitter 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 ¹⁸	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:

$$\Delta C_{CC_{\text{Mineral}}} = [\sum_i (SOC_0 \cdot A)_i - \sum_i (SOC_{(0-T)} \cdot A)_i] / T$$

$$SOC = SOC_{\text{REF}} \cdot F_{\text{LU}} \cdot F_{\text{MG}} \cdot F_I$$

where, SOC₀ is the soil organic carbon stock in the inventory year, t C yr⁻¹, SOC_(0-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,

¹⁸ Olive groves constitute the majority of new plantations (approximately 90%) during 1990-2008. 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 ($SOC_{REF} = 0.8 \cdot 38 + 0.2 \cdot 88 = 48\ tonnes\ C\ ha^{-1}$, 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 7.12**.

Table 7.12 *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

Unlike 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.

$$\Delta C_{CCOrganic} = A_{Organic} \cdot EF$$

where, $\Delta C_{CCOrganic}$ represents CO₂ 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⁻¹yr⁻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⁻¹yr⁻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 CO₂ emissions from lands converted to Grassland and non-CO₂ emissions from wildfires (*Table 7.13*). Changes in soil carbon stock in Cropland converted to Grassland are estimated and reported in the Cropland remaining Cropland category.

Table 7.13 Emissions / removals of greenhouse gases (in kt) from Grassland for the period 1990 - 2008

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 ₂ O	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 CO₂ 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
CO ₂	NO	0.02	2.03	0.37	NO	0.04	0.06	0.05
CH ₄	0.53	0.10	0.13	0.33	0.17	0.27	5.47	0.58
N ₂ O	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
Total (in kt CO₂ eq)	12.30	2.32	5.11	8.02	3.93	6.28	126.48	13.37

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, CO₂ released is assumed to be removed by photosynthesis of vegetation regrowing during the subsequent year and therefore only emissions of non-CO₂ 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 $\Delta C_{CCMineral} = 0$, 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. CO₂ emissions from liming of grasslands were not considered since liming is not applied on these lands. Non-CO₂ emissions from other sources (e.g. CH₄ 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.

$$\Delta C_{LGLB} = A_{\text{Conversion}} \cdot (L_{\text{Conversion}} + \Delta C_{\text{Growth}})$$

$$L_{\text{Conversion}} = C_{\text{After}} - C_{\text{Before}}$$

where, ΔC_{LGLB} is the annual change in carbon stocks in living biomass in land converted to grassland, tonnes C yr⁻¹, $A_{\text{Conversion}}$ is the annual area of land converted to grassland from some initial use, ha yr⁻¹, $L_{\text{Conversion}}$ 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 B_w 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 ($C_{\text{After}} = 0$). 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-CO₂ 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 N₂O and CH₄ emissions associated with organic soils managed for peat extraction and flooded lands in the category Land converted to Wetlands have to be reported¹⁹. 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 Settlements²⁰.

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:

$$\Delta C_{LSLB} = A \bullet (C_{After} - C_{Before})$$

where, ΔC_{LSLB} 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

¹⁹ Parties do not have to prepare estimates of emissions and removals from Wetlands remaining Wetlands, although they may do so if they wish.

²⁰ 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 (C_{After}) 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 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).

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-CO₂ 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:

$$\Delta C_{\text{LOLB}} = A \bullet (C_{\text{After}} - C_{\text{Before}})$$

where, ΔC_{LOLB} 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. ($C_{\text{After}} = 0$).

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 2008 GHG emissions from *Waste* decreased by 33.16% compared to 1990 levels (*Figure 8.1*), while the average annual rate of decrease of emissions for the period 1990 – 2008 is estimated at 1.84%.

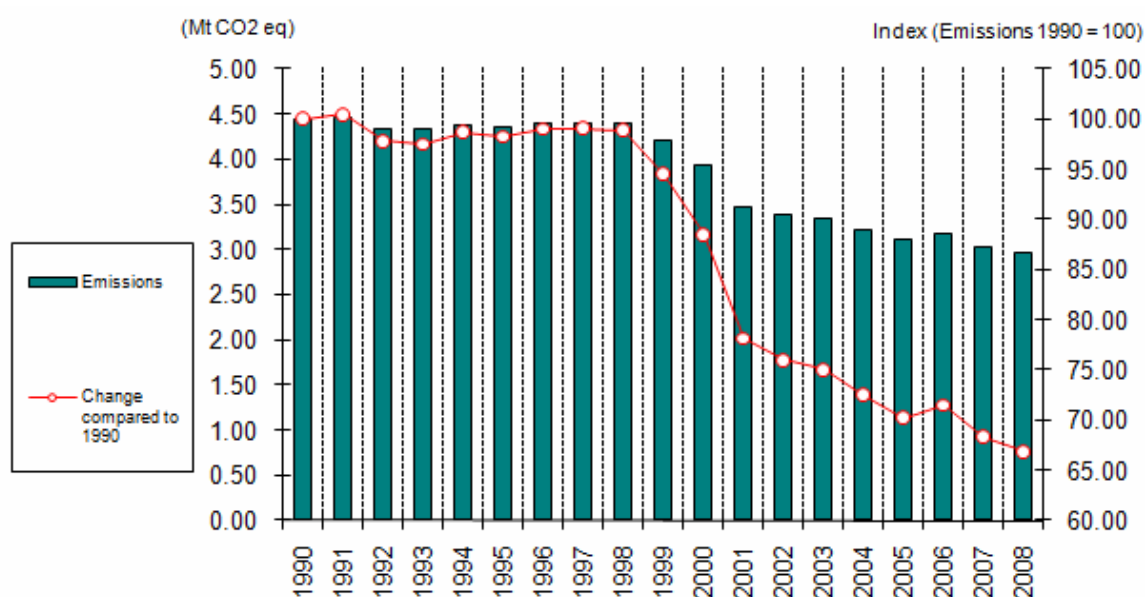


Figure 8.1 Total GHG emissions (in kt CO₂ eq) from Waste for the period 1990 – 2008

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 CO₂ eq) from Waste per gas for the period 1990 – 2008*

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	4117.4	4131.1	4006.5	3993.7	4034.0	4010.8	4045.8	4040.0	4032.6	3829.1	3565.3
N ₂ O	325.1	331.2	338.1	337.3	350.8	353.8	352.6	360.5	361.1	369.8	367.6
Total	4442.7	4462.4	4344.8	4331.2	4385.0	4364.8	4398.6	4400.7	4393.8	4199.1	3933.1
Year	2001	2002	2003	2004	2005	2006	2007	2008			
CO ₂	0.15	0.41	0.79	0.98	1.87	2.26	3.06	3.61			
CH ₄	3107.2	3010.8	2967.4	2853.2	2745.2	2799.5	2654.8	2587.8			
N ₂ O	365.0	365.3	366.4	367.5	373.4	375.1	377.1	378.0			
Total	3472.4	3376.5	3334.5	3221.7	3120.5	3176.9	3034.9	2969.5			

Methane represents the major greenhouse gas from *Waste*, with a contribution which, however, decreased from 92.68% in 1990 to 87.15% in 2008. Overall, CH₄ emissions in 2008 decreased by 37.15% compared to 1990 levels, with an average annual rate of -2.06%.

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 2000 is solid waste disposal on land with a contribution increasing from 40.48% in 1990 to 76.01% in 2008. On the contrary, GHG emissions from wastewater handling present a declining trend, with an average annual rate of -4.07% for the period 1990 – 2008. Carbon dioxide emissions from the incineration of clinical waste present a remarkable increase during the period 1990 – 2008; though the contribution of this source to total GHG emissions of the sector is negligible.

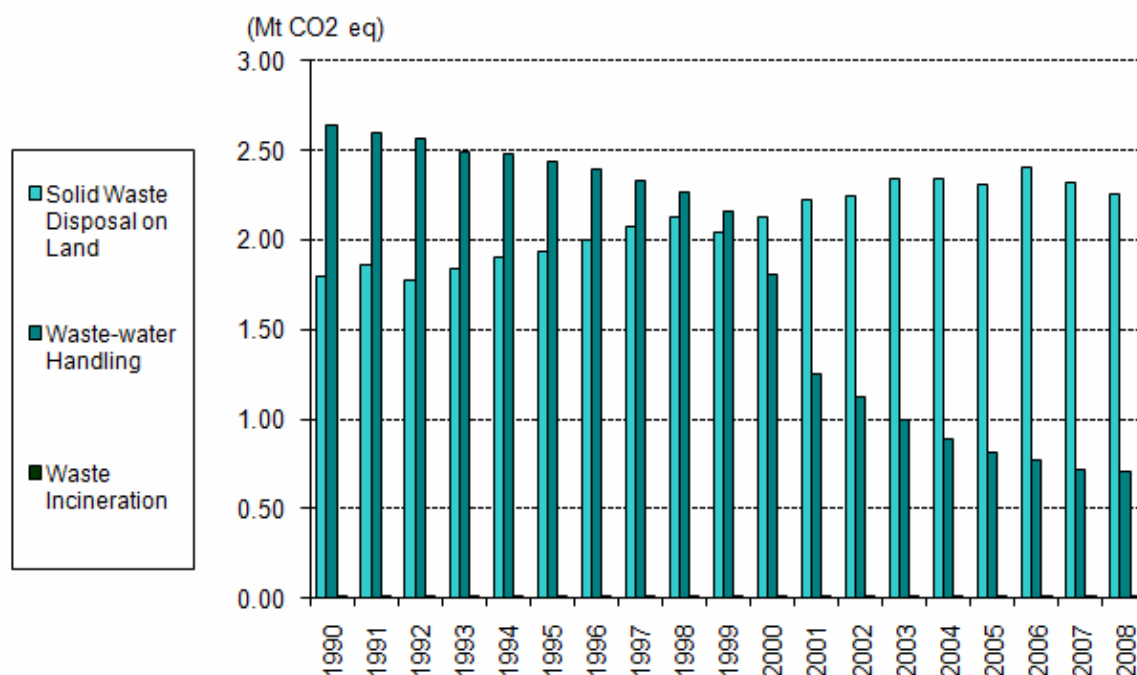


Figure 8.2 *Greenhouse gases emissions (in kt CO₂ eq) from Waste per source category for the period 1990 – 2008*

The emissions from the waste sector decrease for the period 1999-2005 and increase for the period 2005 and 2008. This is observed because, as 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 National Statistical Service of Greece. 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 ₂ O	
	Methodology	Emission Factor	Methodology	Emission Factor	Methodology	Emission Factor
Solid waste disposal on land			T2	D, CS		
Wastewater handling			D	D	D	D
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.

N₂O emissions from industrial wastewater is not estimated due to lack of available methodology.

Table 8.4 *Completeness of the GHG inventory for the waste sector*

	CO ₂	CH ₄	N ₂ O
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		☒	NE
2. Domestic and commercial wastewater		☒	☒
C Waste incineration	☒	☒	☒

NO: Not Occurring

NE: Not Estimated

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 2008 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 of Attica region and the amounts landfilled in the SWDS serving Athens, derive from Waste management sector of the Ministry of Environment, Energy and Climate Change (MEECC), EYDAP and ACMAR.

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 2001-2008 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) for this period (Quantification of objectives of directive 31/99 E.C. on landfill of wastes (p. 195 of the National Inventory Report - Waste Sector)).

CH₄ emissions from solid waste disposal on land in 2008 accounted for 76.01% of total GHG emissions from Waste and for 1.7% of total national emissions (without LULUCF). The average annual rate of increase of emissions from solid waste disposal on land, for the period 1990 – 2008

is estimated at 1.42% (25.5 % total increase between 1990 and 2008). CH₄ emissions from managed and unmanaged solid waste disposal sites are presented in **Table 8.5**.

CH₄ emissions from managed SWDS in 2008 increased by 735% compared to 1990 levels, while emissions from unmanaged SWDS decrease by 8.3%. This difference is due to the reduction of the number of the unmanaged SWDS in operation. Emissions from sewage sludge disposal in 2008 are 15 times higher compared to 1990, while since 2002 the increase is restricted due to a number of issues raised concerning the transfer and disposal of sludge in the managed waste disposal site of Athens. During this period, most of the sewage sludge remains in the wastewater treatment facility of Athens, stored under aerobic conditions with negligible methane production.

Table 8.5 *CH₄ emissions (in kt) from managed and unmanaged solid waste disposal*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Managed SWDS	3.57	7.08	3.12	6.08	9.08	10.26	13.33	16.35	18.43	14.31	18.22
Unmanaged SWDS	81.91	81.27	80.91	80.76	80.72	80.82	81.06	81.33	81.59	81.74	81.89
Sludge treatment	0.17	0.33	0.48	0.61	0.75	0.90	1.01	1.10	1.19	1.27	1.37
Year	2001	2002	2003	2004	2005	2006	2007	2008			
Managed SWDS	22.71	23.85	27.71	28.20	27.49	32.62	30.64	29.78			
Unmanaged SWDS	81.77	81.74	81.87	81.32	80.54	79.63	77.30	75.08			
Sludge treatment	1.46	1.57	1.68	1.80	2.00	2.21	2.41†	2.62†			

†Provisional data

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. In the previous submissions the starting year of the first managed SWDS is assumed to be 1965, however this assumption was reconsidered taking into account the specific 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 CH₄ emissions are the following:

$$\text{CH}_4 \text{ generated at year } t: P_t = \sum_{x=x_0}^t (A \cdot k \cdot MSW_T(x) \cdot MSW_F(x) \cdot Lo(x)) \cdot e^{-k \cdot (t-x)}$$

$$\text{CH}_4 \text{ emissions at year } t: E_t = (P_t - R_t) \cdot (1 - OX)$$

$$Lo(x) = MCF \cdot DOC \cdot DOC_F \cdot F \cdot \frac{16}{12}$$

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 CH₄, 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 CH₄ 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 even at present, a large number of unmanaged SWDS exists: in 1987 and for a number of about 6000 local authorities, almost 4690 unmanaged SWDS were registered (MEECC 1987). 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 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. In the same context, the development

of a national database with detailed data regarding the solid waste management in each managed SWDS is planned.

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 2001-2008 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 **Table 8.6** the estimated data on population served for the whole period 1960-2008 is presented.

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	11221.53	131.44	11.352.97

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 8.7 *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	1.215	2.100	1.225

On the basis of the above, the following MSW quantities for the years 1990 – 2008 were estimated (**Table 8.8**). For the period 2001-2008, 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 8.8 *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†					
Generated MSW	4.266	4.411	4.559	4.64	4.71	4.781	4.854	4.927	5.002	5.077					

†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. However, it must be mentioned that a more detailed and accurate breakdown of solid waste is examined and more information is expected to be provided in the next submissions.

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			
Putrescibles	41.55	41.25	40.95	40.65	40.35	40.05	39.75	39.45			
Textiles	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			
Paper	20.80	21.00	21.20	21.40	21.60	21.80	22.00	22.20			
Plastics	9.30	9.50	9.70	9.90	10.10	10.30	10.50	10.70			
Metals	4.10	4.00	3.90	3.80	3.70	3.60	3.50	3.40			
Glass	4.42	4.40	4.38	4.36	4.34	4.32	4.30	4.28			
Rest	15.58	15.60	15.62	15.64	15.66	15.68	15.70	15.72			

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 2008, the percentage of MSW recycled is estimated at 23 %, 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, 37 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 wet sewage sludge disposed in the managed site of Athens is also presented in *Table 8.11*. Data for 2007 and 2008 are provisional. The solid content of sludge is estimated to be 30%, while 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 – 2008*

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			
Putrescibles	45.57	45.22	44.56	45.22	45.60	45.94	49.10	48.87			
Textiles	3.56	3.56	3.54	3.62	3.67	3.73	4.22	4.24			
Wood	0.86	0.86	0.86	0.88	0.32	0.33	1.30	1.30			
Paper	14.88	15.17	16.00	15.36	15.33	14.28	2.06	1.98			
Plastics	10.01	10.21	10.35	10.66	10.88	11.12	12.81	13.13			
Metals	4.25	4.12	3.97	2.94	2.52	2.53	4.53	4.42			
Glass	3.79	3.76	3.73	3.92	3.97	4.07	5.59	5.58			
Rest	17.09	17.10	17.00	17.40	17.70	17.99	20.39	20.49			

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 (wet)	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	60.00	24.00
1991	1198.41	166.44	1630.78	226.49	60.00	24.00
1992	1246.11	174.92	1733.21	243.29	60.00	24.00
1993	1295.02	183.30	1820.73	257.71	60.00	24.00
1994	1406.12	200.64	1854.26	264.59	65.00	26.00
1995	1477.90	212.31	1911.78	274.64	71.40	28.56
1996	1544.44	223.33	1973.34	285.36	61.00	24.40
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	83.40	33.36
2005	2824.04	410.53	1470.51	213.77	116.81	46.72
2006	2875.51	408.22	1419.55	201.53	125.97	50.39
2007	2926.99	300.50	923.35	94.80	128.63†	51.45
2008	2961.15	302.24	934.12	95.34	135.63†	54.25

†Provisional data

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 evapotranspiration (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 CH₄ recovery is based on assumptions, the volume of biogas flared in the SWDS of Athens and methane that is totally recovered, are presented.

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 CH₄/m³, based on the data collected.

Table 8.12 *CH₄ 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	8.31	8.93	9.72	12.60	13.43	14.47	16.93	26.80	28.08
Year	2001	2002	2003	2004	2005	2006	2007	2008			
Waste landfilled in the SWDS of Patra. Thessalonica and Larissa (kt)	538.8	563.9	590.2	618.0	652.6	681.8	701.7	730.5			
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			
Total CH ₄ recovery (kt)	28.94	33.40	34.81	40.65	47.95	48.43	54.35	58.88			

Only biogas recovered in SWDS of Athens is used to generate energy. The CH₄ emissions from this process are accounted in energy sector.

Other parameters

↳ Methane Correction Factor (MCF): 1 for managed SWDS, 0.6 for unmanaged SWDS. The selection of 0.6 for unmanaged SWDS is based on the fact that the particular conditions in these sites are not clear for the previous years. Many sites which now are operated with managed landfill practices, although they were operated before with some of managed SWDS practises, they could not be clearly indicated as managed sites.

↳ 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. Although in the final centralized review (2009) it was recommended to use 0.5 as DOC_F value, the default value in Revised 1996 IPCC Guidelines and the IPCC Good Practice Guidance is used, 0.77, until a country specific value for Greece is obtained.

↳ 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 0.9% and 0.2%, respectively. The uncertainty associated with activity data is 12% 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 0.3%. The uncertainty associated with activity data is 12% 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 plant-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

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 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

CH₄ emissions from solid waste disposal on land have been recalculated for the period 1990-2007 due to replacement of oxidation factor for managed SWDS from 0 to 0.1, according to recommendation of ERT (centralized review 2009). Moreover, updated data was used for 2007 as far as the recycling waste quantities was concerned. 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**.

8.2.6 Planned improvements

Further investigation regarding composition of disposed wastes is planned. 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. Finally, the collection of data on the sewage sludge disposed in other large managed SWDS of the country is among the future plans, in order to improve the completeness of the emissions inventory for the *Waste* sector.

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	-0.461	-0.880	-0.409	-0.767	-1.102	-1.224	-1.529	-1.806	-1.983	-1.607	-1.956
Impact on total emissions (excl LULUCF)	-0.008	-0.016	-0.007	-0.014	-0.020	-0.022	-0.028	-0.033	-0.035	-0.028	-0.034
Year	2001	2002	2003	2004	2005	2006	2007				
Difference	-2.326	-2.413	-2.693	-2.738	-2.701	-3.069	-5.390				
Impact on total emissions (excl LULUCF)	-0.042	-0.044	-0.050	-0.051	-0.048	-0.059	-0.100				

8.3 Wastewater handling (CRF Source Category 6B)

8.3.1 Description

Domestic and industrial wastewater handling under anaerobic conditions produces CH₄. 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. CH₄ emissions from wastewater handling in 2008 accounted for 0.25% of total GHG emissions and for 11.14% of GHG emissions from *Waste*.

N₂O emissions from human consumption of food and their subsequent treatment through wastewater handling systems (indirect emissions) are also included in the wastewater handling source category. N₂O emissions from this source in 2008 account for 0.29% of total greenhouse gases emissions and 12.73% of greenhouse gases emissions from *Waste*.

Wastewater handling is a key category of CH₄ emissions, which have a substantial contribution in emissions trends (trend assessment). In **Table 8.14** CH₄ and N₂O emissions from wastewater handling for the period 1990 – 2008 are presented.

Table 8.14 CH₄ and N₂O emissions (in kt) from wastewater handling

Year		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Domestic and commercial wastewater	CH ₄	105.31	103.74	101.53	97.34	96.03	94.15	92.19	89.06	85.19	80.49	62.50
Industrial wastewater	CH ₄	5.12	4.29	4.75	5.38	5.52	4.87	5.07	4.55	5.63	4.52	5.80
Human sewage	N ₂ O	1.05	1.07	1.09	1.09	1.13	1.14	1.14	1.16	1.16	1.19	1.19
Year		2001	2002	2003	2004	2005	2006	2007	2008			
Domestic and commercial wastewater	CH ₄	35.87	30.62	25.07	19.14	15.87	13.49	11.89	11.62			
Industrial wastewater	CH ₄	6.16	5.59	4.96	5.41	4.83	5.36	4.18	4.14			
Human sewage	N ₂ O	1.18	1.18	1.18	1.19	1.20	1.21	1.22	1.22			

CH₄ emissions from indirect N₂O emissions increased in 2008 by 16.26% compared to 1990. On the contrary, CH₄ emissions from domestic wastewater handling and industrial wastewater handling in 2008 decreased by 88.97% and 19.21%, 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 90.4% in 2008.

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 served. Emissions from 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 for the first time in the present inventory. 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

CH₄ and N₂O 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 CH₄ 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.

Domestic and commercial wastewater handling

Methane emissions from domestic and commercial wastewater handling are calculated using the following equations:

$$\text{CH}_4 \text{ emissions} = \text{TOW} \times \text{EF} - \text{MR}$$

$$\text{TOW} = P \times D_{\text{dom}}$$

$$\text{EF} = \text{Bo} \times \text{MCFs}$$

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 CH₄/kg BOD for *Bo* was used for the domestic wastewater handling while the value of 0.25 kg CH₄/kg COD for *Bo* 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 – 2008, 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:

- ↳ Dry matter of sludge: 30%
- ↳ Volume of biogas per unit of dry matter: 200 m³/ tn dry matter. The factor results from the data provided by EYDAP.
- ↳ Methane density: 0.7 kg CH₄/ m³
- ↳ Fraction of methane in sludge biogas (F): 0.6

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.

Table 8.15 *BOD (in kt) from domestic and commercial wastewater, sludge and total for the period 1990 – 2008*

Year	Wastewater	Sludge	Total
1990	184.75	2.43	187.18
1991	186.27	2.43	188.70
1992	188.66	2.43	191.09
1993	190.42	2.43	192.85
1994	192.03	2.64	194.66
1995	193.12	2.89	196.02
1996	194.74	2.47	197.22
1997	196.18	2.47	198.66
1998	197.44	2.40	199.85
1999	198.44	2.44	200.88
2000	198.88	2.69	201.57
2001	199.26	2.75	202.01
2002	199.39	3.15	202.54
2003	199.88	3.23	203.12
2004	200.34	3.38	203.72
2005	199.95	4.74	204.68
2006	200.51	5.11	205.61
2007	201.46	5.21	206.67
2008	201.69	5.50	207.19

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 National Statistical Service of Greece) regarding industrial production of approximately 25 industrial sectors / sub-sectors for the period 1990 – 2008. Data on industrial production for 2008 were not available and for this reason production was estimated through linear extrapolation.
- ↳ 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 ($\text{kg COD}/\text{m}^3$ 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 B_0 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 8.16** the degradable organic waste (as COD) for the period 1990 – 2008, is presented.

Table 8.16 *Total COD (in kt) from industrial wastewater for the period 1990 – 2008*

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			
COD (kt)	24.64	22.36	19.85	21.66	19.33	21.44	16.72	16.55			

Indirect N_2O emissions from human consumption of food

Indirect nitrous oxide emissions from human consumption of food and their subsequent treatment through wastewater handling systems are estimated by the following equation:

$$\text{N}_2\text{O emissions} = \text{Protein} \times P \times \text{Frac}_{\text{NPR}} \times \text{EF} (\text{N}_2\text{O-N/N})$$

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 [$\text{EF} (\text{N}_2\text{O-N/N})$] are those suggested by the IPCC Guidelines.

In **Table 8.17** the consumption of protein (kg/person/year) for the period 1990 – 2008, is presented.

Table 8.17 *Annual protein consumption (in kg/person) for the period 1990 – 2008*

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			
Protein (kg/capita)	42.30	42.23	42.23	42.23	42.71	42.71	42.71	42.71			

8.3.3 Uncertainties and time-series consistency

The combined uncertainty of CH₄ emissions of wastewater handling sector as % of total emissions is estimated by 0.3%. 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 N₂O 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 plant-specific data time-series consistency is ensured by performing recalculations according to the IPCC good practice guidance.

8.3.4 Recalculations

CH₄ emissions from commercial wastewater handling have been recalculated because of the availability of updated activity for the 2007. 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 -5.689 and -0.015, respectively.

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 in the Attica region have been estimated. Incineration of clinical waste in a central plant is still limited, despite the fact that the facilities existed are planned to cover the total daily needs of hospitals in Athens.

8.4.2 Methodology

For the estimation of CO₂ emissions, the default method suggested by the IPCC Good Practice Guidance was used. CH₄ and N₂O emissions were estimated for first time 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:

$$\text{CO}_2 \text{ emissions} = CW \times CCW \times FCF \times EF \times 44/12$$

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:

$$\text{CH}_4 \text{ emissions} = CW \times EF_{\text{CH}_4} \text{ and}$$

$$\text{N}_2\text{O emissions} = CW \times EF_{\text{N}_2\text{O}}$$

while the emissions factors' values were 0.06 kg CH₄ / tn waste and 0.1 kg N₂O / tn waste for the CH₄ and for the N₂O, respectively.

In **Table 8.18**, the amount of clinical waste incinerated and emissions released for the period 1990 – 2008 are presented.

8.4.3 Uncertainties and time-series consistency

The combined uncertainty of CO₂ emissions of wastewater handling sector as % of total emissions is estimated by 0.003%. The combined uncertainty of CH₄ emissions of wastewater handling sector as % of total emissions is estimated by 0.0000004%. The combined uncertainty of N₂O emissions of wastewater handling sector as % of total emissions is estimated by 0.0001%.

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 plant-specific data time-series consistency is ensured by performing recalculations according to the IPCC good practice guidance.

Table 8.18 *Clinical waste (in kt) and emissions (in tn) for the period 1990 – 2008*

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 ₂ O	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			
Clinical waste	0.18	0.49	0.94	1.17	2.23	2.70	3.67	4.32			
CO ₂	150	411	785	978	1865	2257	3065	3614			
CH ₄	0.011	0.030	0.056	0.070	0.134	0.162	0.220	0.259			
N ₂ O	0.018	0.049	0.094	0.117	0.223	0.270	0.367	0.432			

8.4.4 Recalculations

Methane and Nitrous oxide emissions were for first time using default methodology and country specific emission factors. Impact of CH₄ and N₂O emissions from clinical waste incineration on waste emissions and on total emissions (excl LULUCF) are lower than 0.00001%.

9. Recalculations and improvements

9.1 *Explanations and justifications for recalculations*

A number of recalculations have been performed since the previous inventory submission in order to improve consistency with UNFCCC reporting guidelines and IPCC guidelines. The recalculations made are driven by the results of Greece's QA/QC system, the findings of the independent audit carried out by a local expert and internal audits taken place by MEECC personnel between September and November of 2009 and the individual reviews of the annual submissions of Greece by nominated experts from the UNFCCC (mainly the centralized review from 21 to 26 September 2008).

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.

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.1.A	Public Electricity and Heat Production	CO ₂ / CH ₄ / N ₂ O	AD, EF	CS and PS EF used for imported NG. AD was updated based on PS data (ETS reports).
1.AA.1.B	Petroleum Refining	CO ₂ / CH ₄ / N ₂ O	AD, EF	EF of refinery gases was updated based on available ETS reports data (2005-2008). AD was updated based on PS data (ETS reports). PS EFs were used. CS EF used for imported NG.
1.AA.1.C	Manufacture of Solid Fuels and Other Energy Industries	CO ₂ / CH ₄ / N ₂ O	AD, EF	Error in CRF compilation. AD was updated based on PS data (ETS reports). EF was changed in order to include CO ₂ emissions from sour gas cleaning operation.
1.AA.2.A	Iron and Steel	CO ₂ / CH ₄ / N ₂ O	EF	CS EF used for imported NG.
1.AA.2.B	Non-Ferrous Metals	CO ₂ / CH ₄ / N ₂ O	A	Non-energy fuels reallocated to industrial processes sector.
1.AA.2.C	Chemicals	CO ₂ / CH ₄ / N ₂ O	AD, EF	CS EF used for imported NG. AD was updated based on PS data (ETS reports). NG for H ₂ production was reallocated to Refineries sector. AD was updated based on PS data (ETS reports). Naptha for H ₂ production was reallocated to Refineries sector.
1.AA.2.D	Pulp, Paper and Print	CO ₂ / CH ₄ / N ₂ O	EF	CS EF used for imported NG.
1.AA.2.E	Food Processing, Beverages and Tobacco	CO ₂ / CH ₄ / N ₂ O	AD, EF	CS EF used for imported NG. AD was updated based on PS data (ETS reports).
1.AA.2.F	Manufacturing Industries and Construction. Other	CO ₂ / CH ₄ / N ₂ O	AD, EF	CS EF used for imported NG. AD was updated based on PS data (ETS reports, petcoke). AD was updated based on PS data (ETS reports, coal, alternative fuels). PS EFs were used.
1.AA.3.B	Road Transportation	CO ₂ / CH ₄ / N ₂ O	AD	AD of biodiesel were corrected.
1.AA.4.A	Commercial/Institutional	CO ₂ / CH ₄ / N ₂ O	M	CS EF used for imported NG.
1.AA.4.B	Residential	CO ₂ / CH ₄ / N ₂ O	M	CS EF used for imported NG.
2. A. 3	Limestone and dolomite use	CO ₂	A	Reallocation of emissions from SO ₂ scrubbing from the energy sector.
2. C. 1	Iron and steel production	CH ₄	M	Estimation for the first time, using the default values from SNAP 040207.
2. C. 2	Ferroalloys production	CO ₂	A	Reallocation of emissions from the energy sector.
2.F.1	Refrigeration and A/C equipment	HFCs	M, AD	Change of charge quantity in large commercial applications, acc to ERT recommendation. Update of AD in transport refrigeration.
2. F. 2	Foam blowing	HFCs	M	Emissions estimated for the first time.
2.F.3	Fire extinguishers	HFCs	M	Emissions estimated for the first time.
2.F.4	Aerosols/MDIs	HFCs	AD	Updated data by the National Organization of Medicines.

IPCC source / sink categories		Gas	Explanation	
4.A	Enteric Fermentation / Dairy Cattle	CH ₄	AD	Updated activity data.
4.B	Manure Management	CH ₄ / N ₂ O	AD	Updated activity data (animal population).
4.D	Agricultural Soils	N ₂ O	AD, M	Updated activity data and nitrogen excretion (Nex) value.
5A	Forest Land	CO ₂ / CH ₄ / N ₂ O	M	Change in forest and forest management definition. Change from the Default method to the 'C stock change' approach in order to improve accuracy and completeness and to decrease uncertainties
5.A.2.1.	Cropland converted to Forest Land	CO ₂	AD	Updated activity data (area under afforestation)
5.B.1	Cropland remaining Cropland	CO ₂	AD	Updated activity data (cultivated areas)
5.B.2	Land converted to Cropland	CO ₂		Estimation for the first time, due to development of a new dataset
5.C.1	Grassland remaining Grassland	CO ₂ / CH ₄ / N ₂ O	AD	Updated activity data (area affected by wildfires)
5.D.2	Land converted to Wetlands	CO ₂		Estimation for the first time, due to development of a new dataset
5.E.2	Land converted to Settlements	CO ₂		Estimation for the first time, due to development of a new dataset
5.F.2	Land converted to Other Land	CO ₂		Estimation for the first time, due to development of a new dataset
6.A	Solid Waste Disposal on Land	CH ₄	AD	Updated activity data (generated solid waste, amount of solid waste sent to managed and unmanaged disposal sites, composition of waste). Replacement of oxidation factor for managed SWDS from 0 to 0.1
6.B.1	Wastewater Handling / Industrial Wastewater	CH ₄	AD	Updated activity data (industrial production).
6.C	Waste incineration	CH ₄ / N ₂ O	M	Country specific emission factors were used

E: Correction of errors. M: Change or refinement of methodology. NS: new sources. A: allocation to different sectors

9.1.2 KP-LULUCF inventory

GHG emissions and removals from KP-LULUCF activities are reported for first time in 2010 submission, hence any recalculations will be reported from the next submission onwards.

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 – 9.5*.

Table 9.2 *Recalculation of CO₂ emissions (differences compared to previous submission, in kt)*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy	-828.77	-800.11	-733.75	-853.07	-846.38	-847.28	-999.95	-847.01	-831.51	-650.74	-1038.15
Fuel Combustion Activities	-828.77	-800.11	-733.75	-853.07	-846.38	-847.28	-999.95	-847.01	-831.51	-650.74	-974.74
Energy Industries	-156.46	-163.83	-155.16	-169.03	-172.07	-178.57	-196.34	-205.61	-213.15	-211.01	-257.97
Manufacturing Industries and Construction	-653.10	-612.48	-551.70	-655.23	-648.71	-643.11	-780.56	-623.25	-600.53	-426.46	-706.62
Transport	-19.21	-23.80	-26.89	-28.81	-25.61	-25.61	-23.05	-17.92	-17.28	-12.80	-9.60
Other Sectors								-0.24	-0.55	-0.46	-0.55
Fugitive Emissions from Fuels											-63.41
Solid fuel											-63.41
Industrial processes	574.87	583.13	559.32	391.72	589.60	625.01	648.55	641.55	544.56	487.07	600.27
Mineral Products											63.41
Metal Production	574.87	583.13	559.32	391.72	589.60	625.01	648.55	641.55	544.56	487.07	536.87
Emissions from Biomass											
Land Use, Land-Use Change and Forestry	743.55	1008.71	185.17	641.44	692.35	1206.92	1066.70	970.04	287.46	895.83	-496.56
Forest Land	734.43	1003.32	170.05	635.12	684.47	1199.41	1052.40	959.85	279.96	874.32	-518.00
Cropland	0.03	0.16	0.11	0.30	0.04	0.09	0.09	0.02	0.04	0.03	0.04
Grassland	0.01	0.21			0.49	3.00		0.08		0.31	
Wetlands	0.00						0.06				
Settlements	2.30	1.35	1.92	1.52	2.00	2.21	5.38	1.63	1.26	4.54	4.61
Other Land	6.77	3.67	13.10	4.50	5.36	2.21	8.76	8.46	6.19	16.62	16.79
TOTAL	489.65	791.73	10.74	180.10	435.57	984.65	715.30	764.58	0.51	732.15	-934.43

Year	2001	2002	2003	2004	2005	2006	2007
Energy	-1006.27	-1039.07	-1146.07	-1090.41	1260.17	887.36	-111.20
Fuel Combustion Activities	-916.87	-973.21	-1058.18	-983.33	1367.25	988.48	-4.41
Energy Industries	-258.95	-265.89	-273.21	-272.28	174.43	-177.89	410.19
Manufacturing Industries and Construction	-647.15	-696.91	-775.90	-708.83	1197.25	1171.80	-399.97
Transport	-10.24	-9.60	-7.68	0.03	0.03	1.49	-6.22
Other Sectors	-0.53	-0.81	-1.38	-2.25	-4.46	-6.91	-8.40
Fugitive Emissions from Fuels	-89.40	-65.86	-87.90	-107.08	-107.08	-101.13	-106.79
Solid fuel	-89.40	-65.86	-87.90	-107.08	-107.08	-101.13	-106.79
Industrial processes	709.65	737.04	779.86	769.84	871.05	768.52	820.50
Mineral Products	89.40	65.86	87.90	107.08	204.06	101.13	106.79
Metal Production	620.26	671.19	691.96	662.75	666.99	667.39	713.70
Emissions from Biomass						-19.54	-34.90
Land Use, Land-Use Change and Forestry	1762.74	1957.82	2030.38	1967.46	1847.37	1850.56	605.51
Forest Land	1735.35	1945.48	2018.27	1903.80	1864.21	1825.06	575.92
Cropland		0.03	0.12	52.73	-25.09	10.65	1.89
Grassland		0.02	2.03	0.37		0.04	0.06
Wetlands	0.13	1.89	0.76	0.94	0.18	0.58	0.20
Settlements	1.98	1.95	1.55	1.50	3.45	5.91	8.43
Other Land	25.28	8.45	7.65	8.13	4.62	8.32	19.02
TOTAL	1466.13	1655.80	1664.16	1646.88	3978.59	3506.43	1314.81

Table 9.3 *Recalculation of CH₄ emissions (differences compared to previous submission. in kt CO₂ eq)*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy	-33.09	-25.89	-34.59	-42.70	-46.11	-40.25	-37.85	-57.90	-105.16	-37.18	-119.27
Fuel Combustion Activities	-0.06	-0.12	-0.10	-0.12	-0.11	-0.10	-0.14	-0.09	-0.07	-0.02	-0.10
Energy Industries	-0.06	-0.12	-0.10	-0.12	-0.11	-0.10	-0.14	-0.09	-0.07	-0.02	-0.10
Manufacturing Industries and Construction											
Transport	-0.14	-0.13	-0.12	-0.14	-0.14	-0.14	-0.17	-0.13	-0.13	-0.09	-0.15
Other Sectors	0.08	0.02	0.03	0.02	0.03	0.04	0.03	0.05	0.05	0.07	0.05
Industrial processes	0.21	0.21	0.19	0.21	0.18	0.20	0.17	0.21	0.23	0.20	0.23
Metal Production	0.21	0.21	0.19	0.21	0.18	0.20	0.17	0.21	0.23	0.20	0.23
Agriculture											
Enteric Fermentation											
Manure Management											
Land Use, Land-Use Change and Forestry	-24.91	-9.45	-27.40	-28.59	-25.00	-16.42	-6.78	-19.88	-62.31	-3.97	-76.89
Forest Land	-37.15	-19.36	-59.81	-51.55	-45.55	-26.48	-15.92	-29.92	-90.44	-7.07	-125.28
Cropland	12.24	9.91	32.41	22.96	20.56	10.06	9.14	10.04	28.12	3.10	48.39
Waste	-8.32	-16.53	-7.29	-14.19	-21.18	-23.93	-31.11	-38.15	-43.00	-33.39	-42.51
Solid Waste Disposal on Land	-8.32	-16.53	-7.29	-14.19	-21.18	-23.93	-31.11	-38.15	-43.00	-33.39	-42.51
Waste-water Handling											
Waste Incineration	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
TOTAL	-33.09	-25.89	-34.59	-42.70	-46.11	-40.25	-37.85	-57.90	-105.16	-37.18	-119.27

Year	2001	2002	2003	2004	2005	2006	2007
Energy	-60.94	-57.07	-65.57	-68.54	-64.88	-87.50	-157.50
Fuel Combustion Activities	-0.09	-1.04	-0.10	-0.10	1.00	-0.01	0.10
Energy Industries	-0.09	-1.04	-0.10	-0.10	1.00	-0.01	0.10
Manufacturing Industries and Construction					0.09	-0.18	0.15
Transport	-0.14	-0.15	-0.17	-0.16	0.86	0.12	-0.06
Other Sectors	0.05	0.05	0.07	0.06	0.05	0.05	0.01
Industrial processes	0.27	0.39	0.36	0.41	0.48	0.51	0.54
Chemical Industry	0.27	0.39	0.36	0.41	0.48	0.51	0.54
Agriculture							-4.19
Enteric Fermentation							-2.50
Manure Management							-1.69
Land Use, Land-Use Change and Forestry	-8.14	-0.77	-1.17	-3.06	-2.24	-7.69	16.63
Forest Land	-17.26	-2.63	-3.39	-9.43	-5.81	-13.18	-90.39
Cropland	9.13	1.85	2.22	6.38	3.57	5.49	107.02
Waste	-52.98	-55.65	-64.67	-65.80	-64.13	-76.11	-152.37
Solid Waste Disposal on Land	-52.98	-55.65	-64.67	-65.80	-64.13	-76.11	-132.02
Waste-water Handling							-20.35
Waste Incineration	0.0002	0.0006	0.0012	0.0015	0.0028	0.0034	0.0046
TOTAL	-60.94	-57.07	-65.57	-68.54	-64.88	-87.50	-157.50

Table 9.4 *Recalculation of N₂O emissions (differences compared to previous submission, in kt CO₂ eq)*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy	-3.01	-2.94	-2.61	-3.09	-3.08	-3.03	-3.70	-2.90	-2.76	-1.89	-3.27
Fuel Combustion Activities	-3.01	-2.94	-2.61	-3.09	-3.08	-3.03	-3.70	-2.90	-2.76	-1.89	-3.27
Energy Industries											
Manufacturing Industries and Construction	-3.16	-2.97	-2.65	-3.13	-3.13	-3.10	-3.75	-2.99	-2.85	-2.01	-3.36
Transport	0.14	0.03	0.04	0.04	0.05	0.07	0.06	0.08	0.10	0.12	0.09
Fugitive Emissions from Fuels											
Oil and Natural Gas											
Solvent and Other Product Use	138.63	139.76	141.53	142.83	144.17	145.17	146.06	147.13	148.01	148.77	149.28
Agriculture	-2148.49	-2150.78	-2156.64	-2171.00	-2192.51	-2218.27	-2239.32	-2251.29	-2257.28	-2262.39	-2269.37
Manure Management											
Agricultural Soils	-33.67	-3.85	-28.86	-202.04	-577.26	9.62	-163.56		153.94	18.33	-152.92
Land Use, Land-Use Change and Forestry	-2.53	-0.96	-2.78	-2.90	-2.54	-1.67	-0.69	-2.02	-6.32	-0.40	-7.80
Forest Land	-3.77	-1.96	-6.07	-5.23	-4.62	-2.69	-1.62	-3.04	-9.18	-0.72	-12.71
Grassland	1.24	1.01	3.29	2.33	2.09	1.02	0.93	1.02	2.85	0.31	4.91
Waste	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056
Waste Incineration	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056
TOTAL	-2015.40	-2014.92	-2020.50	-2034.16	-2053.95	-2077.79	-2097.64	-2109.08	-2118.35	-2115.91	-2131.16

Year	2001	2002	2003	2004	2005	2006	2007
Energy	-3.05	-3.31	-3.64	-3.33	0.43	-0.17	-2.19
Fuel Combustion Activities	-3.05	-3.31	-3.64	-3.33	0.43	-0.17	-2.19
Energy Industries					0.26	-0.27	0.42
Manufacturing Industries and Construction	-3.14	-3.40	-3.77	-3.44	0.08	0.22	-2.50
Transport	0.09	0.09	0.13	0.10	0.09	-0.12	-0.11
Fugitive Emissions from Fuels			0.0002				
Oil and Natural Gas			0.0002				
Solvent and Other Product Use	149.61	150.00	150.43	150.88	151.59	152.28	153.06
Agriculture	-2276.72	-2274.32	-2253.22	-2220.10	-2190.69	-2174.37	-1699.17
Manure Management						-1.62	-3.02
Agricultural Soils	-2276.72	-2274.32	-2253.22	-2220.10	-2190.69	-2174.37	-1699.17
Land Use, Land-Use Change and Forestry	-0.83	-0.08	-0.12	-5.27	-0.26	-0.78	1.69
Forest Land	-1.75	-0.27	-0.34	-0.96	-0.59	-1.34	-9.17
Grassland	0.93	0.19	0.23	-4.31	0.33	0.56	10.86
Waste	0.0056	0.0153	0.0291	0.0363	0.0692	0.0837	0.1136
Waste Incineration	0.0056	0.0153	0.0291	0.0363	0.0692	0.0837	0.1136
TOTAL	-2130.98	-2127.70	-2106.52	-2077.79	-2038.86	-2022.96	-1546.49

Table 9.5 *Recalculation of F-gases emissions (differences compared to previous submission, in kt CO₂ eq)*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
HFC						4.84	14.63	50.17	121.91	233.66	330.96
PFC											
SF ₆											
TOTAL	0.00	0.00	0.00	0.00	0.00	4.84	14.63	50.17	121.91	233.66	330.96
Year	2001	2002	2003	2004	2005	2006					
HFC	448.64	566.18	790.36	947.50	966.72	1049.83	1035.25				
PFC											
SF ₆											
TOTAL	448.64	566.18	790.36	947.50	966.72	1049.83	1035.25				

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 2009 inventory with the present inventory (in Mt CO₂ eq)*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO ₂ emissions											
2009 submission	79.90	79.28	81.52	80.36	82.81	82.34	85.05	89.73	95.04	93.43	100.80
2010 submission	80.39	80.07	81.53	80.54	83.25	83.33	85.76	90.50	95.04	94.16	99.87
Change (%)	0.61	1.00	0.01	0.22	0.53	1.20	0.84	0.85	0.00	0.78	-0.93
CH ₄ emissions											
2009 submission	9.05	9.04	9.01	9.00	9.09	9.09	9.25	9.27	9.41	9.10	9.10
2010 submission	9.02	9.01	8.97	8.95	9.05	9.05	9.21	9.21	9.30	9.06	8.98
Change (%)	-0.37	-0.29	-0.38	-0.47	-0.51	-0.44	-0.41	-0.62	-1.12	-0.41	-1.31
N ₂ O emissions											
2009 submission	12.22	11.90	11.74	10.89	10.73	11.04	11.29	11.08	11.00	10.92	10.80
2010 submission	10.20	9.88	9.72	8.86	8.67	8.96	9.19	8.98	8.88	8.81	8.67
Change (%)	-16.50	-16.94	-17.21	-18.68	-19.15	-18.83	-18.58	-19.03	-19.26	-19.37	-19.74
F-gases emissions											
2009 submission	1.20	1.37	1.16	1.76	2.24	3.34	3.82	4.14	4.59	5.20	3.97
2010 submission	1.20	1.37	1.16	1.76	2.24	3.35	3.84	4.19	4.71	5.43	4.30
Change (%)	0.00	0.00	0.00	0.00	0.00	0.14	0.38	1.21	2.66	4.49	8.33
Total emissions											
2009 submission	105.56	105.15	106.42	105.82	108.36	110.18	113.38	118.13	123.48	123.08	127.13
2010 submission	103.29	102.90	104.22	103.32	106.03	107.87	110.91	115.83	121.16	121.00	124.85
Change (%)	-2.16	-2.14	-2.07	-2.37	-2.15	-2.10	-2.17	-1.95	-1.88	-1.69	-1.79
Year	2001	2002	2003	2004	2005	2006	2007				
CO ₂ emissions											
2009 submission	100.65	100.00	104.47	104.61	106.05	104.53	109.76				
2010 submission	102.12	101.65	106.14	106.26	110.02	108.04	111.07				
Change (%)	1.46	1.66	1.59	1.57	3.75	3.35	1.20				
CH ₄ emissions											
2009 submission	8.57	8.52	8.41	8.31	8.15	8.14	8.27				
2010 submission	8.51	8.47	8.35	8.24	8.09	8.06	8.11				
Change (%)	-0.71	-0.67	-0.78	-0.82	-0.80	-1.07	-1.90				
N ₂ O emissions											
2009 submission	10.63	10.51	10.37	10.29	9.93	9.66	9.44				
2010 submission	8.50	8.38	8.26	8.21	7.89	7.64	7.89				
Change (%)	-20.05	-20.24	-20.32	-20.19	-20.53	-20.94	-16.38				
F-gases emissions											
2009 submission	3.40	3.47	3.02	3.02	2.71	0.68	0.73				
2010 submission	3.85	4.04	3.81	3.97	3.67	1.73	1.77				
Change (%)	13.18	16.30	26.14	31.40	35.72	155.26	141.01				
Total emissions											
2009 submission	128.21	127.78	131.30	131.35	131.83	128.09	131.85				
2010 submission	126.18	125.86	129.56	129.84	132.83	128.69	131.88				
Change (%)	-1.58	-1.50	-1.33	-1.15	0.76	0.47	0.02				

9.2.2 KP-LULUCF inventory

GHG emissions and removals from KP-LULUCF activities are reported for first time in 2010 submission, hence any recalculations will be reported from the next submission onwards.

9.3 *Implications for emissions trends*

9.3.1 GHG inventory

Total GHG emissions (without LULUCF) in the current submission are a little lower for the period 1990 to 2004 while are quite similar for period 2005 to 2007 compared to emissions reported in the 2009 submission. The emissions trends in Greece for the period 1990 – 2007 (without LULUCF) according to the inventories submitted in 2009 & 2010 are shown in **Figure 9.1**. The recalculations with the most significant effect were in: sector 4.D for the whole time-series 1990-2007 (due to updating of nitrogen excretion (Nex) values), industrial processes and solvents sectors for the whole time-series 1990-2007 due to the inclusion to the inventory of emissions of categories that were reported as “NE” in previous submissions, sector 2.F.1.2 for the years 1995-2007 due to a methodological change (change of charge quantity in large commercial applications) and the recalculation performed in the 1.A.2 sector for the years 2005-2007.

The average annual rate of emissions increase for the period 1990 – 2007 in the present inventory is calculated to be similar compared to the one that had been calculated in the previous inventory (1.63% and 1.47% respectively).

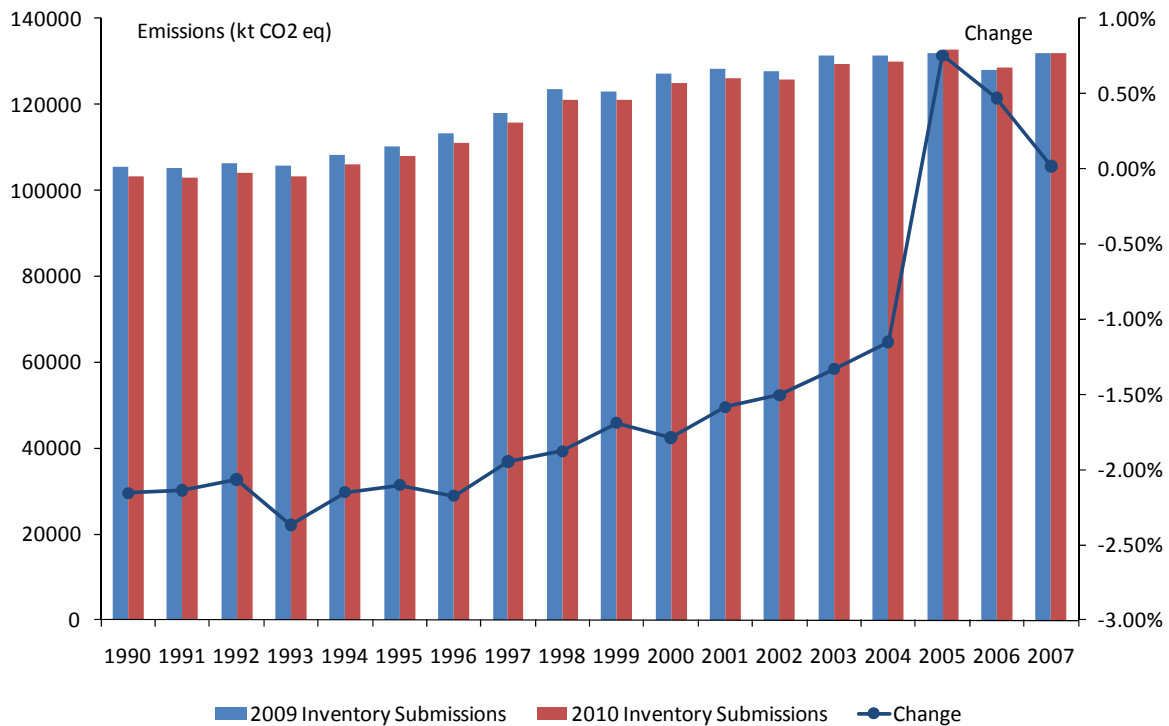


Figure 9.1 *GHG emissions trends in Greece for the period 1990 – 2007 (without LULUCF) according to the inventories submitted in 2009 & 2010*

9.3.2 KP-LULUCF inventory

GHG emissions and removals from KP-LULUCF activities are reported for first time in 2010 submission, hence any recalculations will be reported from the next submission onwards.

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 1990-2008. 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.

In year 2010 the second inventory audit by an independent national expert will take place. Based on the finding of this review improving actions will be planned and executed, too.

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 2009 review of Greek GHG inventory is presented.

Table 9.7 *Documentation of major changes in methodological descriptions compared to previous year NIR*

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS Please tick where the latest NIR includes major changes in methodological descriptions compared to the previous year NIR	RECALCULATIONS Please tick where this is also reflected in recalculations compared to the previous year CRF	REFERENCE 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	√	√	PS CO2 EF for NG (1.A.1a and b), PS AD for NG (1.A.1a, b and c) . Time series consistency CO2 from Liquids (1.A.1.b), PS AD liquid and gases (1.A.1b).
2. Manufacturing Industries and Construction	√	√	CS CO2 EF for NG, 1.A.2b Solid fuels reallocated to IP sector.
3. Transport	√	√	1.A.3d NE emissions were calculated.
4. Other Sectors	√	√	CS CO2 EF for NG
5. Other			
B. Fugitive Emissions from Fuels			
1. Solid Fuels	√	√	SO2 scrubbing reallocated to IP sector
2. Oil and Natural Gas			
2. Industrial Processes			
A. Mineral Products	√	√	Reallocation of SO2 scrubbing from the energy sector.
B. Chemical Industry			
C. Metal Production	√	√	Reallocation of fuels used as reducing agents from the energy sector. NE CH4 emissions were estimated in the iron and steel sector.
D. Other Production			
E. Production of Halocarbons and SF6			
F. Consumption of Halocarbons and SF6	√	√	Corrections due to updated data in the ODS sectors. Also, inclusion of new categories (foam blowing, fire equipment).
G. Other			
3. Solvent and Other Product Use	√	√	NE N2O emissions were estimated.
4. Agriculture			
A. Enteric Fermentation			
B. Manure Management			
C. Rice Cultivation			
D. Agricultural Soils	√	√	N2O emissions were recalculated because updated Nex value for goats from 40 kg N/head/year to 12 kg N/head/year were used.
E. Prescribed Burning of Savannas			
F. Field Burning of Agricultural Residues			
G. Other			
5. Land Use, Land-Use Change and Forestry			
A. Forest Land	√	√	Change from the Default method to the 'C stock change' approach
B. Cropland	√	√	Estimation for the first time, CO2 from Land converted to Cropland
C. Grassland	√	√	Estimation for the first time, CO2 from Land converted to Grassland
D. Wetlands	√	√	Estimation for the first time, CO2 from Land converted to Cropland
E. Settlements	√	√	Estimation for the first time, CO2 from Land converted to Wetlands
F. Other Land	√	√	Estimation for the first time, CO2 from Land converted to Settlements
G. Other	√	√	Estimation for the first time, CO2 from Land converted to Other land
6. Waste			
A. Solid Waste Disposal on Land	√	√	Replacement of oxidation factor for managed SWDS from 0 to 0.1
B. Waste-water Handling			
C. Waste Incineration	√	√	NE CH4 and N2O emissions were estimated.
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

GHG emissions and removals from KP-LULUCF activities are reported for first time in 2010 submission, hence any recalculations will be reported from the next submission onwards.

Table 9.8 *Reporting on the outcomes of the 2009 review of Greek GHG inventory*

Category	Review	Response by Greece
General (Completeness)	8. The ERT encourages Greece to explore the possibility of reporting CRF table 7 for all years of the time series in its next annual submission.	The reporting is complete in the 2010 submission.
	9. The ERT recommends that Greece improve the completeness of its next annual submission, especially for those categories that are known to occur within the Party and for which methodologies are available. The ERT encourages the Party to explore approaches available in the scientific literature, to estimate emissions for categories that do not have methodologies prescribed in the Revised 1996 IPCC guidelines nor the IPCC good practice guidance, with a view to enhance further, to the extent possible, the completeness and accuracy of its inventory. The ERT also recommends that the Party, when reporting emissions data for the first time for a given category, ensure that emissions data are provided for the entire inventory time series, and that the choice of methods and EFs are clearly explained in the NIR.	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 1990-2008. 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)	22. The ERT encourages Greece to explore the possibility of reporting CRF table 7 for all years of the time series in its next inventory submission.	The key categories analysis is provided for all the inventory years in the 2010 submission (paragraph 1.5.1 of NIR).
General (Uncertainties)	23. It also reiterates the recommendation of the previous ERT that Greece report an uncertainty analysis for 1990 without including the base year under the Kyoto Protocol (1995) for the F-gases.	Done (paragraph 1.7.1 of NIR).
Energy	51. The ERT noticed that the implied emission factors (IEFs) for CO ₂ from liquid fuels in both the chemicals and other (manufacturing industries and construction) were lower than	The non-energy use of fuels from fuel combustion was removed and this amount was subtracted from the apparent energy

Category	Review	Response by Greece
	<p>those of other Parties.</p> <p>In response to a question during the review, Greece explained that this is due to non-energy use of fuels being included as fuel combustion in order to balance the sectoral approach with the reference approach.</p> <p>The ERT noted that this is not in accordance with the Revised 1996 IPCC Guidelines and recommends that Greece remove the non-energy use of fuels from fuel combustion and subtract this amount from the apparent energy consumption in the reference approach. The ERT further reiterates the recommendation of the previous review for any relevant process emissions reported in the energy sector to be reallocated to the industrial processes sector</p>	<p>consumption in the reference approach (paragraph 3.2.4.2 of NIR).</p> <p>New reallocation from energy to the industrial processes sector in 2010 submission are the following:</p> <ol style="list-style-type: none"> 1. 1.B.1.c (SO₂ scrubbing) to 2.A.3 2. Non energy use of solid fuels from 1.A.2.b moved to 2.C.2.
Energy	<p>52. There is a marked difference between the CO₂ IEFs for stationary combustion for the years up to 2004 and for the years from 2005 on. For example, the CO₂ IEF for liquid fuels for iron and steel increased by 11.4 per cent (from 68.49 t/TJ in 2004 to 76.32 t/TJ in 2005), the CO₂ IEF for gaseous fuels in the public electricity and heat production sector drops from a constant value of 55.82 t/TJ for the period 1990-2004 to 55.01 t/TJ in 2005, and the CO₂ IEF for liquid fuels in petroleum refining decreases by 5.7 per cent (from 72.92 t/TJ in 2004 to 68.78 t/TJ in 2005). Greece explained that these changes result from using IPCC default EFs for the 1990-2004 period and EFs from verified EU ETS reports for the years 2005-2007. The ERT recommends that Greece justify that the EU ETS data have been prepared and incorporated into the inventory submission in line with the principles of the IPCC good practice guidance and ensure time-series consistency in next annual submission.</p>	<p>Corrected and / or justified (paragraph 3.2.4.5 of NIR).</p>

Category	Review	Response by Greece
Energy	53. The ERT noticed that the IEF values of CO ₂ for chemicals for 1990 (114.3 t/TJ) and 1991 (146.7 t/TJ) are some of the highest of all reporting Parties (48.98.397.82 t/TJ for 1990) for these years and higher than the IPCC default range (94.6-106.7 t/TJ), and higher than the subsequent years. Values reported by Greece. In response to a question raised by the ERT during the review, Greece explained that the high 1991 value is due to an incorrect value for fuel consumption in CRF Reporter and will be corrected in the next annual submission.	Corrected (paragraphs 3.2.4.3 and 3.2.4.5 of NIR).
Industrial Processes	57. According to the NIR and to information provided by Greece during the review, it is working to improve the completeness of the inventory regarding these categories. The ERT encourages this effort.	The completeness plan for the IP sector is being implemented and updated according to data availability. Data on new categories have been used in the 2010 submission. When not available, estimations have been performed. All the respective information is available in the NIR (paragraph 4.1.3)
Industrial Processes	59. The ERT concluded the recalculation methodologies used are in line with the IPCC good practice guidance. The recalculated estimates between 1990 and 2004 in mineral products are on average 2.5 per cent lower, those in iron and steel production some 58 per cent lower, whereas the estimates between 2005 and 2006 have not changed. During the review, Greece also informed the ERT about the steps taken to ensure completeness of the reporting of these categories. The ERT recommends that Greece include this information in the next annual submission.	Information on completeness included in NIR, paragraph 4.13.
Industrial Processes	62. Following the recommendation of the previous review, emissions from ammonia production have been moved to the industrial processes sector from the energy sector. However,	Both issues are currently under investigation. Data on the liquid fuels used in the previous years for ammonia production continue to be

Category	Review	Response by Greece
	<p>this reallocation is only partial, because it covers only natural gas used as feedstocks, whereas emissions from use of lignite (up to 1991) and liquid fuels (up to 1999) are still included in the energy sector. This causes an inconsistency in the time series and fluctuations in the IEFs as raised in the previous stage of the review. The inconsistency is due to the fact that until 1997, emissions and AD are reported as included elsewhere (I.E.). For 1998 and 1999, the AD cover ammonia production using both natural gas and liquid fuels, but the estimated emissions include only those resulting from the use of natural gas. Since 2000 the AD and emissions are both for natural gas use only, which correctly reflects the situation in ammonia production in the country since 2000. The ERT recommends Greece to improve the time-series consistency of the category estimates in its next annual submission. The ERT also encourages Greece to apply QA/QC procedures to the obtained plant-specific data, especially concerning the use of natural gas as feedstocks or for energy.</p>	<p>unavailable.</p>
Industrial Processes	<p>65. Emissions from refrigeration and air conditioning have been estimated using the IPCC tier 2a methodology. Following the recommendation of the previous review, data collection has been extended by using market surveys and organizing meetings with experts. Based on the new data, major changes have been made to the underlying calculation parameters. In the previous submission, the charge of large commercial applications was estimated to be 100 kg, while the IPCC best estimate for medium and large applications is 50.2,000 kg. In the recalculated estimate, Greece has changed this factor to 10 kg. The recalculated emissions are on average 88 per cent</p>	<p>Greece has prepared a plan in order to move to plant-specific QA/QC on the specific category. For the time being and in order to be in line with the IPCC GPG, a value that belongs in the suggested by IPCC range has been used in the current submission. Possibly by next year updated data will be able to improve the accuracy of the estimates.</p>

Category	Review	Response by Greece
	lower between 1995 and 2006 than the emissions in the previous submission. Noting the large impact of the recalculation on the estimates and the deviation of some of the country-specific factors from the IPCC good practice guidance, the ERT recommends that Greece investigate the parameters used for calculation in this category, compare them with the values in the IPCC good practice guidance and either confirm that their use is justified or recalculate the time series, as appropriate, in the next annual submission.	
Industrial Processes	66. The emissions reported under limestone and dolomite use cover uses in iron and steel, aluminium and ceramics production. Limestone use for sulphur dioxide scrubbing and the related emissions are included in the energy sector. During the review, Greece informed the ERT that the reporting of these emissions in the industrial processes sector has already been scheduled for the next annual submission. The ERT welcomes this planned improvement and recommends that Greece investigate whether the reporting under the EU ETS, which is used as a basis for the estimates, includes all limestone used for scrubbing in Greece.	Emissions from SO ₂ scrubbing have been reallocated by the energy sector. All the limestone used has been included according to current knowledge. All the available information has been included in the respective paragraph of the NIR (paragraph 4.4)
Industrial Processes	67. The estimation of CO ₂ emissions from ferroalloys production is based on the laterite consumption. The AD and EF are confidential. The non-energy use of fuels in ferroalloys production is reported in the energy sector. It is stated in the NIR that the information on the use of fuels as reducing agents has been requested from the plants concerned and the data will be used to allocate relevant emissions to the industrial processes sector. The ERT encourages Greece to implement this improvement in the next annual submission.	Emissions have been reallocated by the energy sector. All the information on the implemented methodology used is available at the respective paragraph of the NIR (paragraph 4.10)

Category	Review	Response by Greece
Industrial Processes	<p>68. PFC emissions from aluminium production are estimated using the tier 3b methodology based on plant-specific measurements. The previous review recommended that Greece endeavour to obtain information on the functioning or otherwise of the anode effect termination system in place for the control of PFCs as a means of verifying the variations in emissions. Greece has provided information on the trend fluctuations in the NIR. The ERT commends Greece for this improvement in transparency. The data on aluminium production are confidential. According to the NIR, CO₂ emissions are estimated based on a reference CO₂ EF and aluminium production. The previous review recommended that Greece obtain plant-specific AD for the net anode carbon consumption as a reducing agent for the CO₂ emissions estimation as opposed to using the tier 1a method based on a default emission factor (tonne carbon per tonne aluminium) and aluminium production data. In response to a question raised during the review, Greece informed the ERT that these data have now been obtained from the plant concerned. The ERT encourages Greece to use the new plant-specific data to recalculate the entire time series accordingly.</p>	<p>For the time being, emissions continue to be performed in conjunction with the aluminium production and the emission factor reported in the IPCC Guidelines. In that way, although data are plant-specific, the EF used is the default and no recalculation has been performed. The possibility to collect additional information is under investigation. See also NIR, paragraph 4.11.</p>
Agriculture	<p>75. The ERT noted that the average Y_m of 4.84 per cent reported for sheep is the lowest of all reporting Parties (4.84–7 per cent). In response to a question from the ERT, Greece provided Y_m values used for sheep subcategories (5 per cent for lambs and 7 per cent for mature sheep). The ERT noted that the 4.84 per cent reported by Greece is below the 5 per cent Y_m for lambs. The ERT concluded that the resulting value is not plausible and recommends that Greece check the calculation</p>	<p>Error in crf compilation. The corrected value is 6.69% (paragraph 6.2.2 of NIR).</p>

Category	Review	Response by Greece
	and include information on the calculation of the average Ym and the resulting values in the NIR of its next annual submission.	
Agriculture	76. The ERT noted that for the nitrogen excretion (Nex) value for goats, Greece uses the IPCC default of 40 kg N/head/year for other animals in Mediterranean countries. This value for goats appears very high compared with the value of 12 kg N/head/year for the similarly sized sheep and is the highest of all reporting Parties (5.76–40 kg N/head/year), with the exception of Japan. In response to a question from the ERT during the review, Greece stated that it is working on a country-specific Nex value for goats. The ERT encourages this planned improvement.	The same Nex value with this of sheep, namely 12 kg N/head/year, was used for goats. Recalculation was performed for the whole period 1990-2007 (paragraph 6.5.1 and 6.6.5 of NIR).
V. Land use, land-use change and forestry A. Sector overview	83. In the 2009 submission Greece has provided for the first time an overview of the different landuse categories in the country and a land-use matrix for 2006/2007. Greece used several sources and assumptions, including an assumption that the area of forest land remaining forest land is the same as that estimated by the first national forest inventory (1992), as well as an assumption that only cropland that has been converted to forest land since 1994 and recorded under European Commission regulation 2080/92 and 1257/99 is considered. In response to a question from the ERT during the review, Greece stated that for the most recent estimates of land-use areas it used a country-specific data source from 1995 (.Distribution of the Country.s Area by Basic Categories of Land Use., NSSG). A more recent source from NSSG with data for 1999.2000 was not used owing to inconsistency of the area data and because these are pre-census data. The ERT welcomes Greece.s efforts	Greece, in order to improve accuracy and completeness of the reported estimates and to be compliant with the reporting needs under the KP art. 3.3 and 3.4, has developed two new databases within the Ministry of Environment, Energy and Climate Change; one concerning areas under land use change and one related to the managed forests. These data series are used for first time in the 2010 submission. Moreover, a new mapping system based on remote sensing is planned to be launched in 2010, in order to have complete and updated estimates of all land uses and land use changes, that will be used in the 2011 submission.

Category	Review	Response by Greece
	to present the patterns of land use in the country in a more transparent manner. However, it recommends that Greece try to use more up-to-date data from NSSG for future submissions.	
V. Land use, land-use change and forestry A. Sector overview	85. Greece does not report all instances of deforestation (e.g. land-use changes to settlements are not estimated) and reports that a system for recording deforestation is under preparation and would be available in 2010. Greece only has one (first national) forest inventory and is not planning to start a second one. Greece does report forest land burnt by wildfires under reforestation and started to research the impact of wildfires on the biomass. While Greece selected forest management as an Article 3, paragraph 4 activity, it now uses several tier 1 methods for estimating emissions and removals in forest land remaining forest land and does not report changes in soil carbon stock for cropland converted to forest land owing to a lack of data	The new database on land use changes aggregates annually statistical data on all instances of deforestation from the local Forest Offices. In the 2010 submission, Greece changes its method for estimating emissions and removals in forest land remaining forest land, from the Default to the 'C stock change' method, in order to be consistent with KP reporting. The new methodology use more up-to-date data, encompasses the influence of wildfire and other disturbances on C stocks and consist a tier 2 method.
V. Land use, land-use change and forestry A. Sector overview	86. Greece reported in the NIR on a project launched by the Ministry of Rural Development and Food responding to the requirement to develop a methodology for estimating emissions by sources and removals by sinks for activities under Article 3, paragraph 3, and activity elected under Article 3, paragraph 4, of the Kyoto Protocol. This project is being carried out by the National Agricultural Research Foundation under the oversight of MRDF and a progress report has already been submitted. Greece stated that the provision of information on anthropogenic GHG emissions by sources and removals by sinks of the above activities is mandatory from 2010 onwards and that this information will be included in the next annual submission. The ERT strongly recommends that the Party	The project 'Development of the National System for the estimation of GHG emissions and removals from the LULUCF sector' concluded in July 2009, describing the appropriate methods and projects to be developed for estimating emissions by sources and removals by sinks for reporting both under the Convention and the Kyoto Protocol. The Ministry of Environment, Energy and Climate Change has already implemented to a great extent the outcomes of this study in the 2010 submission and reports on emissions by sources and removals by sinks for activities

Category	Review	Response by Greece
	ensure that an annual submission of its LULUCF activities under Article 3, paragraph 3, and its elected activity under Article 3, paragraph 4, of the Kyoto Protocol is prepared and reported in accordance with paragraphs 5-9 of the annex to decision 15/CMP.1.	under Article 3, paragraph 3 and paragraph 4, of the Kyoto Protocol, in accordance with paragraphs 5-9 of the annex to decision 15/CMP.1.
V. Land use, land-use change and forestry 1. Forest land remaining forest land . CO2	87. Forest land remaining forest land makes up almost half of the total land-use area of Greece. Wildfires cause large inter-annual variations in emissions and removals - in 2007, 112,762.92 ha were affected by wildfires, about 10 times more than in 2006. The large area of fires decreased removals in 2007 to 2,451.82 Gg CO ₂ . Increased removals in forest land remaining forest land in recent years are mainly attributable to a reduction in felling. During the review, Greece explained that this reduction in felling (a 5 per cent decrease since 1990) is related to national felling regulations and to initiatives in conservation and sustainable development of existing forest land; individual trees are now felled, rather than entire sub-areas of forest. The ERT recommends that Greece include this explanation in its next annual submission.	The influence of disturbances and fellings on emissions and removals from this category is covered by the new methodology. Appropriate explanation on the driving forces behind the observed trends in emissions/removals is given in the NIR.
V. Land use, land-use change and forestry 1. Forest land remaining forest land . CO2	88. Greece uses the assumption of 35 years for regrowth of vegetation after wildfires. About 1.2 Mha of forest land are included in the calculation of carbon stocks attributable to regrowth on areas affected by wildfires. The ERT noted that in Greece, forest land burned by wildfires is claimed to be under reforestation. The ERT advises Greece to improve the documentation on the approach taken for these areas in the inventory and to note that for reporting activities under Article 3, paragraph 3, of the Kyoto Protocol, the definition of reforestation is restricted to areas that did not contain forest on	Forest areas burnt do not lose their forest use/character and are reforested either naturally (natural regeneration) or after the human intervention. This management activity (reforestation as it is called in Greek forestry terminology) should not be confused with the term Reforestation as defined under the Kyoto Protocol. However, the new methodology uses a new approach for the estimation of carbon stock

Category	Review	Response by Greece
	31 December 1989.	changes due to wildfires at the forest level, which is well described in the NIR.
V. Land use, land-use change and forestry 2. Land converted to forest land . CO2	90. Greece uses a mix of tier 1 and tier 2 approaches for estimating the changes in the carbon stocks in living biomass, as for forest land remaining forest land. The ERT reiterates the recommendation of the previous review to apply more country-specific EFs.	Greece is currently planning a project aiming at producing country-specific EFs in order to be used in the key category 'Land converted to forest land'/ key subcategory 'living biomass'.
Waste	96. Emissions were determined for all the categories except for CH ₄ from industrial sludge (owing to a lack of AD), N ₂ O from industrial wastewater and sludge (lack of a suitable method), N ₂ O from domestic and commercial sludge (also owing to the lack of a method), and CH ₄ and N ₂ O from clinical waste incineration (lack of EFs). Greece has reported on its efforts to estimate these emissions and include them in future submissions.	CH ₄ and N ₂ O emissions from clinical waste incineration were estimated (paragraph 8.4 of NIR).
Waste	102. According to the CRF table 6.A (additional information), an oxidation factor of zero was used for SWDS. That value would overestimate the emissions calculated for the managed SWDS. The value recommended for managed SWDS covered with oxidizing material is 0.1. The ERT suggests that Greece reassess the value used for the oxidation factor for managed SWDS and revise it, if necessary.	Done (paragraph 8.2.2-Other parameters- of NIR).
Waste	104. The DOC and DOC _f for sludge are both estimated at 40 per cent. Justification is not provided for the value used for DOC _f , which differs from the default. During the review Greece provided additional information on this issue, and the ERT recommends that it include this in the next NIR.	Done (paragraph 8.2.2-Other parameters- of NIR).
Waste	105. Recovery and flaring of biogas take place in the four major managed SWDS of Greece but detailed data are only available	Done (paragraph 8.2.2- Biogas flaring - of NIR).

Category	Review	Response by Greece
	for Athens. Methane recovered from landfills is also used to generate energy. From the information provided in the NIR it is not clear if all the emissions from biogas flared with energy use were reported under the energy sector. In response to a question from the ERT, Greece explained that in the 2010 submission, detailed information will be provided on the CH ₄ recovery used for energy generation. The ERT reiterates the encouragement of the previous ERT that Greece improve the calculation of CH ₄ emissions in this category by collecting data on the amount of CH ₄ recovery with and without energy use. Furthermore, the ERT recommends that Greece clearly report the allocation of emissions between the waste and energy sectors.	
Waste	107. According to the NIR the maximum methane production potential (Bo) factor used for industrial wastewater handling is similar to that used for domestic wastewater handling (0.6 kg CH ₄ /kg BOD (biochemical oxygen demand)). If no country-specific data are available, it is good practice to use the IPCC chemical oxygen demand (COD) default value for Bo (0.25 kg CH ₄ /kg COD). In response to a question raised by the ERT during the review, the Party stated that it does in fact use the default values for Bo for both industrial wastewater and domestic wastewater as recommended by the IPCC good practice guidance. The ERT suggests that Greece include clarification on this issue in the next annual submission.	Done (paragraph 8.3.2 of NIR).
Conclusions and recommendations	119. The inventory is generally in line with the Revised 1996 IPCC Guidelines, the IPCC good practice guidance and the IPCC good practice guidance for LULUCF. There are minor deviations in the allocation of emissions between the energy,	Inconsistencies in timeseries in the energy sector were rectified (paragraph 3.2.4.5 of NIR). For minor deviations in the allocation of emissions between the energy and industrial

Category	Review	Response by Greece
	industrial processes and waste sectors, inconsistent timeseries in the energy (stationary combustions), industrial processes (iron and steel production) and waste (wastewater handling) sectors, and use of methodologies not in line with the IPCC good practice guidance within the waste sector (solid waste disposal on land).	processes see previous responses. No inconsistency has been identified in the iron and steel category.

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 CO₂ per year, or 1650 kt CO₂ 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)}

To current inventory year From previous inventory year		Article 3.3 activities		Article 3.4 activities				Other ⁽⁵⁾	Total area at the beginning of the current inventory year ⁽⁶⁾
		Afforestation and Reforestation	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	33,27	NO						33,27
	Deforestation		3,09						3,09
Article 3.4 activities	Forest Management (if elected)		NO	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	0,06	0,00	NA	NA	NA	11.992,20	11.992,26
Total area at the end of the current inventory year		33,27	3,15	1.167,12	NA	NA	NA	11.992,20	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*

TABLE NIR 1. SUMMARY TABLE
Activity coverage and other information relating to activities under Article 3.3 and elected activities under Article 3.4

Activity		Change in carbon pool reported ⁽¹⁾					Greenhouse gas sources reported ⁽²⁾						
		Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil	Fertilization ⁽³⁾	Drainage of soils under forest management	Disturbance associated with land-use conversion to croplands	Liming	Biomass burning ⁽⁴⁾		
											CO ₂	CH ₄	N ₂ O
Article 3.3 activities	Afforestation and Reforestation	R	R	NR	NR	NR	NO			NO	R	R	R
	Deforestation	R	R	NR	NR	NR			NO	NO	R	R	R
	Forest Management	R	R	NR	NR	NR	NO	NO		NO	R	R	R
Article 3.4 activities	Cropland Management	NA	NA	NA	NA	NA			NA	NA	NA	NA	NA
	Grazing Land Management	NA	NA	NA	NA	NA				NA	NA	NA	NA
	Revegetation	NA	NA	NA	NA	NA				NA	NA	NA	NA

⁽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 in a carbon pool are not reported, it must be demonstrated i

⁽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 activity under Article 3.4. Indicate NA (not applicable) for eac

⁽³⁾ N₂O 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 separate fertilizer applied to Forest Land from Agriculture, it may report a

⁽⁴⁾ If CO₂ 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 component of CH₄. Parties that include CO₂ emissions from biomass burning

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 ₂ O	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 2009 (X-1) the respective software application has been used, which is included in this reporting submission (SEF_GR_2010_1_13-21-50 4-2-2010.xls).

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 ICER 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, ICERs, 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/crrepekpaaproduct/en/index.htm>

The information is provided through the Web site of UNFCCC (SEF 2009):

<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 916/2007/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 CO₂ 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.

13. Information on changes in national registry

There are no changes in the national registry system since the last year's submission.

The GR registry concluded successfully the connection with ITL through the "Go Live" process. Moreover, 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 development 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 countries' 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 omitted. 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 liberalisation (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 market 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 strengthening 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 Developing 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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- United Nations Framework Convention on Climate Change (UNFCCC), 2008, "Report of the individual review of the greenhouse gas inventories of Greece submitted in 2007 and 2008", FCCC/ARR /2008 /GRC
- United Nations Framework Convention on Climate Change (UNFCCC), 2010, "Report of the individual review of the annual submission of Greece submitted in 2009", FCCC/ARR /2009 /GRC

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. 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 in the current inventory has been performed for the total of the time series (years 1990-2008) on both level and trend analysis basis. The main key categories of year 2008 are also the key categories for the previous years. Any differences are due to the fluctuation 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 2008*

IPCC source categories	GHG	Base year (Gg CO ₂ eq)	Current year (Gg CO ₂ eq)	Level Assessment	Cumulative total of column E
Stationary Combustion Solid fuels	CO2	39,220.21	41,652.18	32.83	32.83
Stationary Combustion Liquid fuels	CO2	21,327.77	29,657.50	23.37	56.20
Road Transportation	CO2	11,742.20	19,066.55	15.03	71.23
Stationary Combustion Gaseous fuels	CO2	295.94	7,805.95	6.15	77.38
Cement Production	CO2	5,640.90	6,053.53	4.77	82.15
Enteric fermentation	CH4	2,877.43	2,909.30	2.29	84.44
Solid waste disposal on land	CH4	1,798.51	2,256.99	1.78	86.22
ODS substitutes	HFC	0.00	2,077.34	1.64	87.86
Animal Production	N2O	1,926.85	1,896.58	1.49	89.35
Navigation	CO2	1,824.81	1,885.28	1.49	90.84
Indirect N2O from nitrogen used in agr.	N2O	2,899.37	1,824.25	1.44	92.28
Coal Mining (surface)	CH4	1,095.27	1,387.02	1.09	93.37
Direct N2O from agr. soils	N2O	2,740.61	1,364.49	1.08	94.44
Civil Aviation	CO2	716.84	1,262.65	1.00	95.44
Ferroalloys	CO2	622.23	652.43	0.51	95.95
Manure management	CH4	496.76	483.41	0.38	96.33
Wastewater handling	N2O	325.05	377.89	0.30	96.63
Nitric Acid Production	N2O	1,109.04	367.42	0.29	96.92
Limestone & Dolomite Use	CO2	285.60	362.73	0.29	97.21
Stationary Combustion Liquid fuels	N2O	385.19	360.14	0.28	97.49
Lime Production	CO2	431.97	341.76	0.27	97.76
Wastewater handling	CH4	2,318.94	330.84	0.26	98.02
Manure management	N2O	301.45	290.36	0.23	98.25
Aluminium Production	CO2	231.96	254.14	0.20	98.45
Ammonia Production	CO2	0.00	244.30	0.19	98.64
Iron and Steel Production	CO2	92.70	207.49	0.16	98.81
Road Transportation	N2O	122.76	203.05	0.16	98.97
Solvent and other product use	CO2	169.71	160.68	0.13	99.09
Stationary Combustion Solid fuels	N2O	152.18	160.22	0.13	99.22
Oil, Natural Gas and Other sources	CH4	91.59	154.97	0.12	99.34
Solvent and other product use	N2O	138.63	153.45	0.12	99.46
Railways	CO2	202.69	113.39	0.09	99.55
Rice Production	CH4	69.10	105.02	0.08	99.63
Road Transportation	CH4	108.19	97.81	0.08	99.71
Aluminium Production	PFCs	257.62	74.17	0.06	99.77
Stationary Combustion Biomass	CH4	81.62	73.32	0.06	99.83
Stationary Combustion Biomass	N2O	41.71	41.26	0.03	99.86
Field burning of agr.residues	CH4	27.06	32.43	0.03	99.89
Stationary Combustion Liquid fuels	CH4	17.03	22.21	0.02	99.90
Other Mineral (Glass)	CO2	20.20	17.15	0.01	99.92
Navigation	N2O	14.35	14.97	0.01	99.93
Other transportation	CO2	0.00	14.32	0.01	99.94
Railways	N2O	24.22	13.84	0.01	99.95
Civil Aviation	N2O	7.71	13.48	0.01	99.96
Field burning of agr.residues	N2O	10.05	12.43	0.01	99.97
SF6 from electrical equipment	SF6	3.07	7.53	0.01	99.98
Stationary Combustion Solid fuels	CH4	6.87	7.39	0.01	99.98
Stationary Combustion Gaseous fuels	N2O	0.51	6.86	0.01	99.99
Oil, Natural Gas and Other sources	CO2	70.23	5.32	0.00	99.99

IPCC source categories	GHG	Base year (Gg CO ₂ eq)	Current year (Gg CO ₂ eq)	Level Assessment	Cumulative total of column E
Waste incineration	CO2	0.15	3.61	0.00	100.00
Stationary Combustion Gaseous fuels	CH4	0.10	2.92	0.00	100.00
Railways	CH4	2.38	1.36	0.00	100.00
Navigation	CH4	3.69	0.67	0.00	100.00
Iron and Steel Production	CH4	0.21	0.46	0.00	100.00
Civil Aviation	CH4	0.26	0.41	0.00	100.00
Other transportation	N2O	0.00	0.12	0.00	100.00
Oil, Natural Gas and Other sources	N2O	0.20	0.01	0.00	100.00
Other transportation	CH4	0.00	0.01	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		103,287.23	126,887.36	100.00	

Table I.2 Key categories analysis with LULUCF – Level assessment for 2008

IPCC source categories	GHG	Current year (Gg CO ₂ eq) (absolute values)	Level Assessment with LULUCF	Cumulative total
Stationary Combustion Solid fuels	CO2	41,652.18	32.01	32.01
Stationary Combustion Liquid fuels	CO2	29,657.50	22.79	54.80
Road Transportation	CO2	19,066.55	14.65	69.46
Stationary Combustion Gaseous fuels	CO2	7,805.95	6.00	75.46
Cement Production	CO2	6,053.53	4.65	80.11
Enteric fermentation	CH4	2,909.30	2.24	82.34
Solid waste disposal on land	CH4	2,256.99	1.73	84.08
ODS substitutes	HFC	2,077.34	1.60	85.67
Forest Land remaining Forest Land	CO2	2,052.47	1.58	87.25
Animal Production	N2O	1,896.58	1.46	88.71
Navigation	CO2	1,885.28	1.45	90.16
Indirect N2O from nitrogen used in agr.	N2O	1,824.25	1.40	91.56
Coal Mining (surface)	CH4	1,387.02	1.07	92.63
Direct N2O from agr. soils	N2O	1,364.49	1.05	93.67
Civil Aviation	CO2	1,262.65	0.97	94.65
Cropland remaining Cropland	CO2	801.13	0.62	95.26
Ferroalloys	CO2	652.43	652.43	0.50
Manure management	CH4	483.41	483.41	0.37
Wastewater handling	N2O	377.89	377.89	0.29
Nitric Acid Production	N2O	367.42	367.42	0.28
Limestone & Dolomite Use	CO2	362.73	362.73	0.28
Stationary Combustion Liquid fuels	N2O	360.14	360.14	0.28
Conversion to Forest Land	CO2	-350.63	350.63	0.27
Lime Production	CO2	341.76	341.76	0.26
Wastewater handling	CH4	330.84	330.84	0.25
Manure management	N2O	290.36	290.36	0.22
Aluminium Production	CO2	254.14	254.14	0.20
Ammonia Production	CO2	244.30	244.30	0.19
Iron and Steel Production	CO2	207.49	207.49	0.16
Road Transportation	N2O	203.05	203.05	0.16
Solvent and other product use	CO2	160.68	160.68	0.12
Stationary Combustion Solid fuels	N2O	160.22	160.22	0.12
Oil, Natural Gas and Other sources	CH4	154.97	154.97	0.12
Solvent and other product use	N2O	153.45	153.45	0.12
Railways	CO2	113.39	113.39	0.09
Rice Production	CH4	105.02	105.02	0.08
Road Transportation	CH4	97.81	97.81	0.08
Aluminium Production	PFCs	74.17	74.17	0.06
Stationary Combustion Biomass	CH4	73.32	73.32	0.06
Stationary Combustion Biomass	N2O	41.26	41.26	0.03
Field burning of agr.residues	CH4	32.43	32.43	0.02
Stationary Combustion Liquid fuels	CH4	22.21	22.21	0.02
Other Mineral (Glass)	CO2	17.15	17.15	0.01
Navigation	N2O	14.97	14.97	0.01
Other transportation	CO2	14.32	14.32	0.01
Railways	N2O	13.84	13.84	0.01
Civil Aviation	N2O	13.48	13.48	0.01
Field burning of agr.residues	N2O	12.43	12.43	0.01
Grassland remaining Grassland	CH4	12.09	12.09	0.01
SF6 from electrical equipment	SF6	7.53	7.53	0.01

IPCC source categories	GHG	Current year (Gg CO ₂ eq) (absolute values)	Level Assessment with LULUCF	Cumulative total
Stationary Combustion Solid fuels	CH4	7.39	7.39	0.01
Forest Land remaining Forest Land	CH4	6.94	6.94	0.01
Stationary Combustion Gaseous fuels	N2O	6.86	6.86	0.01
Conversion to Other land	CO2	5.96	5.96	0.00
Oil, Natural Gas and Other sources	CO2	5.32	5.32	0.00
Waste incineration	CO2	3.61	3.61	0.00
Stationary Combustion Gaseous fuels	CH4	2.92	2.92	0.00
Railways	CH4	1.36	1.36	0.00
Grassland remaining Grassland	N2O	1.23	1.23	0.00
Conversion to Settlements	CO2	1.05	1.05	0.00
Forest Land remaining Forest Land	N2O	0.70	0.70	0.00
Navigation	CH4	0.67	0.67	0.00
Iron and Steel Production	CH4	0.46	0.46	0.00
Civil Aviation	CH4	0.41	0.41	0.00
Other transportation	N2O	0.12	0.12	0.00
Conversion to Grassland	CO2	0.05	0.05	0.00
Oil, Natural Gas and Other sources	N2O	0.01	0.01	0.00
Conversion to Cropland	CO2	0.01	0.01	0.00
Other transportation	CH4	0.01	0.01	0.00
Other Chemicals	CH4	0.00	0.00	0.00
HFC-23 Emissions from HCFC-22 Manufacture	HFC	0.00	0.00	0.00
Conversion to Wetland	CO2	0.00	0.00	0.00
TOTAL		130,119.63	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
Stationary Combustion Solid fuels	CO ₂	39,220.21	37.97	37.97
Stationary Combustion Liquid fuels	CO ₂	21,327.77	20.65	58.62
Road Transportation	CO ₂	11,742.20	11.37	69.99
Cement Production	CO ₂	5,640.90	5.46	75.45
Indirect N ₂ O from nitrogen used in agr.	N ₂ O	2,899.37	2.81	78.26
Enteric fermentation	CH ₄	2,877.43	2.79	81.04
Direct N ₂ O from agr. soils	N ₂ O	2,740.61	2.65	83.70
Wastewater handling	CH ₄	2,318.94	2.25	85.94
Animal Production	N ₂ O	1,926.85	1.87	87.81
Navigation	CO ₂	1,824.81	1.77	89.57
Solid waste disposal on land	CH ₄	1,798.51	1.74	91.32
Nitric Acid Production	N ₂ O	1,109.04	1.07	92.39
Coal Mining (surface)	CH ₄	1,095.27	1.06	93.45
HFC-23 Emissions from HCFC-22 Manufacture	HFC	935.06	0.91	94.36
Civil Aviation	CO ₂	716.84	0.69	95.05
Ferroalloys	CO ₂	622.23	0.60	95.65
Manure management	CH ₄	496.76	0.48	96.13
Lime Production	CO ₂	431.97	0.42	96.55
Stationary Combustion Liquid fuels	N ₂ O	385.19	0.37	96.92
Wastewater handling	N ₂ O	325.05	0.31	97.24
Manure management	N ₂ O	301.45	0.29	97.53
Stationary Combustion Gaseous fuels	CO ₂	295.94	0.29	97.82
Limestone & Dolomite Use	CO ₂	285.60	0.28	98.09
Aluminium Production	PFCs	257.62	0.25	98.34
Aluminium Production	CO ₂	231.96	0.22	98.57
Railways	CO ₂	202.69	0.20	98.76
Solvent and other product use	CO ₂	169.71	0.16	98.93
Stationary Combustion Solid fuels	N ₂ O	152.18	0.15	99.08
Solvent and other product use	N ₂ O	138.63	0.13	99.21
Road Transportation	N ₂ O	122.76	0.12	99.33
Road Transportation	CH ₄	108.19	0.10	99.43
Iron and Steel Production	CO ₂	92.70	0.09	99.52
Oil, Natural Gas and Other sources	CH ₄	91.59	0.09	99.61
Stationary Combustion Biomass	CH ₄	81.62	0.08	99.69
Oil, Natural Gas and Other sources	CO ₂	70.23	0.07	99.76
Rice Production	CH ₄	69.10	0.07	99.83
Stationary Combustion Biomass	N ₂ O	41.71	0.04	99.87
Field burning of agr.residues	CH ₄	27.06	0.03	99.89
Railways	N ₂ O	24.22	0.02	99.92
Other Mineral (Glass)	CO ₂	20.20	0.02	99.94
Stationary Combustion Liquid fuels	CH ₄	17.03	0.02	99.95
Navigation	N ₂ O	14.35	0.01	99.97
Field burning of agr.residues	N ₂ O	10.05	0.01	99.98
Civil Aviation	N ₂ O	7.71	0.01	99.98
Stationary Combustion Solid fuels	CH ₄	6.87	0.01	99.99
Navigation	CH ₄	3.69	0.00	99.99
SF ₆ from electrical equipment	SF ₆	3.07	0.00	100.00
Railways	CH ₄	2.38	0.00	100.00
Other Chemicals	CH ₄	0.52	0.00	100.00

IPCC source categories	GHG	Base year (Gg CO ₂ eq)	Level Assessment (Base Year)	Cumulative total
Stationary Combustion Gaseous fuels	N2O	0.51	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
Stationary Combustion Gaseous fuels	CH4	0.10	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
Ammonia Production	CO2	0.00	0.00	100.00
ODS substitutes	HFC	0.00	0.00	100.00
TOTAL		103,287.23	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
Stationary Combustion Solid fuels	CO2	39,220.21	37.06	37.06
Stationary Combustion Liquid fuels	CO2	21,327.77	20.15	57.21
Road Transportation	CO2	11,742.20	11.09	68.30
Cement Production	CO2	5,640.90	5.33	73.63
Indirect N2O from nitrogen used in agr.	N2O	2,899.37	2.74	76.37
Enteric fermentation	CH4	2,877.43	2.72	79.09
Direct N2O from agr. soils	N2O	2,740.61	2.59	81.68
Wastewater handling	CH4	2,318.94	2.19	83.87
Animal Production	N2O	1,926.85	1.82	85.69
Navigation	CO2	1,824.81	1.72	87.42
Solid waste disposal on land	CH4	1,798.51	1.70	89.12
Forest Land remaining Forest Land	CO2	1,308.36	1.24	90.35
Cropland remaining Cropland	CO2	1,205.41	1.14	91.49
Nitric Acid Production	N2O	1,109.04	1.05	92.54
Coal Mining (surface)	CH4	1,095.27	1.03	93.57
HFC-23 Emissions from HCFC-22 Manufacture	HFC	935.06	0.88	94.46
Civil Aviation	CO2	716.84	0.68	95.13
Ferroalloys	CO2	622.23	0.59	95.72
Manure management	CH4	496.76	0.47	96.19
Lime Production	CO2	431.97	0.41	96.60
Stationary Combustion Liquid fuels	N2O	385.19	0.36	96.96
Wastewater handling	N2O	325.05	0.31	97.27
Manure management	N2O	301.45	0.28	97.56
Stationary Combustion Gaseous fuels	CO2	295.94	0.28	97.83
Limestone & Dolomite Use	CO2	285.60	0.27	98.10
Aluminium Production	PFCs	257.62	0.24	98.35
Aluminium Production	CO2	231.96	0.22	98.57
Railways	CO2	202.69	0.19	98.76
Solvent and other product use	CO2	169.71	0.16	98.92
Stationary Combustion Solid fuels	N2O	152.18	0.14	99.06
Solvent and other product use	N2O	138.63	0.13	99.19
Road Transportation	N2O	122.76	0.12	99.31
Road Transportation	CH4	108.19	0.10	99.41
Iron and Steel Production	CO2	92.70	0.09	99.50
Oil, Natural Gas and Other sources	CH4	91.59	0.09	99.59
Stationary Combustion Biomass	CH4	81.62	0.08	99.66
Oil, Natural Gas and Other sources	CO2	70.23	0.07	99.73
Rice Production	CH4	69.10	0.07	99.80
Stationary Combustion Biomass	N2O	41.71	0.04	99.83
Field burning of agr.residues	CH4	27.06	0.03	99.86
Railways	N2O	24.22	0.02	99.88
Other Mineral (Glass)	CO2	20.20	0.02	99.90
Stationary Combustion Liquid fuels	CH4	17.03	0.02	99.92
Navigation	N2O	14.35	0.01	99.93
Grassland remaining Grassland	CH4	14.03	0.01	99.94
Forest Land remaining Forest Land	CH4	10.93	0.01	99.96
Field burning of agr.residues	N2O	10.05	0.01	99.96
Civil Aviation	N2O	7.71	0.01	99.97
Stationary Combustion Solid fuels	CH4	6.87	0.01	99.98

IPCC source categories	GHG	Base year (Gg CO ₂ eq) (absolute values)	Level Assessment with LULUCF	Cumulative total
Conversion to Other land	CO2	6.77	0.01	99.98
Navigation	CH4	3.69	0.00	99.99
SF6 from electrical equipment	SF6	3.07	0.00	99.99
Railways	CH4	2.38	0.00	99.99
Conversion to Settlements	CO2	2.30	0.00	100.00
Grassland remaining Grassland	N2O	1.42	0.00	100.00
Forest Land remaining Forest Land	N2O	1.11	0.00	100.00
Other Chemicals	CH4	0.52	0.00	100.00
Stationary Combustion Gaseous fuels	N2O	0.51	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
Stationary Combustion Gaseous fuels	CH4	0.10	0.00	100.00
Conversion to Cropland	CO2	0.03	0.00	100.00
Conversion to Grassland	CO2	0.01	0.00	100.00
Conversion to Wetland	CO2	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
Ammonia Production	CO2	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		100,810.07	105,837.61	

Table I.5 *Key categories analysis without LULUCF – Trend assessment for 2008*

IPCC source categories	GHG	Base year (Gg CO ₂ eq)	Current year (Gg CO ₂ eq)	Trend Assessment	Contribution to trend (%)	Cumulative total
Stationary Combustion Gaseous fuels	CO2	295.94	7,805.95	4.77	20.66	20.66
Stationary Combustion Solid fuels	CO2	39,220.21	41,652.18	4.19	18.12	38.78
Road Transportation	CO2	11,742.20	19,066.55	2.98	12.88	51.66
Stationary Combustion Liquid fuels	CO2	21,327.77	29,657.50	2.22	9.59	61.25
Wastewater handling	CH4	2,318.94	330.84	1.62	6.99	68.24
ODS substitutes	HFC	0.00	2,077.34	1.33	5.77	74.01
Direct N2O from agr. soils	N2O	2,740.61	1,364.49	1.28	5.56	79.57
Indirect N2O from nitrogen used in agr.	N2O	2,899.37	1,824.25	1.11	4.82	84.39
Nitric Acid Production	N2O	1,109.04	367.42	0.64	2.76	87.15
Cement Production	CO2	5,640.90	6,053.53	0.56	2.43	89.58
Enteric fermentation	CH4	2,877.43	2,909.30	0.40	1.74	91.32
Animal Production	N2O	1,926.85	1,896.58	0.30	1.31	92.62
Civil Aviation	CO2	716.84	1,262.65	0.25	1.06	93.68
Navigation	CO2	1,824.81	1,885.28	0.23	0.99	94.67
Ammonia Production	CO2	0.00	244.30	0.16	0.68	95.35
Aluminium Production	PFCs	257.62	74.17	0.16	0.67	96.02
Lime Production	CO2	431.97	341.76	0.12	0.52	96.55
Railways	CO2	202.69	113.39	0.09	0.38	96.92
Manure management	CH4	496.76	483.41	0.08	0.35	97.28
Stationary Combustion Liquid fuels	N2O	385.19	360.14	0.07	0.31	97.59
Ferroalloys	CO2	622.23	652.43	0.07	0.31	97.90
Iron and Steel Production	CO2	92.70	207.49	0.06	0.26	98.16
Oil, Natural Gas and Other sources	CO2	70.23	5.32	0.05	0.22	98.39
Manure management	N2O	301.45	290.36	0.05	0.22	98.61
Road Transportation	N2O	122.76	203.05	0.03	0.15	98.75
Solvent and other product use	CO2	169.71	160.68	0.03	0.13	98.89
Solid waste disposal on land	CH4	1,798.51	2,256.99	0.03	0.13	99.02
Oil, Natural Gas and Other sources	CH4	91.59	154.97	0.03	0.12	99.14
Coal Mining (surface)	CH4	1,095.27	1,387.02	0.03	0.12	99.25
Road Transportation	CH4	108.19	97.81	0.02	0.10	99.35
Aluminium Production	CO2	231.96	254.14	0.02	0.09	99.43
Stationary Combustion Biomass	CH4	81.62	73.32	0.02	0.07	99.51
Stationary Combustion Solid fuels	N2O	152.18	160.22	0.02	0.07	99.58
Wastewater handling	N2O	325.05	377.89	0.01	0.06	99.64
Rice Production	CH4	69.10	105.02	0.01	0.06	99.70
Solvent and other product use	N2O	138.63	153.45	0.01	0.05	99.74
Railways	N2O	24.22	13.84	0.01	0.04	99.79
Other transportation	CO2	0.00	14.32	0.01	0.04	99.83
Limestone & Dolomite Use	CO2	285.60	362.73	0.01	0.03	99.86
Stationary Combustion Biomass	N2O	41.71	41.26	0.01	0.03	99.89
Other Mineral (Glass)	CO2	20.20	17.15	0.00	0.02	99.91
Stationary Combustion Gaseous fuels	N2O	0.51	6.86	0.00	0.02	99.93
Civil Aviation	N2O	7.71	13.48	0.00	0.01	99.94
Navigation	CH4	3.69	0.67	0.00	0.01	99.95
SF6 from electrical equipment	SF6	3.07	7.53	0.00	0.01	99.96
Waste incineration	CO2	0.15	3.61	0.00	0.01	99.97
Stationary Combustion Gaseous fuels	CH4	0.10	2.92	0.00	0.01	99.98
Navigation	N2O	14.35	14.97	0.00	0.01	99.98
Railways	CH4	2.38	1.36	0.00	0.00	99.99

IPCC source categories	GHG	Base year (Gg CO ₂ eq)	Current year (Gg CO ₂ eq)	Trend Assessment	Contribution to trend (%)	Cumulative total
Stationary Combustion Liquid fuels	CH ₄	17.03	22.21	0.00	0.00	99.99
Stationary Combustion Solid fuels	CH ₄	6.87	7.39	0.00	0.00	100.00
Field burning of agr.residues	CH ₄	27.06	32.43	0.00	0.00	100.00
Oil, Natural Gas and Other sources	N ₂ O	0.20	0.01	0.00	0.00	100.00
Iron and Steel Production	CH ₄	0.21	0.46	0.00	0.00	100.00
Other transportation	N ₂ O	0.00	0.12	0.00	0.00	100.00
Civil Aviation	CH ₄	0.26	0.41	0.00	0.00	100.00
Field burning of agr.residues	N ₂ O	10.05	12.43	0.00	0.00	100.00
Other transportation	CH ₄	0.00	0.01	0.00	0.00	100.00
Other Chemicals	CH ₄	0.52	0.00	0.00	0.00	100.00
HFC-23 Emissions from HCFC-22 Manufacture	HFC	935.06	0.00	0.00	0.00	100.00
TOTAL		103,287.23	126,887.36	23.11	100.00	

Table I.6 Key categories analysis with LULUCF – Trend assessment for 2008

IPCC source / sink categories	GHG	Base year (Gg CO ₂ eq)	Current year (Gg CO ₂ eq)	Trend Assessment (Absolute)	Contribution to trend (%)	Cumulative total
Stationary Combustion Gaseous fuels	CO2	295.94	7,805.95	4.90	19.86	19.86
Stationary Combustion Solid fuels	CO2	39,220.21	41,652.18	4.27	17.28	37.14
Road Transportation	CO2	11,742.20	19,066.55	3.07	12.42	49.56
Stationary Combustion Liquid fuels	CO2	21,327.77	29,657.50	2.30	9.30	58.85
Wastewater handling	CH4	2,318.94	330.84	1.66	6.71	65.56
ODS substitutes	HFC	0.00	2,077.34	1.37	5.54	71.11
Direct N2O from agr. soils	N2O	2,740.61	1,364.49	1.32	5.33	76.44
Indirect N2O from nitrogen used in agr.	N2O	2,899.37	1,824.25	1.14	4.63	81.06
Nitric Acid Production	N2O	1,109.04	367.42	0.65	2.65	83.71
Cement Production	CO2	5,640.90	6,053.53	0.57	2.32	86.03
Cropland remaining Cropland	CO2	-1,205.41	-801.13	0.45	1.81	87.84
Enteric fermentation	CH4	2,877.43	2,909.30	0.41	1.66	89.50
Animal Production	N2O	1,926.85	1,896.58	0.31	1.25	90.75
Forest Land remaining Forest Land	CO2	-1,308.36	-2,052.47	0.29	1.19	91.94
Civil Aviation	CO2	716.84	1,262.65	0.25	1.02	92.96
Navigation	CO2	1,824.81	1,885.28	0.23	0.94	93.91
Conversion to Forest Land	CO2	0.00	-350.63	0.23	0.94	94.84
Ammonia Production	CO2	0.00	244.30	0.16	0.65	95.49
Aluminium Production	PFCs	257.62	74.17	0.16	0.65	96.14
Lime Production	CO2	431.97	341.76	0.12	0.50	96.64
Railways	CO2	202.69	113.39	0.09	0.36	97.00
Manure management	CH4	496.76	483.41	0.08	0.34	97.34
Stationary Combustion Liquid fuels	N2O	385.19	360.14	0.07	0.30	97.64
Ferroalloys	CO2	622.23	652.43	0.07	0.30	97.93
Iron and Steel Production	CO2	92.70	207.49	0.06	0.25	98.18
Oil, Natural Gas and Other sources	CO2	70.23	5.32	0.05	0.22	98.40
Manure management	N2O	301.45	290.36	0.05	0.21	98.61
Road Transportation	N2O	122.76	203.05	0.03	0.14	98.75
Solid waste disposal on land	CH4	1,798.51	2,256.99	0.03	0.13	98.89
Solvent and other product use	CO2	169.71	160.68	0.03	0.13	99.01
Coal Mining (surface)	CH4	1,095.27	1,387.02	0.03	0.11	99.13
Oil, Natural Gas and Other sources	CH4	91.59	154.97	0.03	0.11	99.24
Road Transportation	CH4	108.19	97.81	0.02	0.09	99.33
Aluminium Production	CO2	231.96	254.14	0.02	0.08	99.42
Stationary Combustion Biomass	CH4	81.62	73.32	0.02	0.07	99.49
Stationary Combustion Solid fuels	N2O	152.18	160.22	0.02	0.07	99.56
Wastewater handling	N2O	325.05	377.89	0.01	0.06	99.61
Rice Production	CH4	69.10	105.02	0.01	0.05	99.67
Solvent and other product use	N2O	138.63	153.45	0.01	0.04	99.71
Railways	N2O	24.22	13.84	0.01	0.04	99.75
Other transportation	CO2	0.00	14.32	0.01	0.04	99.79
Limestone & Dolomite Use	CO2	285.60	362.73	0.01	0.03	99.83
Stationary Combustion Biomass	N2O	41.71	41.26	0.01	0.03	99.85
Other Mineral (Glass)	CO2	20.20	17.15	0.01	0.02	99.87
Forest Land remaining Forest Land	CH4	10.93	6.94	0.00	0.02	99.89
Stationary Combustion Gaseous fuels	N2O	0.51	6.86	0.00	0.02	99.91
Grassland remaining Grassland	CH4	14.03	12.09	0.00	0.01	99.92
Civil Aviation	N2O	7.71	13.48	0.00	0.01	99.93
Navigation	CH4	3.69	0.67	0.00	0.01	99.94

IPCC source / sink categories	GHG	Base year (Gg CO ₂ eq)	Current year (Gg CO ₂ eq)	Trend Assessme nt (Absolute)	Contribution to trend (%)	Cumulative total
SF6 from electrical equipment	SF6	3.07	7.53	0.00	0.01	99.95
Waste incineration	CO2	0.15	3.61	0.00	0.01	99.96
Stationary Combustion Gaseous fuels	CH4	0.10	2.92	0.00	0.01	99.97
Navigation	N2O	14.35	14.97	0.00	0.01	99.97
Conversion to Other land	CO2	6.77	5.96	0.00	0.01	99.98
Conversion to Settlements	CO2	2.30	1.05	0.00	0.00	99.99
Railways	CH4	2.38	1.36	0.00	0.00	99.99
Stationary Combustion Liquid fuels	CH4	17.03	22.21	0.00	0.00	99.99
Stationary Combustion Solid fuels	CH4	6.87	7.39	0.00	0.00	100.00
Field burning of agr.residues	CH4	27.06	32.43	0.00	0.00	100.00
Forest Land remaining Forest Land	N2O	1.11	0.70	0.00	0.00	100.00
Grassland remaining Grassland	N2O	1.42	1.23	0.00	0.00	100.00
Oil, Natural Gas and Other sources	N2O	0.20	0.01	0.00	0.00	100.00
Iron and Steel Production	CH4	0.21	0.46	0.00	0.00	100.00
Other transportation	N2O	0.00	0.12	0.00	0.00	100.00
Field burning of agr.residues	N2O	10.05	12.43	0.00	0.00	100.00
Civil Aviation	CH4	0.26	0.41	0.00	0.00	100.00
Conversion to Grassland	CO2	0.01	0.05	0.00	0.00	100.00
Conversion to Cropland	CO2	0.03	0.01	0.00	0.00	100.00
Other transportation	CH4	0.00	0.01	0.00	0.00	100.00
Other Chemicals	CH4	0.52	0.00	0.00	0.00	100.00
HFC-23 Emissions from HCFC-22 Manufacture	HFC	935.06	0.00	0.00	0.00	100.00
Conversion to Wetland	CO2	0.00	0.00	0.00	0.01	100.02
TOTAL		100,810.07	123,711.18	24.69		

The results of the key categories analysis for the year 2008 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 2008

Quantitative method used	Tier 1			
IPCC source categories	GHG	Key source category flag	If flag is yYes, Criteria for identification	Comments
ENERGY SECTOR				
Stationary Combustion Liquid fuels	CO2	Yes	Level, Trend	
Stationary Combustion Liquid fuels	CH4	No		
Stationary Combustion Liquid fuels	N2O	No		
Stationary Combustion Solid fuels	CO2	Yes	Level, Trend	
Stationary Combustion Solid fuels	CH4	No		
Stationary Combustion Solid fuels	N2O	No		
Stationary Combustion Gaseous fuels	CO2	Yes	Level, Trend	
Stationary Combustion Gaseous fuels	CH4	No		
Stationary Combustion Gaseous fuels	N2O	No		
Stationary Combustion Biomass	CH4	No		
Stationary Combustion Biomass	N2O	No		
Road Transportation	CO2	Yes		
Road Transportation	CH4	No		
Road Transportation	N2O	No		
Civil Aviation	CO2	Yes	Level, Trend	
Civil Aviation	CH4	No		
Civil Aviation	N2O	No		
Navigation	CO2	Yes	Level, Trend	
Navigation	CH4	No		
Navigation	N2O	No		
Railways	CO2	No		
Railways	CH4	No		
Railways	N2O	No		
Other transportation	CO2	No		
Other transportation	CH4	No		
Other transportation	N2O	No		
Coal Mining (surface)	CH4	Yes	Level	
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	
Lime Production	CO2	No		
Limestone & Dolomite Use	CO2	No		
Other Mineral (Glass)	CO2	No		
Other Chemicals	CH4	No		
Nitric Acid Production	N2O	Yes	Trend	
Ammonia Production	CO2	Yes	Trend	
Iron and Steel Production	CO2	No		
Iron and Steel Production	CH4	No		
Ferroalloys	CO2	No		
Aluminium Production	CO2	No		
Aluminium Production	PFCs	No		
HFC-23 Emissions from HCFC-22 Manufacture	HFC	No		
ODS substitutes	HFC	Yes	Level, Trend	
SF6 from electrical equipment	SF6	No		
Solvent and other product use	CO2	No		

Quantitative method used	Tier 1			
IPCC source categories	GHG	Key source category flag	If flag is yYes, Criteria for identification	Comments
Solvent and other product use	N2O	No		
AGRICULTURE				
Enteric fermentation	CH4	Yes	Level, Trend	
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	
Animal Production	N2O	Yes	Level, Trend	
Indirect N2O from nitrogen used in agr.	N2O	Yes	Level, Trend	
Rice Production	CH4	No		
WASTE				
Solid waste disposal on land	CH4	Yes	Level	
Wastewater handling	CH4	Yes	Trend	
Wastewater handling	N2O	No		
Waste incineration	CO2	No		
LULUCF				
Forest Land remaining Forest Land	CO2	Yes	Level, Trend	
Forest Land remaining Forest Land	CH4	No		
Forest Land remaining Forest Land	N2O	No		
Cropland remaining Cropland	CO2	Yes	Level, Trend	
Grassland remaining Grassland	CH4	No		
Grassland remaining Grassland	N2O	No		
Conversion to Forest Land	CO2	Yes	Trend	
Conversion to Cropland	CO2	No		
Conversion to Grassland	CO2	No		
Conversion to Wetland	CO2	No		
Conversion to Settlements	CO2	No		
Conversion to Other land	CO2	No		

Table I.8 **Table NIR.3 for year 2008**

Information type	Unit	2008
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 CO₂ 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 as a source of plant specific activity data and in order to calculate plant specific CO₂ emission factors per sector (IPCC source category) and fuel. We also capitalize on them to estimate CH₄ and N₂O 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
<i>of which: Feedstocks</i>	Non-energy uses	
Non-ferrous metals	1.A.2b	0301 – Industry / Combustion in boilers, gas turbines and stationary engines 030322 – Alumina production 030311 – Cement 030312 – Lime
Non-metallic minerals	1.A.2f	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 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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
Imports	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	13
Exports	0	0	14	0	0	0	0	22	6	21	21	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
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
Transfers	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
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
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
CHP plants ²¹	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
BKB plants	350	351	203	178	214	191	157	169	133	124	236	265	345	419	422	411	266	188	39
FINAL CONSUMPTION	1,172	935	500	682	510	531	641	527	464	310	464	250	156	195	199	256	376	317	336
INDUSTRY	515	432	379	552	406	408	503	418	362	235	381	172	156	195	195	224	345	313	304
Iron and steel	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
Non-ferrous metals ²²	299	318	359	445	333	342	439	359	355	233	379	170	156	195	195	224	345	313	304
Non-metallic minerals	17	20	13	22	15	4	4	2	2	2	2	2	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
OTHER SECTORS	78	125	121	130	104	123	138	109	102	75	83	78	0	0	4	32	31	4	32
Agriculture	19	25	33	40	30	40	45	30	30	48	53	50	0	0	0	20	30	0	0
Commercial and public	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
Non-specified	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

²¹ Fuel consumption in CHP plants is included in electricity plants.²² Accounted in Industrial Processes sector.

Table II.3 *Energy balance of natural gas in TJ (GCV) for the period 1990 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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
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
Stock changes	0	0	0	0	0	0	-218	-150	-238	-32	-1,224	-1,255	192	-319	1,220	141	-11	336	-697
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
Transfers	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
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
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
CHP plants ²³	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
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
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
Distribution losses	0	0	0	0	0	0	0	94	40	36	568	466	27	64	235	331	393	305	224
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
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
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
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
Feedstocks of chemical industry ²⁴	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
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
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
Transport equipment	0	0	0	0	0	0	0	9	74	62	46	81	55	66	68	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	81	91	0	27	75	87	139	140
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	213	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
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
Wood and wood products	0	0	0	0	0	0	0	0	0	0	0	0	0	1	26	35	28	41	38
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

²³ Fuel consumption in CHP plants is added to the respective industrial sectors²⁴ Not included in totals.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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
Non-specified	0	0	0	0	0	0	0	0	5	0	241	792	456	403	593	618	501	761	640
TRANSPORT	0	0	0	0	0	0	0	0	0	0	0	325	557	567	537	629	670	815	977
Road transport	0	0	0	0	0	0	0	0	0	0	0	284	449	495	493	552	582	667	660
Pipeline transport	0	0	0	0	0	0	0	0	0	0	0	41	108	72	44	77	88	148	317
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
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
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
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

Table II.4 *Energy balance of heavy fuel oil (in kt) for the period 1990 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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
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
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
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
Stock changes	-80	-223	121	196	204	81	-72	7	-41	45	-32	25	-66	-36	159	-47	16	-261	219
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
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
Statistical differences	-245	186	143	-14	-17	-178	139	60	-117	-89	-37	-72	-38	-68	-128	-62	-26	-163	-82
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
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
CHP plants ²⁵	34	49	58	67	58	58	55	39	30	24	27	19	20	9	7	6	7	5	68
ENERGY SECTOR	266	279	260	210	273	274	295	294	320	313	372	358	397	351	416	442	482	465	448
Petroleum refineries	266	279	260	210	273	274	295	294	320	313	372	358	397	351	416	442	482	465	448
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
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
Iron and steel	101	96	97	86	78	47	21	16	18	8	18	19	20	17	13	4	5	5	4
Chemical industry	92	45	43	26	24	29	106	124	159	81	87	82	82	74	110	106	123	120	99
Of which: Feedstock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-ferrous metals	185	157	161	157	144	142	162	185	151	211	214	216	227	224	235	177	198	193	166
Non-metallic minerals	159	174	188	177	165	179	178	182	94	67	89	86	86	78	132	138	157	153	130
Transport equipment	0	0	0	0	0	0	2	2	2	2	3	3	3	3	3	3	4	4	3
Machinery	0	0	0	0	0	0	13	13	13	12	15	15	15	10	7	6	7	7	6
Mining	22	21	23	21	20	50	67	52	42	42	43	43	45	3	3	3	4	4	3
Food and tobacco	241	250	255	257	240	235	249	224	236	181	208	187	188	205	164	104	125	122	102
Paper, pulp	84	81	80	71	65	59	77	85	66	66	81	66	67	64	47	42	47	46	38
Wood and wood products	0	3	2	2	2	4	3	1	2	2	2	2	2	2	2	2	3	3	3
Construction	0	27	26	22	21	50	20	17	21	18	30	30	35	30	25	28	32	31	27

²⁵ 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
Textile and leather	111	93	108	91	82	88	140	137	101	79	92	81	77	68	60	54	46	42	36
Non-specified	157	160	113	0	0	16	29	7	23	0	0	0	0	0	0	0	40	42	36
TRANSPORT	237	231	255	201	256	268	245	340	538	591	236	335	283	306	375	326	359	350	292
Internal navigation	237	231	255	201	256	268	245	340	538	591	236	335	283	306	375	326	359	350	292
OTHER SECTORS	62	79	78	55	40	21	28	28	28	28	28	34	35	36	44	47	60	59	52
Agriculture	0	20	21	15	15	10	15	15	15	15	15	18	18	19	21	23	31	30	30
Commercial and public	13	20	19	15	10	11	13	13	13	13	13	16	17	17	23	24	29	29	22
Residential	36	35	38	25	15	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
NON-ENERGY USE	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 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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
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
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
International marine bunkers	510	514	657	718	801	966	776	771	758	706	750	612	549	497	472	384	398	365	339
Stock changes	-169	162	99	-51	-32	67	-166	-133	-468	419	108	35	-251	129	-204	-271	-204	178	-180
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
Transfers	0	0	0	-25	0	-171	-554	-667	-592	-646	-208	89	36	1	141	140	-20	32	78
Statistical differences	7	-23	-47	-150	-2	-176	-177	-158	-244	-83	-98	-61	-16	-214	254	-59	-449	-453	-291
TRANSFORMATION	315	319	339	287	272	305	381	367	371	336	382	376	465	499	452	429	438	514	425
Electricity plants	314	312	338	287	272	305	381	367	371	336	382	376	465	499	448	424	427	507	415
CHP plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	5	11	7	10
ENERGY SECTOR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	26	27	26
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
INDUSTRY SECTOR	354	319	290	296	320	457	490	500	525	560	504	500	500	550	227	439	486	435	419
Iron and steel	41	20	20	26	28	18	5	11	12	20	13	13	15	17	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
<i>Of which: Feedstock</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Non-ferrous metals	0	25	24	25	27	38	28	13	21	23	23	23	20	23	1	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
Transport equipment	0	2	2	2	2	12	12	7	15	17	16	15	15	16	15	17	18	18	17
Machinery	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
Food and tobacco	33	35	33	39	42	59	45	37	49	53	51	51	50	52	22	23	23	21	20
Paper, pulp	12	11	10	14	15	8	5	10	9	10	10	10	10	14	2	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
Construction	0	1	1	1	1	1	75	94	118	126	130	130	135	140	131	140	142	127	122
Textile and leather	17	16	15	20	22	18	10	3	5	8	10	10	7	8	5	5	4	3	3
Non-specified	144	135	112	95	102	198	224	235	195	195	150	150	156	177	0	194	238	210	202

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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
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
Rail	63	49	47	48	52	43	45	42	42	40	40	40	40	40	40	40	41	37	36
Internal navigation	336	357	348	350	325	285	229	236	352	289	263	345	330	301	308	328	358	320	309
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
Agriculture	820	888	822	802	808	750	761	760	760	760	760	770	850	929	786	806	845	757	731
Commercial and public	145	167	155	150	160	165	200	192	195	195	203	270	278	300	285	365	371	332	321
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
Non-specified	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

Table II.6 *Energy balance of gasoline (in kt) for the period 1990 – 2008*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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
Imports	213	162	345	242	98	217	180	45	152	477	415	116	514	749	1,059	1,023	1,002	609	629
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
Stock changes	-45	59	-171	11	141	34	-4	-115	-69	169	-27	3	-122	53	11	1	-259	59	-32
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
Transfers	0	0	0	0	0	0	42	4	28	17	22	167	153	166	121	99	140	76	161
Statistical differences	27	-36	-65	-23	-7	141	-119	-50	-19	0	-123	-7	-5	-6	-159	2	-100	-448	-131
TRANSFORMATION	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
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
<i>INDUSTRY</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>
<i>TRANSPORT</i>	<i>2,373</i>	<i>2,447</i>	<i>2,532</i>	<i>2,594</i>	<i>2,645</i>	<i>2,724</i>	<i>2,890</i>	<i>2,985</i>	<i>3,106</i>	<i>3,165</i>	<i>3,230</i>	<i>3,336</i>	<i>3,493</i>	<i>3,650</i>	<i>3,730</i>	<i>3,888</i>	<i>3,931</i>	<i>4,108</i>	<i>4,031</i>
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
<i>OTHER SECTORS</i>	<i>50</i>	<i>52</i>	<i>50</i>	<i>50</i>	<i>50</i>	<i>50</i>	<i>50</i>	<i>50</i>	<i>50</i>	<i>50</i>	<i>50</i>	<i>49</i>	<i>50</i>	<i>35</i>	<i>33</i>	<i>30</i>	<i>28</i>	<i>29</i>	<i>28</i>
Agriculture	50	52	50	50	50	50	50	50	50	50	50	49	50	35	33	30	28	29	28
Non specified	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

Annex III: CO₂ 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:

$$\text{Apparent consumption} = \text{Primary production} + \text{Imports} - \text{Exports} - \text{International bunkers} + \text{Stock change}$$

The apparent consumption of secondary fuels is estimated by the following equation:

$$\text{Apparent consumption} = \text{Imports} - \text{Exports} - \text{International bunkers} + \text{Stock change}$$

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 CO₂.

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 CO₂ 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 CO₂ emissions.

Carbon emissions from all fuels are multiplied by 44/12 to be converted to CO₂ emissions, and are summed, giving the total amount of CO₂ 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 - 2008*

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

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 2008

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	59.00	19,286.00	1,063.00		328.00	17,954.00	41.54	NCV	745,809.16	20.00	14,916.18	NA	14,916.18	0.99	54,145.75
		Orimulsion		NA	NA	NA		NA	NA	NA	NCV	NA	NA	NA	NA	NA	NA	NA
		Natural Gas Liquids		3.00	NA	NA		NA	3.00	41.56	NCV	124.67	17.20	2.14	NA	2.14	0.99	7.78
	Secondary Fuels	Gasoline	kt		629.00	1,081.00	NA	32.00	-484.00	43.96	NCV	-21,276.64	18.90	-402.13	NA	-402.13	0.99	-1,459.73
		Jet Kerosene	kt		490.00	922.00	NA	52.00	-484.00	44.59	NCV	-21,581.56	19.46	-419.99	NA	-419.99	0.99	-1,524.56
		Other Kerosene			NA	15.00	NA	-4.00	-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		2,598.00	2,087.00	339.00	180.00	-8.00	43.00	NCV	-344.00	20.20	-6.95	NO	-6.95	0.99	-25.22
		Residual Fuel Oil	kt		2,304.00	1,301.00	2,815.00	-219.00	-1,593.00	40.19	NCV	-64,022.67	21.10	-1,350.88	NA	-1,350.88	0.99	-4,903.69
		Liquefied Petroleum Gas (LPG)	kt		46.00	284.00		-6.00	-232.00	47.31	NCV	-10,975.92	17.20	-188.79	NO	-188.79	0.99	-685.29
		Ethane			NA	NA		NA	NA	NA	NCV	NA	NA	NA	NO	NA,NO	NA	NA,NO
		Naphtha	kt		41.00	147.00		20.00	-126.00	45.01	NCV	-5,671.26	20.00	-113.43	20.02	-133.44	0.99	-484.40
		Bitumen	kt		NA	273.00		-6.00	-267.00	40.19	NCV	-10,730.73	20.00	-214.61	376.98	-591.60	0.99	-2,147.50
		Lubricants	kt		7.00	112.00	24.00	51.17	-180.17	40.19	NCV	-7,241.03	20.00	-144.82	7.64	-152.46	0.99	-553.42
		Petroleum Coke	kt		992.67	NA		113.00	879.67	32.00	NCV	28,149.33	25.77	725.27	NA	725.27	0.99	2,632.73
		Refinery Feedstocks	kt		2,170.00	NA		-146.00	2,316.00	42.50	NCV	98,430.00	20.00	1,968.60	NA	1,968.60	0.99	7,146.02
		Other Oil			NA	84.00		-1.00	-83.00	40.19	NCV	-3,335.77	20.00	-66.72	44.21	-110.92	0.99	-402.66
Other Liquid Fossil												NA		NA	NA	NA	NA	
Other non-specified				NA	NA	NA	NA	NA	NA	NCV		NA	NA	NA	NA	NA	NA	NA
Liquid Fossil Totals												726,841.32		14,694.24	448.85	14,245.40		51,710.79
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	664.00	2.00	NA	139.00	523.00	26.04	NCV	13,621.01	26.44	360.20	NA	360.20	0.98	1,294.31
		Sub-bituminous Coal		NA	NA	NA	NA	NA	NA	NA	NCV	NA	NA	NA	NA	NA	NA	NA
		Lignite	kt	65,720.00	13.00	NA		1,101.00	64,632.00	5.18	NCV	334,729.13	33.95	11,364.64	NA	11,364.64	0.98	40,836.95
		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	BKE ⁽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			1.00	NA	NA	1.00	30.23	NCV	30.23	29.50	0.89	NA	0.89	0.98	3.20
Other Solid Fossil												NA		NA	NA	NA	NA	
Other non-specified				NA	NA	NA	NA	NA	NA	NCV		NA	NA	NA	NA	NA	NA	NA
Solid Fossil Totals												348,394.57		11,726.10	NA,NO	11,726.10		42,135.79
Gaseous Fossil		Natural Gas (Dry)	TJ	612.90	146,809.80	NA		4,981.96	142,440.74	1.00	NCV	142,440.74	15.04	2,142.68	8.16	2,134.52	1.00	7,826.58
Other Gaseous Fossil												NA		NA	NA	NA		NA
Other non-specified				NA	NA	NA	NA	NA	NA	NCV		NA	NA	NA	NA	NA	NA	NA
Gaseous Fossil Totals												142,440.74		2,142.68	8.16	2,134.52		7,826.58
Total												1,217,676.63		28,563.02	457.01	28,106.02		101,673.15
Biomass total												40,061.03		1,156.47	NA	1,156.47		4,198.00
		Solid Biomass		36,545.00	67.00	NA		NA	36,612.00	1.00	NCV	36,612.00	29.90	1,094.70	NA	1,094.70	0.99	3,973.76
		Liquid Biomass		1,826.12	181.91	NA		NA	2,008.03	1.00	NCV	2,008.03	20.00	40.16	NA	40.16	0.99	145.78
		Gas Biomass		1,441.00	NA	NA		NA	1,441.00	1.00	NCV	1,441.00	15.00	21.62	NA	21.62	0.99	78.46

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 CO₂, CH₄, N₂O and F-gases emissions. As mentioned in Chapter 1.7, in previous submissions 1995 was used as base year for F-gases emissions. However, following the recommendation made by the Expert Review Team (ERT) in the current analysis 1990 was used as base year for all gases.

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.
- ☞ In this submission for the first time the 100% of emissions were used for the uncertainty analysis. This improvement was performed after a recommendation made by the Expert Review Team (ERT) during the centralized review in September 2009.
- ☞ 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	Gas	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%.
Road transport	CO ₂	Default IPCC uncertainty is 5%.	Uncertainty of emissions of CO ₂ 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 CO ₂ 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 assessment.
Ferroalloys	CO ₂	Plant specific data (IPCC GPG)	The exact carbon content of all sources is reported. CS

IPCC Source category	Gas	Reasoning for activity data uncertainty	Reasoning for emission factor uncertainty
			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 fermentation	CH ₄	Uncertainty given by NSSG for the livestock population data	According to Good Practice Guidance. Page 4.27
Manure	CH ₄	Uncertainty given by NSSG for the livestock	Country specific data taking into account that there is a wide

IPCC Source category	Gas	Reasoning for activity data uncertainty	Reasoning for emission factor uncertainty
management		population data	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	According to Good Practice Guidance for poor quality data	Estimated value according to Good Practice Guidance Page 5.12. Table 5.2
Unmanaged solid waste disposal	CH ₄	According to Good Practice Guidance for poor quality data	Estimated value according to Good Practice Guidance . Page 5.12. Table 5.2
Municipal Sludge Disposal on Land	CH ₄	According to Good Practice Guidance for poor quality data	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 ₂ O	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 ₂ O	Default IPCC uncertainty is 5%.	IPCC default.
Navigation	N ₂ O	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default.
Civil Aviation	N ₂ O	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default.
Railway	N ₂ O	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default
Other transportation	N ₂ O	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC default.
Nitric Acid	N ₂ O	Plant specific data (IPCC GPG)	N ₂ O may be generated as by product and the Nox abatement may or may not reduce N ₂ O (IPCC GPG).
Manure management	N ₂ O	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
Agricultural	N ₂ O	Uncertainty given by NSSG for the crop production	Country specific data.

IPCC Source category	Gas	Reasoning for activity data uncertainty	Reasoning for emission factor uncertainty
soils - direct emissions		data	
Agricultural soils - indirect emissions	N ₂ O	Uncertainty given by NSSG for the fertilizers consumption data	According to Good Practice Guidance. Page 4.75
Animal Production	N ₂ O	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 ₂ O	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 ₂ O	According to Good Practice Guidance . Page 5.19 Table 5.3 and Page 5.23 Table 5.5	Country specific
Waste incineration	N ₂ O	According to Good Practice Guidance. Page 5.30	According to Good Practice Guidance. Page 5.30
Forest Land remaining Forest Land	N ₂ O	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 ₂ O	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."
SF ₆ from electrical equipment	SF ₆	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	%	%	%	%	%	%	%	%	%
1A 1,2,4	Stationary Combustion - solid fuels	CO ₂	39220.21	41652.18	5	5	7.1	2.3	-0.0630	0.4033	-0.31	2.85	2.87
1A 1,2,4	Stationary Combustion - liquid fuels	CO ₂	21327.77	29657.50	5	5	7.1	1.7	0.0334	0.2871	0.17	2.03	2.04
1A 1,2,4	Stationary Combustion - gaseous fuels	CO ₂	295.94	7805.95	5	5	7.1	0.4	0.0721	0.0756	0.36	0.53	0.64
1A3	Road transport	CO ₂	11742.20	19066.55	5	5	7.1	1.1	0.0449	0.1846	0.22	1.31	1.32
1A3	Navigation	CO ₂	1824.81	1885.28	5	5	7.1	0.1	-0.0035	0.0183	-0.02	0.13	0.13
1A3	Civil Aviation	CO ₂	716.84	1262.65	5	5	7.1	0.1	0.0037	0.0122	0.02	0.09	0.09
1A3	Railway	CO ₂	202.69	113.39	5	5	7.1	0.0	-0.0013	0.0011	-0.01	0.01	0.01
1A3	Other transportation	CO ₂	0.00	14.32	5	5	7.1	0.0	0.0001	0.0001	0.00	0.00	0.00
1B	Oil and Natural gas	CO ₂	70.23	5.32	5	300	300.0	0.0	-0.0008	0.0001	-0.24	0.00	0.24
2A1	Cement Production	CO ₂	5640.90	6053.53	2	2	2.8	0.1	-0.0085	0.0586	-0.02	0.17	0.17
2A2	Lime Production	CO ₂	431.97	341.76	5	6	7.8	0.0	-0.0018	0.0033	-0.01	0.02	0.03
2A3	Limestone & Dolomite Use	CO ₂	285.60	362.73	10	5	11.2	0.0	0.0001	0.0035	0.00	0.05	0.05
1A7	Other Mineral (Glass)	CO ₂	20.20	17.15	5	3	5.8	0.0	-0.0001	0.0002	0.00	0.00	0.00
2B1	Ammonia Production	CO ₂	0.00	244.30	3	6	6.7	0.0	0.0024	0.0024	0.01	0.01	0.02
2C1	Iron and Steel Production	CO ₂	92.70	207.49	5	5	7.1	0.0	0.0009	0.0020	0.00	0.01	0.01
2C2	Ferroalloys	CO ₂	622.23	652.43	7	7	9.9	0.1	-0.0011	0.0063	-0.01	0.06	0.06
2C3	Aluminium Production	CO ₂	231.96	254.14	3	5	5.8	0.0	-0.0003	0.0025	0.00	0.01	0.01
3	Solvent and other product use	CO ₂	169.71	160.68	5	300	300.0	0.4	-0.0005	0.0016	-0.14	0.01	0.14
6C	Waste incineration	CO ₂	0.15	3.61	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
		Total CO ₂	82896.10	109760.98									

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	105.83	5	100	100.1	0.1	-0.0002	0.0010	-0.02	0.01	0.02
1A3	Road transport	CH ₄	108.19	97.81	4	40	40.2	0.0	-0.0003	0.0009	-0.01	0.01	0.01
1A3	Navigation	CH ₄	3.69	0.67	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1A3	Civil Aviation	CH ₄	0.26	0.41	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1A3	Railway	CH ₄	2.38	1.36	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1A3	Other transportation	CH ₄	0.00	0.01	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	154.97	5	300	300.0	0.4	0.0004	0.0015	0.12	0.01	0.12
1B	Coal Mining	CH ₄	1095.27	1387.02	2	300	300.0	3.3	0.0004	0.0134	0.12	0.04	0.13
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	0.46	5	4	6.4	0.0	0.0000	0.0000	0.00	0.00	0.00
4A	Enteric fermentation	CH ₄	2877.43	2909.30	5	30	30.4	0.7	-0.0061	0.0282	-0.18	0.20	0.27
4B	Manure management	CH ₄	496.76	483.41	5	50	50.2	0.2	-0.0012	0.0047	-0.06	0.03	0.07
4C	Rice cultivation	CH ₄	69.10	105.02	2	40	40.0	0.0	0.0002	0.0010	0.01	0.00	0.01
4F	Field burning of agr. residues	CH ₄	27.06	32.43	20	20	28.3	0.0	0.0000	0.0003	0.00	0.01	0.01
6A1	Managed solid waste disposal	CH ₄	74.90	625.28	12	40	41.8	0.2	0.0052	0.0061	0.21	0.10	0.23
6A2	Unmanaged solid waste disposal	CH ₄	1720.02	1576.77	12	72	73.0	0.9	-0.0052	0.0153	-0.37	0.26	0.45
6A3	Municipal Sludge Disposal on Land	CH ₄	3.59	54.94	12	40	41.8	0.0	0.0005	0.0005	0.02	0.01	0.02
6B	Wastewater handling	CH ₄	2318.94	330.84	30	100	104.4	0.3	-0.0244	0.0032	-2.44	0.14	2.44
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			8995.52	7866.53									

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	N ₂ O	579.58	568.48	5	300	300.0	1.3	-0.0014	0.0055	-0.42	0.04	0.42
1A3	Road transport	N ₂ O	122.76	203.05	5	50	50.2	0.1	0.0005	0.0020	0.03	0.01	0.03
1A3	Navigation	N ₂ O	14.35	14.97	5	300	300.0	0.0	0.0000	0.0001	-0.01	0.00	0.01
1A3	Civil Aviation	N ₂ O	7.71	13.48	5	300	300.0	0.0	0.0000	0.0001	0.01	0.00	0.01
1A3	Railway	N ₂ O	24.22	13.84	5	300	300.0	0.0	-0.0002	0.0001	-0.05	0.00	0.05
1A3	Other transportation	N ₂ O	0.00	0.12	5	300	300.0	0.0	0.0000	0.0000	0.00	0.00	0.00
1B	Oil and Natural gas	N ₂ O	0.20	0.01	5	300	300.0	0.0	0.0000	0.0000	0.00	0.00	0.00
2B	Nitric Acid	N ₂ O	1109.04	367.42	2	20	20.1	0.1	-0.0096	0.0036	-0.19	0.01	0.19
3	Solvent and other product use	N ₂ O	138.63	153.45	5	300	300.0	0.4	-0.0002	0.0015	-0.05	0.01	0.05
4B	Manure management	N ₂ O	301.45	290.36	50	100	111.8	0.3	-0.0008	0.0028	-0.08	0.20	0.21
4D	Agricultural soils - direct emissions	N ₂ O	2740.61	1364.49	20	400	400.5	4.3	-0.0194	0.0132	-7.75	0.37	7.76
4D	Agricultural soils - indirect emissions	N ₂ O	2899.37	1824.25	20	50	53.9	0.8	-0.0168	0.0177	-0.84	0.50	0.98
4D	Animal Production	N ₂ O	1926.85	1896.58	50	100	111.8	1.7	-0.0046	0.0184	-0.46	1.30	1.38
4F	Field burning of agr. residues	N ₂ O	10.05	12.43	20	20	28.3	0.0	0.0000	0.0001	0.00	0.00	0.00
6B	Wastewater handling	N ₂ O	325.05	377.89	5	10	11.2	0.0	-0.0002	0.0037	0.00	0.03	0.03
6C	Waste incineration	N ₂ O	0.01	0.13	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
		Total N ₂ O	10199.86	7100.96									
2E	HFC-23 Emissions from HCFC-22 Manufacture	HFC	935.06	0.00	50	50	70.7	0.0	-0.0111	0.0000	-0.56	0.00	0.56
2F	Substitutes for ODS	HFC	0.00	2077.34	150	200	250.0	4.1	0.0201	0.0201	4.02	4.27	5.86
		Total HFC	935.06	2077.34									
2C	PFC from Aluminium	PFC	257.62	74.17	3	6	6.7	0.0	-0.0023	0.0007	-0.01	0.00	0.01
2F	SF ₆ from electrical equipment	SF ₆	3.07	7.53	100	50	111.8	0.0	0.0000	0.0001	0.00	0.01	0.01
TOTAL			103287.23	126887.50				7.918					10.911

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	%	%	%	%	%	%	%	%	%
1A 1,2,4	Stationary Combustion - solid fuels	CO ₂	39220.21	41652.18	5	5	7.1	2.4	-0.0640	0.4132	-0.32	2.92	2.94
1A 1,2,4	Stationary Combustion - liquid fuels	CO ₂	21327.77	29657.50	5	5	7.1	1.7	0.0345	0.2942	0.17	2.08	2.09
1A 1,2,4	Stationary Combustion - gaseous fuels	CO ₂	295.94	7805.95	5	5	7.1	0.4	0.0738	0.0774	0.37	0.55	0.66
1A3	Road transport	CO ₂	11742.20	19066.55	5	5	7.1	1.1	0.0461	0.1891	0.23	1.34	1.36
1A3	Navigation	CO ₂	1824.81	1885.28	5	5	7.1	0.1	-0.0035	0.0187	-0.02	0.13	0.13
1A3	Civil Aviation	CO ₂	716.84	1262.65	5	5	7.1	0.1	0.0038	0.0125	0.02	0.09	0.09
1A3	Railway	CO ₂	202.69	113.39	5	5	7.1	0.0	-0.0013	0.0011	-0.01	0.01	0.01
1A3	Other transportation	CO ₂	0.00	14.32	5	5	7.1	0.0	0.0001	0.0001	0.00	0.00	0.00
1B	Oil and Natural gas	CO ₂	70.23	5.32	5	300	300.0	0.0	-0.0008	0.0001	-0.24	0.00	0.24
2A1	Cement Production	CO ₂	5640.90	6053.53	2	2	2.8	0.1	-0.0086	0.0600	-0.02	0.17	0.17
2A2	Lime Production	CO ₂	431.97	341.76	5	6	7.8	0.0	-0.0019	0.0034	-0.01	0.02	0.03
2A3	Limestone & Dolomite Use	CO ₂	285.60	362.73	10	5	11.2	0.0	0.0001	0.0036	0.00	0.05	0.05
1A7	Other Mineral (Glass)	CO ₂	20.20	17.15	5	3	5.8	0.0	-0.0001	0.0002	0.00	0.00	0.00
2B1	Ammonia Production	CO ₂	0.00	244.30	3	6	6.7	0.0	0.0024	0.0024	0.01	0.01	0.02
2C1	Iron and Steel Production	CO ₂	92.70	207.49	5	5	7.1	0.0	0.0009	0.0021	0.00	0.01	0.02
2C2	Ferroalloys	CO ₂	622.23	652.43	7	7	9.9	0.1	-0.0011	0.0065	-0.01	0.06	0.06
2C3	Aluminium Production	CO ₂	231.96	254.14	3	5	5.8	0.0	-0.0003	0.0025	0.00	0.01	0.01
3	Solvent and other product use	CO ₂	169.71	160.68	5	300	300.0	0.4	-0.0005	0.0016	-0.14	0.01	0.14
5.A.1	Forest Land remaining Forest Land	CO ₂	-1308.36	-2052.47	5	34	34.0	-0.6	-0.0044	-0.0204	-0.15	-0.14	0.21
5.A.2	Conversion to Forest Land	CO ₂	0.00	-350.63	5	113	112.8	-0.3	-0.0035	-0.0035	-0.39	-0.02	0.39
5.B.1	Cropland remaining Cropland	CO ₂	-1205.41	-801.13	12	53	54.0	-0.3	0.0067	-0.0079	0.35	-0.14	0.38
5.B.2	Conversion to Cropland	CO ₂	0.03	0.01	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	0.05	10	50	51.0	0.0	0.0000	0.0000	0.00	0.00	0.00

A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO ₂ eq	Gg CO ₂ eq	%	%	%	%	%	%	%	%	%
5.E.2	Conversion to Settlements	CO ₂	2.30	1.05	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	5.96	10	50	51.0	0.0	0.0000	0.0001	0.00	0.00	0.00
6C	Waste incineration	CO ₂	0.15	3.61	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
		Total CO ₂	80391.44	106563.83									
1A 1,2,4	Stationary Combustion - all fuels	CH ₄	105.62	105.83	5	100	100.1	0.1	-0.0002	0.0010	-0.02	0.01	0.02
1A3	Road transport	CH ₄	108.19	97.81	4	40	40.2	0.0	-0.0003	0.0010	-0.01	0.01	0.01
1A3	Navigation	CH ₄	3.69	0.67	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1A3	Civil Aviation	CH ₄	0.26	0.41	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1A3	Railway	CH ₄	2.38	1.36	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
1A3	Other transportation	CH ₄	0.00	0.01	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	154.97	5	300	300.0	0.4	0.0004	0.0015	0.13	0.01	0.13
1B	Coal Mining	CH ₄	1095.27	1387.02	2	300	300.0	3.4	0.0004	0.0138	0.13	0.04	0.13
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	0.46	5	4	6.4	0.0	0.0000	0.0000	0.00	0.00	0.00
4A	Enteric fermentation	CH ₄	2877.43	2909.30	5	30	30.4	0.7	-0.0062	0.0289	-0.18	0.20	0.28
4B	Manure management	CH ₄	496.76	483.41	5	50	50.2	0.2	-0.0013	0.0048	-0.06	0.03	0.07
4C	Rice cultivation	CH ₄	69.10	105.02	2	40	40.0	0.0	0.0002	0.0010	0.01	0.00	0.01
4F	Field burning of agr. residues	CH ₄	27.06	32.43	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	6.94	11	70	70.9	0.0	-0.0001	0.0001	0.00	0.00	0.00
5.C.1	Grassland remaining Grassland	CH ₄	14.03	12.09	10	70	70.7	0.0	-0.0001	0.0001	0.00	0.00	0.00
6A1	Managed solid waste disposal	CH ₄	74.90	625.28	12	40	41.8	0.2	0.0053	0.0062	0.21	0.11	0.24
6A2	Unmanaged solid waste disposal	CH ₄	1720.02	1576.77	12	72	73.0	0.9	-0.0053	0.0156	-0.38	0.27	0.46
6A3	Municipal Sludge Disposal on Land	CH ₄	3.59	54.94	12	40	41.8	0.0	0.0005	0.0005	0.02	0.01	0.02
6B	Wastewater handling	CH ₄	2318.94	330.84	30	100	104.4	0.3	-0.0249	0.0033	-2.49	0.14	2.50

A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO ₂ eq	Gg CO ₂ eq	%	%	%	%	%	%	%	%	%
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	9020.48	7885.56									
1A 1,2,4	Stationary Combustion - all fuels	N ₂ O	579.58	568.48	5	300	300.0	1.4	-0.0014	0.0056	-0.42	0.04	0.43
1A3	Road transport	N ₂ O	122.76	203.05	5	50	50.2	0.1	0.0005	0.0020	0.03	0.01	0.03
1A3	Navigation	N ₂ O	14.35	14.97	5	300	300.0	0.0	0.0000	0.0001	-0.01	0.00	0.01
1A3	Civil Aviation	N ₂ O	7.71	13.48	5	300	300.0	0.0	0.0000	0.0001	0.01	0.00	0.01
1A3	Railway	N ₂ O	24.22	13.84	5	300	300.0	0.0	-0.0002	0.0001	-0.05	0.00	0.05
1A3	Other transportation	N ₂ O	0.00	0.12	5	300	300.0	0.0	0.0000	0.0000	0.00	0.00	0.00
1B	Oil and Natural gas	N ₂ O	0.20	0.01	5	300	300.0	0.0	0.0000	0.0000	0.00	0.00	0.00
2B	Nitric Acid	N ₂ O	1109.04	367.42	2	20	20.1	0.1	-0.0099	0.0036	-0.20	0.01	0.20
3	Solvent and other product use	N ₂ O	138.63	153.45	5	300	300.0	0.4	-0.0002	0.0015	-0.05	0.01	0.05
4B	Manure management	N ₂ O	301.45	290.36	50	100	111.8	0.3	-0.0008	0.0029	-0.08	0.20	0.22
4D	Agricultural soils - direct emissions	N ₂ O	2740.61	1364.49	20	400	400.5	4.4	-0.0198	0.0135	-7.93	0.38	7.94
4D	Agricultural soils - indirect emissions	N ₂ O	2899.37	1824.25	20	50	53.9	0.8	-0.0172	0.0181	-0.86	0.51	1.00
4D	Animal Production	N ₂ O	1926.85	1896.58	50	100	111.8	1.7	-0.0046	0.0188	-0.46	1.33	1.41
4F	Field burning of agr. residues	N ₂ O	10.05	12.43	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 ₂ O	1.11	0.70	11	70	70.9	0.0	0.0000	0.0000	0.00	0.00	0.00
5.C.1	Grassland remaining Grassland	N ₂ O	1.42	1.23	10	70	70.7	0.0	0.0000	0.0000	0.00	0.00	0.00
6B	Wastewater handling	N ₂ O	325.05	377.89	5	10	11.2	0.0	-0.0002	0.0037	0.00	0.03	0.03
6C	Waste incineration	N ₂ O	0.01	0.13	5	100	100.1	0.0	0.0000	0.0000	0.00	0.00	0.00
		Total N ₂ O	10202.40	7102.89									
2E	HFC-23 Emissions from HCFC-22 Manufacture	HFC	935.06	0.00	50	50	70.7	0.0	-0.0111	0.0000	-0.56	0.00	0.56
2F	Substitutes for ODS	HFC	0.00	2077.34	150	200	250.0	4.1	0.0201	0.0201	4.02	4.27	5.86

A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO ₂ eq	Gg CO ₂ eq	%	%	%	%	%	%	%	%	%
		Total HFC	935.06	2077.34									
2C	PFC from Aluminium	PFC	257.62	74.17	3	6	6.7	0.0	-0.0023	0.0007	-0.01	0.00	0.01
2F	SF6 from electrical equipment	SF6	3.07	7.53	100	50	111.8	0.0	0.0000	0.0001	0.00	0.01	0.01
TOTAL			100810.07	123711.32			8.154						11.183

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 SO₂

Nitrogen oxides

Emissions of nitrogen oxides in 2008 increased by 20.76% compared to 1990 levels, with an average annual rate of increase estimated at 1.15% for the period 1990 - 2008. Emissions of NO_x derive by 99.19% from the energy sector and especially from transport, which is responsible for the 40.37% of total NO_x emissions. In **Table V.1** NO_x emissions by source category for the period 1990 – 2008 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 2008 decreased by 46.06% approximately compared to 1990 levels, with an average annual rate of decrease estimated at 2.56% for the period 1990 – 2008. CO emissions derive by 90.84% from the energy sector and especially from transport, which is responsible for the 67.63% of total CO emissions. In **Table V.2** CO emissions by source category for the period 1990 – 2008 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 27.21% in 2008 compared to 1990, with an average annual rate of decrease estimated at 1.51%. NMVOC emissions derive by 50% from the energy sector and especially from transport, which is responsible for the 23.81% of total NMVOC emissions. In **Table V.3** NMVOC emissions by source category for the period 1990 – 2008 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 2008 decreased by 5.09% compared to 1990 levels, with an average annual rate of decrease estimated at 0.28% for the period 1990 - 2008. SO₂ emissions derive by 98.36% from the energy sector and mainly from the energy industries, which are responsible for the 74.06% of total SO₂ emissions. In **Table V.4** SO₂ emissions by source category for the period 1990 – 2008 are presented.

- ✎ The calculation of SO₂ 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 SO₂ 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 – 2008*

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
TOTAL	295.8	312.7	322.3	319.5	327.3	314.5	319.4	329.0	352.0	343.8	335.6	350.6	350.4	361.2	359.4	394.8	369.7	378.0	357.2
Energy	292.5	309.3	318.7	316.2	324.0	311.4	316.4	325.8	348.7	341.1	331.8	347.8	347.7	358.6	356.6	392.0	367.0	373.6	354.3
Fuel combustion	292.1	308.9	318.3	315.7	323.6	310.9	315.9	325.4	348.3	340.6	331.3	347.4	347.2	358.1	356.2	391.5	366.4	372.9	353.6
<i>Energy industries</i>	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
<i>Industry</i>	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
<i>Transport</i>	148.9	158.3	162.3	163.0	165.4	163.1	161.3	165.3	184.8	180.0	157.5	162.4	155.6	156.0	153.7	165.6	149.8	150.4	144.2
<i>Other sectors</i>	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
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
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	1.2
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	0.4
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	0.4
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
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
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
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
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
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

Table V.2 *CO emissions (in kt) by source category, for the period 1990 – 2008*

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
TOTAL	1284.8	1303.5	1326.3	1325.8	1323.3	1321.5	1351.7	1346.6	1358.7	1309.0	1324.4	1262.5	1229.9	1192.1	1153.8	933.4	838.6	792.4	693.1
Energy	1224.5	1236.1	1253.2	1260.0	1256.8	1265.0	1297.1	1286.6	1282.7	1255.5	1234.8	1204.0	1177.1	1140.4	1096.8	877.9	783.6	675.3	629.6
Fuel combustion	1224.3	1235.9	1253.0	1259.7	1256.5	1264.7	1296.9	1286.4	1282.5	1255.3	1234.6	1203.8	1176.8	1140.1	1096.6	877.6	783.3	674.9	629.2
<i>Energy industries</i>	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
<i>Industry</i>	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
<i>Transport</i>	913.2	921.6	941.3	948.4	943.4	953.9	984.8	970.1	964.5	938.6	912.2	881.5	854.8	838.3	797.6	712.1	616.9	499.8	468.7
<i>Other sectors</i>	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
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
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
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
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
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
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
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
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
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
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
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

Table V.3 *NMVOC emissions (in kt) by source category. for the period 1990 – 2008*

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
TOTAL	300.5	311.8	320.6	325.7	334.5	336.0	341.6	343.1	351.4	350.0	351.2	346.2	342.5	334.4	327.9	274.2	211.6	205.9	218.7
Energy	216.8	224.7	233.5	238.8	248.6	246.6	252.3	253.0	256.3	251.7	248.3	244.1	238.2	236.9	224.8	186.7	113.8	114.3	109.4
Fuel combustion	194.6	203.1	210.7	216.8	225.2	221.3	226.5	226.5	228.9	225.2	219.7	215.8	209.0	206.9	195.9	154.9	80.6	79.5	75.7
<i>Energy industries</i>	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
<i>Industry</i>	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
<i>Transport</i>	160.3	168.1	176.5	182.9	191.1	187.5	192.2	191.8	194.5	190.8	184.3	180.4	173.5	172.4	162.3	131.8	56.9	55.5	52.1
<i>Other sectors</i>	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
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
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	55.2
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
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
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
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
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
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
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
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
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
	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

Table V.4 *SO₂ emissions (in kt) by source category. for the period 1990 – 2008*

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
TOTAL	471.6	512.8	528.9	524.6	516.3	539.2	529.1	522.5	530.0	548.4	499.5	504.5	515.7	554.1	548.3	529.5	535.7	540.5	447.6
Energy	462.0	503.7	520.6	516.8	508.3	530.4	520.5	513.6	520.9	539.0	491.0	496.1	507.2	545.5	539.6	519.4	528.0	532.7	440.2
Fuel combustion	455.5	496.3	512.3	507.4	501.5	523.5	514.7	507.1	512.5	530.6	482.0	488.4	498.1	536.0	532.2	511.1	517.2	520.2	427.8
<i>Energy industries</i>	299.3	340.9	361.6	373.2	381.9	407.3	386.7	379.5	378.5	405.3	370.6	372.2	383.5	421.7	414.2	414.4	402.0	406.4	365.9
<i>Industry</i>	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
<i>Transport</i>	33.2	33.4	34.8	31.1	36.2	30.5	29.1	30.6	45.3	48.7	23.9	28.3	24.7	26.3	31.2	29.2	31.9	29.0	24.8
<i>Other sectors</i>	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
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
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
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
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
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
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
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
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
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

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.1 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.1 *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.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.2.1 Forest Land converted to Wetlands	Lack of AD
Carbon	5 LULUCF	5.D.2.2 Cropland converted to Wetlands	Lack of AD
Carbon	5 LULUCF	5.D.2.4 Settlements converted to Wetlands	Lack of AD
Carbon	5 LULUCF	5.D.2.5 Other Land converted to Wetlands	Lack of AD
Carbon	5 LULUCF	5.E.2.2 Cropland converted to Settlements	Lack of AD
Carbon	5 LULUCF	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	Some lands have may been converted to Other Lands, but activity data are not adequate to estimate GHG emissions/removals
CH4	1 Energy	1.B.2.D Geothermal	Lack of background information and methodological approach
CH4	4 Agriculture	4.A 4.A Enteric Fermentation	There has not been an appropriate Emission Factor estimated
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

Sources and sinks not estimated (NE)			
GHG	Sector	Source/sink category	Explanation
			source.
CH4	5 LULUCF	5.D.2 5.D.2 Land converted to Wetlands	Lack of activity data
CH4	6 Waste	6.B.1 6.B.1 Industrial Wastewater	Lack of activity data
CH4	6 Waste	6.B.1 6.B.1 Industrial Wastewater	Lack of activity data
CH4	6 Waste	6.B.1 6.B.1 Industrial Wastewater	Lack of activity data
CH4	6 Waste	6.B.2.1 6.B.2.1 Domestic and Commercial (w/o human sewage)	Lack of background data
CH4	6 Waste	6.B.2.1 6.B.2.1 Domestic and Commercial (w/o human sewage)	Lack of background data
CH4	6 Waste	6.C.2 Other non-specified	There are not sufficient data which would allow estimates for this source.
CO2	1 Energy	1.B.2.D Geothermal	Lack of background information and methodological 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
CO2	6 Waste	6.C.2 Other non-specified	There are not sufficient data which would allow estimates for this source.
HFCs	2 Industrial Processes	2.F.1 Refrigeration and Air Conditioning Equipment	Lack of AD for potential emisisions.
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 emisisions.
HFCs	2 Industrial Processes	2.F.4 Aerosols/ Metered Dose Inhalers	Lack of AD for potential emisisions.
HFCs	2 Industrial Processes	2.F.5 Solvents	Lack of AD for potential emissions.
N2O	1 Energy	1.B.2.D Geothermal	Lack of background information and methodological approach
N2O	5 LULUCF	5.D.2 5.D.2 Land converted to Wetlands	Lack of activity data
N2O	6 Waste	6.B.1 6.B.1 Industrial Wastewater	Lack of methodological approach
N2O	6 Waste	6.B.1 6.B.1 Industrial Wastewater	Lack of activity data
N2O	6 Waste	6.B.2.1 6.B.2.1 Domestic and Commercial (w/o human sewage)	Lack of methodological approach
N2O	6 Waste	6.C.2 Other non-specified	There are not sufficient data which would allow estimates for this source.
PFCs	2 Industrial Processes	2.F.3 Fire Extinguishers	Lack of AD for potential emisisions.
PFCs	2 Industrial Processes	2.F.5 Solvents	Lack of AD for potential emissions.

Sources and sinks not estimated (NE)			
GHG	Sector	Source/sink category	Explanation
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.P3.1 In bulk	Lack of AD for potential emissions.
SF6	2 Industrial Processes	2.F.P3.2 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		Gains in carbon in living biomass after the establishment of tree crops are included in Cropland remaining Cropland	There are not activity data on new tree crops disaggregated by the previous land use
Carbon	5.A.1 Forest Land remaining Forest Land		Included in Gains	It is not possible to separate carbon Losses from carbon 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		
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.
CO2	1.B.2.A.4 Refining / Storage		Included in fuel combustion sector.	

Sources and sinks reported elsewhere (IE)				
GHG	Source/sink category	Allocation as per IPCC Guidelines	Allocation used by the Party	Explanation
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.
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.

