NATIONAL GREENHOUSE GAS INVENTORY REPORT 1990-2014

Annual Report for submission under the "United Nations Framework Convention on Climate Change"

TURKISH STATISTICAL INSTITUTE

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EXECUTIVE SUMMARY

ES.1 Background Information on Greenhouse Gas Inventories

Turkey, as an Annex I party to the United Nations Framework Convention on Climate Change (UNFCCC), reports annually on greenhouse gas (GHG) inventories. This National Inventory Report (NIR) contains national GHG emission/removal estimates for the period of 1990-2014.

Pursuant to Decision 24/CP.5, all Parties listed in Annex I of the UNFCCC are required to prepare and submit annual NIR containing detail and complete information on the entire process of preparation of such GHG inventories. The purpose of such reports is to ensure the transparency, consistency and comparability of inventories and support the independent review process.

Together with the inventory tables, Turkey submits a NIR, which refers to the period covered by the inventory tables and describes the methods and data sources on which the pertinent calculations are based. The report, and the report tables in the Common Reporting Format (CRF), has been prepared pursuant to the UNFCCC guidelines on annual inventories (24/CP.19) and in conformance with the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National GHG Inventories (IPCC Guidelines, 2006).

The annual GHG inventory provides information on the trends in national GHG emissions and removals since 1990. This information is essential for the planning and monitoring of climate policies.

The Turkish Statistical Institute (TurkStat) is the responsible agency for compiling the National GHG Inventory. Turkey's GHG emissions inventory is prepared by "GHG Emissions Inventory Working Group" which is set up by the decision of the Coordination Board on Climate Change (CBCC). TurkStat is the responsible organization for the coordination of working group (WG). Moreover, TurkStat has been designated as the focal point of National Emission Inventory by the decision taken by CBCC in 2009.

The Official Statistics Programme (OSP), based on the Statistics Law of Turkey No. 5429, has been prepared for a 5-year-period in order to determine the basic principles and standards dealing with the production and dissemination of official statistics and to produce reliable, timely, transparent and impartial data required at national and international level. The responsibility for compiling the National

GHG Inventory has also been given to TurkStat by the OSP. The inventory preparation is a joint work of GHG emission inventory WG.

The main institutions involved in GHG inventory are;

- Turkish Statistical Institute (TurkStat), (Environment, Energy and Transport Statistics Department)
- Ministry of Energy and Natural Resources (MENR). (General Directorate of Energy Affairs)
- Ministry of Transport, Maritime Affairs and Communications (MTMAC), (General Directorate of Foreign Affairs and European Union)
- Ministry of Environment and Urbanization (MoEU), (General Directorate of Environmental Management)
- Ministry of Forestry and Water Affairs (MFWA), (General Directorate of Forest)
- Ministry of Food, Agriculture and Livestock (MFAL), (General Directorate of Agriculture Reform)

The National GHG Emissions/Removals are calculated by using IPCC 2006 Guidelines. The Emission Inventory includes direct GHGs as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), florinated gases (F gases) - Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs),Sulphur hexafluoride (SF_6) - and GHG precursors as nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO), and GHG precursor Sulphur dioxide (SO_2) emissions originated from energy, industrial processes and product use (IPPU), agricultural activities, and waste. The emissions and removals from land use, land use change and forestry (LULUCF) are also included in the inventory.

ES.2 Summary of the National Emission and Removal Related Trends

Turkey's total GHG emissions, excluding the LULUCF sector, were estimated to be 467.6 Mt of CO_2 equivalent (CO_2 eq.) in 2014. This represents an increase of 28.7 Mt, or 6.5%, in emissions compared to 2013, and an increase of 125% above 1990 levels (Table ES 1).

Table ES 1 Greenhouse gas emissions (Excluding LULUCF), 1990-2014

	1990	1995	2000	2005	2010	2012	2013	2014
Total (Mt CO_2 eq.)	207.8	239.0	296.8	345.2	395.3	447.5	438.8	467.6
Change compared to 1990 (%)	-	15.0	42.9	66.2	90.2	115.4	111.2	125.0

Turkey's total GHG emissions, including the LULUCF sector, were 407.7 Mt CO_2 eq. in 2014. Thus, LULUCF included total emissions increased 7.2% as compared to 2013 emissions. There is a 129.6% increase from 1990 to 2014 (Table ES 2).

Table ES 2 Overview of GHG emissions and removals, 1990-2014

(Mt CO_2 eq.)

GHG emissions	1990	1995	2000	2005	2010	2012	2013	2014
CO_2 emissions including LULUCF	116.5	148.6	196.3	235.4	273.2	312.6	296.5	322.3
CO_2 emissions excluding LULUCF	146.8	178.8	232.5	279.1	320.4	363.1	355.0	382.2
CH_4	43.8	43.9	44.8	44.6	51.4	58.0	56.2	57.1
N_2O	16.5	15.8	18.4	19.0	19.6	21.1	23.2	23.3
HFCs	NO	NO	0.1	1.1	3.1	4.3	4.5	4.9
PFCs	0.7	0.6	0.6	0.6	NE	NE	NE	NE
SF_6	NE	NE	0.3	0.8	0.8	0.9	NE	NE
Total (including LULUCF)	177.5	208.9	260.6	301.5	348.1	396.9	380.4	407.7
Total (excluding LULUCF)	207.8	239.0	296.8	345.2	395.3	447.5	438.8	467.6

Total GHG emissions as CO_2 eq. for the year 2014 were 467.6 Mt (excluding LULUCF). In overall 2014 emissions, the energy sector had the largest portion with 72.5%. The energy sector was followed by the sectors of IPPU with 13.4%, the agriculture with 10.6% and the waste with 3.5%. GHG emissions by sectors are given in Table ES 3.

Table ES 3 Greenhouse gas emissions by sectors, 1990-2014

(Mt CO_2 eq.)

Year	Energy	Industrial processes	Agriculture	Waste	Total (Excluding LULUCF)
1990	132.5	23.1	41.2	10.9	207.8
1991	136.6	24.4	41.9	11.2	214.1
1992	142.6	24.7	42.1	11.4	220.8
1993	150.5	25.5	43.0	11.7	230.6
1994	147.0	25.5	40.3	11.9	224.7
1995	160.1	27.0	39.8	12.2	239.0
1996	175.2	28.0	40.8	12.6	256.7
1997	188.1	29.6	39.1	13.1	269.9
1998	187.7	29.8	40.8	13.4	271.8
1999	187.4	28.7	41.3	13.9	271.4
2000	214.4	28.4	39.6	14.4	296.8
2001	198.3	28.6	37.0	14.9	278.8
2002	206.0	30.0	35.7	15.4	287.1
2003	219.1	31.6	37.1	15.8	303.7
2004	229.2	34.3	37.0	16.4	316.9
2005	252.7	37.8	37.9	16.9	345.2
2006	275.2	39.8	38.9	17.4	371.3
2007	306.1	41.1	38.5	17.7	403.4
2008	295.3	43.5	36.5	17.8	393.1
2009	280.9	45.8	38.0	17.9	382.5
2010	286.0	51.8	39.3	18.1	395.3
2011	298.2	58.2	41.1	18.4	415.9
2012	321.3	62.4	45.8	18.0	447.5
2013	310.0	63.2	49.3	16.2	438.8
2014	339.1	62.8	49.5	16.1	467.6

As shown in Table ES 3, emissions from energy increased by 9.4% to 339.1 Mt CO_2 eq. in 2014 as compared to 2013. However, there is 156% increase as compared to 1990. Emissions in the IPPU sector decreased to 62.8 Mt CO_2 eq. in 2014 which is 0.6% lower than the emissions in 2013. Emissions in the agriculture and waste sectors were 49.5 and 16.1 Mt CO_2 eq. respectively in 2014.

ES.3 Overview of Emission Estimates and Trends

The highest portion of total CO_2 emissions originated from energy sector with 85.2%. The remaining 14.6% originated from IPPU and 0.2% from agriculture in 2014. CO_2 emissions from energy increased 9.4% compared to 2013 while increased 161.2% as compared to 1990. CO_2 emissions from industrial processes decreased 1% compared to 2013 and increased 158% as compared to 1990.

The largest portion of CH_4 emissions originated from agriculture activities with 54.3% while 25% from waste, and 20.7% from energy and industrial processes. CH_4 emissions from agriculture increased 0.9% compared to 2013. It increased 12.6% as compared to 1990. CH_4 emissions from waste decreased 1.1% compared to 2013. However, it increased 48.6% as compared to 1990 depending on increase in the amount of managed waste.

While 75.9% of N_2O emission was from agricultural activities, 8.3% was from energy, 8% was from waste and 7.8% was from IPPU. There is a 0.3% increase and 41% increase in total N_2O emissions as compared to 2013 and 1990 respectively. GHG emissions by sectors are given in Table ES 4.

Table ES 4 GHG emissions, 1990-2014

(kt)

GHG sources	1990	1995	2000	2005	2010	2012	2013	2014
CO_2 Emissions								
Total	146 750.6	178 812.4	232 549.2	279 130.7	320 356.7	363 126.0	354 961.0	382 213.4
Energy	124 596.7	152 710.2	205 191.9	244 078.9	273 530.4	308 133.2	297 607.8	325 470.7
Industrial processes	21 691.2	25 673.6	26 737.5	34 434.8	46 178.5	54 350.8	56 544.8	55 954.9
Agriculture	459.9	425.9	617.5	613.2	645.0	639.8	807.3	787.7
Waste	2.8	2.7	2.3	3.9	2.9	2.2	1.2	0.1
CH_4 Emissions								
Total	1 752.8	1 755.3	1 792.9	1 783.6	2 056.6	2 321.1	2 247.1	2 285.5
Energy	263.9	234.2	304.5	280.2	438.2	457.9	422.8	467.9
Industrial processes	1.8	1.9	1.9	3.6	2.5	43.8	16.5	5.2
Agriculture	1 103.2	1 088.5	973.7	892.0	962.1	1 174.0	1 231.4	1 242.1
Waste	383.9	430.8	512.7	607.8	653.7	645.4	576.4	570.3
N_2O Emissions								
Total	55.4	52.9	61.8	63.7	65.8	70.9	77.9	78.1
Energy	4.3	5.0	5.2	5.3	5.2	5.8	6.2	6.5
Industrial processes	2.3	2.3	2.0	2.4	5.5	6.0	6.0	6.1
Agriculture	44.2	40.7	49.3	50.4	49.1	53.0	59.5	59.3
Waste	4.5	4.9	5.3	5.6	6.0	6.1	6.2	6.2

ES.4 Indirect GHG Emissions

Emissions of CO, NO_x and NMVOC are also included in the report because they influence climate change indirectly. Table ES 5 shows the indirect GHG emissions. CO emissions are 2.5 Mt in 2014 with more than 99% of them from energy sector. NO_x emissions are 1.1 Mt in 2014 and more than 99% of which is from energy. NMVOC emissions are about 1 Mt in 2014. The largest portion of NMVOC emissions is from industrial process and product uses with 36.7% and this figure is followed by energy with 32.5%. SO_2 emissions are 2.1 Mt and 99.8% is sourced from energy sector in 2014.

Table ES 5 Indirect GHG emissions, 1990-2014

(kt)

Indirect GHG sources	1990	1995	2000	2005	2010	2012	2013	2014
CO Emissions								
Total	**2 023.0**	**2 008.0**	**1 995.7**	**1 896.3**	**2 544.7**	**3 302.4**	**2 539.6**	**2 465.6**
Energy	1 998.0	1 976.6	1 967.2	1 878.5	2 529.5	3 289.9	2 525.8	2 460.2
Industrial processes	8.6	8.8	8.5	8.1	7.7	6.7	10.7	5.2
Waste	16.4	22.6	20.0	9.7	7.5	5.9	3.0	0.2
NO_x Emissions								
Total	**562.0**	**700.0**	**836.1**	**874.2**	**937.4**	**1 081.7**	**1 037.9**	**1 051.4**
Energy	560.1	689.2	827.4	870.0	933.2	1 077.4	1 033.9	1047.5
Industrial processes	0.95	9.53	7.62	3.60	3.70	3.93	3.87	3.89
Waste	0.93	1.29	1.14	0.55	0.43	0.33	0.17	0.01
NMVOC Emissions								
Total	**834.3**	**907.9**	**953.0**	**917.7**	**974.8**	**1032.4**	**986.7**	**955.7**
Energy	347.8	374.6	380.0	343.6	393.4	403.8	327.5	310.9
Industrial processes	250.9	275.5	315.9	318.0	331.1	340.9	345.6	350.9
Agriculture	230.7	226.2	218.7	217.5	211.3	247.7	271.8	250.4
Waste	4.9	31.7	38.4	38.6	39.1	40.0	41.8	43.5
SO_2 Emissions								
Total	**1 747.2**	**1 886.4**	**2 329.6**	**2 103.6**	**2 557.8**	**2 713.0**	**1 940.2**	**2 144.5**
Energy	1 746.3	1 885.6	2 328.7	2 102.8	2 557.0	2 712.2	1 939.3	2 143.8
Industrial processes	0.8	0.8	0.8	0.7	0.7	0.8	1.0	0.7
Waste	0.03234	0.04455	0.03938	0.01920	0.01474	0.01155	0.00600	0.00044

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SYMBOL AND ABBREVIATIONS

AD	Activity data
AFOLU	Agriculture, Forestry and Other Land Use
AIS	Automatic Identification System
ALPA	Anatolian Lime Producers Association
BCEF	Biomass conversion and expansion factor
BEF	Biomass expansion factor
BOD	Biochemical oxygen demand
BOF	Basic oxygen furnace
BOTAŞ	Petroleum Pipeline Company
BWD	Basic wood density
C	Carbon
C_2F_6	Hexafluoroethane
$CaCO_3$	Calcium carbonate
CAGR	Compound annual growth rate
$CaMg(CO_3)_2$	Dolomite
CaO	Calcium oxide
CBCC	Coordination Board on Climate Change
CBCCAM	Coordination Board on Air Management and Climate Change
CF	Carbon fraction
CF_4	Carbon tetrafluoride
CFCs	Chlorofluorocarbons
CH_4	Methane
CKD	Cement kiln dust
CL-SL	Cropland converted to settlements
cm	Centimeter
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2 eq.	Carbon dioxide equivalent

COD	Chemical oxygen demand
CORINAIR	Core Inventory of Air Emissions in Europe
CORINE	Coordinate Information on the Environment
CRF	Common Reporting Format
CS	Country specific
CSC	Carbon stock change
D	Default
DG	Directorate of General
dm	Dry matter content
DOC	Degradable organic carbon
DOCF	Fraction of degradable organic carbon
EAF	Electric arc furnace
ECRAN	Environment and Climate Regional Accession Network
EF	Emission factor
EHCIP	Environmental Heavy Cost Investment Planning
EMEP	European Monitoring and Evaluation Programme
EMRA	Energy Market Regulatory Authority
ENVANIS	Inventory Statistical System for Forests
ERT	Expert Review Team
EU	European Union
F	Fraction of methane
FAO	Food and Agriculture Organization of the United Nations
FCF	Fossil carbon content
F gases	Florinated gases
FOD	First Order Decay
g	gram
GDF	General Directoriate of Forestry
GDP	Gross Domestic Product
GHG	Greenhouse gas
GIS	Geographical Information System
GJ	Gigajoule
GL-SL	Grasslands converted to settlement
GW	Gigawatt

GWh	Gigawatt hour
ha	Hectare
HAC	High activity clay
HFCs	Hydrofluorocarbons
HWP	Harvested wood product
ICP	International Cooperative Programme
IE	Included elsewhere
IEA	International Energy Agency
IEF	Implied emission factor
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial processes and product use
IW	Industrial Waste
k	Methane generation rate constant
kha	Kilo hecrate
km	kilometer
kt	Kilo tonnes
ktoe	Kilo tonnes of oil equivalent
kW	Kilowatt
kWh	Kilowatt hour
L	Litter
LPG	Liquefied petroleum gas
LTO	Landing and take-off
LULUCF	Land Use, Land Use Change and Forestry
MCF	Methane correction factor
MCT	Ministry of Customs and Trade
ME	Main engine
MENR	Ministry of Energy and Natural Resources
MFAL	Ministry of Food, Agriculture and Livestock
MFWA	Ministry of Forestry and Water Affairs
$MgCO_3$	Magnesium carbonate
MgO	Magnesium oxide
MJ	Megajoule
MMS	Manure management systems

MoEF	Ministry of Environment and Forestry
MoEU	Ministry of Environment and Urbanization
MRV	Monitoring, Reporting, Verification
MSm^3	Million standard cubic meter
MSW	Municipal solid waste
Mt	Million tonnes
MTMAC	Ministry of Transport, Maritime Affairs and Communications
MW	Megawatt
N	Nitrogen
N_2O	Nitrous oxide
NA	Not applicable
Na_2CO_3	Sodium carbonate
NaCl	Sodium cloride
NCV	Net calorific value
NE	Not estimated
NES	EU Integrated Environmental Adaptation Strategy
NH_3	Ammonia
NIR	National Inventory Report
NMVOC	Non-methane volatile organic compounds
NO	Not occured
NO_x	Nitrogen oxides
ODS	Ozone-depleting substances
ODU	Oxidised During Use
OHF	Open hearth furnace
OSP	Official Statistics Programme
OX	Oxidation factor
PFCs	Perfluorocarbons
PRODCOM	Industrial Production Statistics Survey
QA/QC	Quality assurance and quality control
R	Root-to-shoot ratio
S	Soil
SEM	Ship Emission Model
SF_6	Sulphur hexafluoride

SFOC	Specific Fuel Oil Consumption
SO_2	Sulphur dioxide
SO_x	Sulphur oxide
SWDS	Solid waste disposal sites
t	Tonnes
T	Degrees of treatment utilization
T1	Tier 1
T2	Tier 2
T3	Tier 3
TACCC	Transparency, accuracy, comparability, consistency, and completeness
TADPK	Tobacco and Alcohol Market Regulatory Authority
TCMA	Turkish Cement Manufacture Association
TEİAŞ	Turkish Electricity Transmission Company
TJ	Terajoule
TLA	Turkish Lime Association
TOBB	The Union of Chambers and Commodity Exchanges of Turkey
TOR	Terms of Reference
TOW	Total organics in wastewater
TPES	Total Primary Energy Supply
TRGM	General Directorate of Agricultural Reform
TUBITAK	Scientific and Technical Research Council of Turkey
TurkStat	Turkish Statistical Institute
TÜPRAŞ	Turkish Petroleum Refineries Co.
TWh	Terawatt hour
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
Vol	Volume
WF	Waste fractions
WG	Working group
yr	year

1. INTRODUCTION

1.1. Background Information on GHG Inventories

The UNFCCC and The Kyoto Protocol were ratified by The Republic of Turkey in 2004 and 2009 respectively. As an Annex I party to Convention, Turkey is required to develop annual inventories on emissions and removals of GHG not controlled by the Montreal Protocol using the IPCC Guidelines. Inventory covers all emissions and removals sources described in IPCC Guidelines. Until 2014, the national GHG inventory was prepared in accordance with the methodologies in Revised 1996 IPCC Guidelines, the 2000 and the 2003 IPCC Good Practice Guidance. Since 2015, emissions and removals have been estimatned and reported in line with the 2006 IPCC Guidelines for National GHG Inventories.

2006 IPCC Guidelines were provided for the following sectors:

- Energy
- Industrial Processes and Product Use
- Agriculture
- Land Use, Land Use Change and Forestry
- Waste

The Emission Inventory includes direct GHGs as CO_2, CH_4, N_2O, HFCs, SF_6, PFCs, and indirect gases as NO_x, NMVOC and CO, and SO_2 emissions originated from energy, IPPU, agricultural activities, and waste. The emissions and removals from LULUCF are also included in the inventory.

The National GHG Inventory consists of the NIR and the CRF tables in accordance with the UNFCCC reporting guidelines (24/CP.19).

In this report, the national GHG emissions from 1990 to 2014, emission sources, emission factors (EFs), difference between reference and sectoral approach, emission trends, fluctuations, changes, uncertainty estimations and key source categories were evaluated in detail.

1.2. Institutional Arrangements

1.2.1. Institutional, legal and procedural arrangements

The national GHG inventory is prepared under the auspices of the "GHG Emissions Inventory Working Group" which was established in 2001 by the former CBCC (renamed as "Coordination Board on Air Management and Climate Change" (CBCCAM) in 2013).

Under the Coordination Board there are the following seven WG:

- GHG Mitigation WG
- Climate Change Adverse Effects and Adaptation WG
- National GHG Inventory WG
- Finance WG
- Technology Development and Transfer WG
- Education, Capacity Building WG
- Air Management WG

TurkStat is responsible for the coordination of National GHG Inventory WG and, in accordance with national legislation, has the responsibility for the compilation of the national GHG inventory through the OSP. The OSP is based on the Statistics Law of Turkey No. 5429 and was prepared in 2007 for a 5-year-period in order to identify the basic principles and standards dealing with the production and dissemination of official statistics and to produce reliable, timely, transparent and impartial data required at national and international level.

The national inventory arrangements are designed and operated to ensure the TACCC and timeliness of the national GHG inventories. The quality requirements are fulfilled by implementing consistently inventory quality management procedures.

The main institutions involved in the preparation of the GHG inventory are shown in Table 1.1.

Table 1.1 Institutions and organizations responsible for NIR according to sectors

Sector	CRF category	Collection of activity data	Selection of methods and EFs	Calculations
Energy	Energy – 1 (Excluding 1.A.1.a- Electricity and heat generation and 1.A.3-Transport)	MENR TurkStat	TurkStat	TurkStat
	Electricity and heat generation - 1.A.1.a	MENR	MENR	MENR
	Transport	MENR MTMAC	MTMAC	MTMAC
Industrial Processes and Other Product Uses	Industrial activities - 2 (except F gases)	TurkStat	TurkStat	TurkStat
	F gases	MoEU	MoEU	MoEU
Agriculture	Agriculture – 3	TurkStat	TurkStat	TurkStat
Land Use, Land Use Change and Forestry	LULUCF – 4	MFWA, MFAL	MFWA, MFAL	MFWA, MFAL
Waste	Waste – 5	TurkStat	TurkStat	TurkStat

1.2.2. Overview of inventory planning, preparation and management

The inventory planning system of Turkey is conducted in line with QA/QC (Quality assurance and quality control) plan. Planning stage is under the responsibility of GHG Inventory WG. Planning activities include data collection and processing, selection of EF estimation methodology, compilation of CRF and NIR, review process and response generation, documentation and archiving, verification through time series consistency and cross checks, reporting and publication process.

Every year in the autumn, about October, WG meeting is organized to agree on a work plan and calendar for the following submission.

Information required for the inventory are mostly covered by OSP. OSP based on the Statistics Law of Turkey No. 5429, has been prepared for a 5-year-period in order to determine the basic principles and standards dealing with the production and dissemination of official statistics and to produce reliable, timely, transparent and impartial data required at national and international level. The responsibility for compiling the National GHG Inventory has also been given to TurkStat by OSP.

Distribution of work for data gathering, processing and estimation of emissions are as follows: The emissions from energy sector are calculated by TurkStat using the energy balance tables of MENR. Also TurkStat compiles fuel consumption data from refineries and coke plants. Moreover, it compiles waste incineration data from all waste incinerator. The emissions from electricity generation are calculated on the basis of data gathered from every single unit of power plants' fuel consumption by the MENR. Country specific (CS) CO_2 EFs of natural gas, Turkey lignite, hard coal, fuel oil and diesel oil are estimated through analysis and chromatography reports, and also slag and ash analyses.

The emissions from the transportation sector are calculated by the MTMAC. Emissions and removals from land use, land-use change and forestry are provided by the MFAL and the MFWA. Emissions from F gases are estimated by the MoEU. Emissions from fuel combustion (except for public electricity and heat production, and transport), the fugitive emissions, emissions from IPPU, agricultural activities, waste are calculated by TurkStat.

Every sector expert that performs the emission estimation has access to CRF Reporter software in order to enter data, and writes the related section or sub-section of NIR. TurkStat compiles and make key source and uncertainty analysis and finally overviews national emission inventory, and submit it to the UNFCCC Secretariat.

1.2.3. Quality assurance, quality control and verification

QA/QC and verification procedures are an integral and indispensable part of the national GHG inventory of Turkey. These procedures constitute a robust QA/QC plan with the objective of ensuring the quality of the reported information and the continuous improvement of the inventory.

The data used in the preparation of the national GHG inventory for the agriculture, waste, and industrial processes sections are derived from agricultural statistics, industrial production statistics, and waste statistics databases of TurkStat. TurkStat is producing all its statistics according to the European Code of Practice Principles in statistics. Therefore high quality data are used in the inventory.

The national GHG emissions in the energy sector are estimated by using fuel consumption data derived from energy balance tables by the MENR. These data are compared with International Energy Agency (IEA) data. Inconsistencies between two data sets are identified and the reasons for these inconsistencies are investigated.

Turkey's QA/QC plan was prepared by the GHG emission inventory WG in 2013 under the coordination of TurkStat. The QA/QC plan is at the stage of approval by the CBCCAM. The main objective of the

QA/QC plan is to ensure that the national GHG inventory is prepared in accordance with the basic principles of transparency, accuracy, comparability, consistency, and completeness – in short TACCC.

As TurkStat is the coordinating institution for the whole national GHG inventory, the parts of Inventory – NIR and CFR, the QA/QC manager approves the inventory after the required QA/QC checks are applied.

Specific QA/QC activities include checking the following:

- Assumptions and criteria employed for selection of activity data (AD) and for other calculation parameters
- Data entry errors
- Calculations for emissions and removals
- Selection of parameters, units and conversion factors
- Completeness of database folders
- Consistency of data and parameters used in emission and removal calculations
- Consistency of time series.

Quality Control

Quality control procedures for all categories are applied by sectoral experts in line with the TACCC principles (see Table 1.2). Sectoral experts responsible for each category of the national GHG inventory perform general and sector specific quality checks and fill quality control checklists, which are forwarded to TurkStat for final quality control assessment.

Table 1.2 Quality control procedures for each principle of the national GHG inventory

Principle	Quality control procedures
Transparency	• Check that AD are documented according to the references • Check that references stated in calculation tables are also present in inventory document • Check that changes in data or methodology are documented along with their reasons • Check that all calculations are included in archive • Check whether units, parameters, and conversion factors are presented appropriately • Check for any unexplained or unusual trends for AD or other calculation parameters in time series • Check value of implied emission/removal factors across time series and investigate unexplained outliers • Check for any unexplained or unusual trends for AD or other calculation parameters in time series
Accuracy	• Check with independent calculations or calculations made with alternative methods • Check with reference calculations • Compare with different references • Check the applicability of data • Compare aggregated data with national data • Check a sample of AD for data entry errors • Review spreadsheets with computerized checks and/or quality check reports • Check that assumptions and criteria for selection of AD, EFs and other estimation parameters are in line with IPCC Guidance • Check that information in calculation tables and inventory document is acceptable. • Check if units are properly labeled and correctly carried through from beginning to end of calculation • Check that conversion factors are correct • Check that temporal and spatial adjustment factors are used correctly • Check the data relationships (comparability) and data processing steps (e.g., equations) in calculation tables • Check a representative sample of calculations, by hand or electronically • Check the aggregation of emission results within a category
Completeness	• Check completeness • Check inventory files for completeness • Check completeness of calculation tables and inventory (i.e., include all relevant information)
Comparability	• Check the suitability of EFs to national conditions and similar emission data • Check by comparing with alternative factors (factor assumptions of IPCC, factors of other countries, literature) • Search for more representative data options • Check for consistency with IPCC inventory guidelines and good practices, particularly if changes occur
Consistency	• Check historical data for emission comparisons, sources and significant sub sources • Check trends • Check methodology for filling in time series for data that are not available annually • Check inconsistencies for different sites • When methods or data have changed, check consistency of time series inputs and calculations

Quality Assurance

Domestic QA activities are conducted by European Union (EU) Project or other local project. In this scope; in 2014; external experts were invited to investigate Turkish GHG Inventory for all categories before in-country review. Latest project related with inventory is EU funded Project Technical Assistance For Support To Mechanisms for Monitoring Turkey's GHG Emissions aims to strengthen existing capacities in Turkey and assist the Country to:

- Fully implement a monitoring mechanism of GHG emissions in Turkey, in line with the EU Monitoring Mechanism Regulation 525/2013 repealing Decision 280/2004/EC, and
- Better fulfill its reporting requirements to the UNFCCC, including national GHG inventories, National Communications and Biennial Reports.

With this project, many workshops and meetings were organized on inventory sectors to review and detect weakness of the inventory to improve.

In addition to domestic QA procedures, teams of experts (commonly referred to as expert review teams – ERTs) review annually the Turkish national GHG inventory (under the auspices of the UNFCCC) and provide recommendations that are used to improve the national GHG inventory. The first in-country review took place in 2008; while the most recent one was in 2014. The recommendations of these reviews are published in reports on the UNFCCC website (*http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/9477.php*).

In-country review held in 2014 in Turkey. Most of the findings and recommendations of ERT considered and necessary improvements made in 2013 inventory. However, 2013 inventory was the first year of the use 2006 IPCC guidelines and the new CRF Reporter GHG inventory software Web Application. Implementing software and new guidelines for the first time inevitably caused some problems. Therefore before starting the 2014 inventory preparation, the inventory team re-examine the 2013 inventory and try to determine the conditions that were not meet the TACCC criteria. Based on the outcomes of the examination some AD revisions, reallocation of emissions or error corrections were made in 2014 inventory (see Table 10.1).

Verification

Verification activities typically include comparing inventory estimates with independent estimates to either confirm the reasonableness of the inventory estimates or identify major discrepancies. In current situation, in Turkey, there is no other emission calculation to compare whole inventory or sub-sectors. After the verification process of the monitoring, reporting, verification (MRV) system which will be implemented in 2017, most of the categories of the inventory will be compared with private sectors emissions reporting.

Documentation and Archiving

Regarding, documentation and archiving, all sectoral experts archive all inputs used in the inventory process, outputs, selected EFs, work files, e-mails and official letters on their computer, on a network server with restricted access or on an external drive as softcopy or as hardcopy. Archiving is done according to Regulation on State Archive Services (*http://mevzuat.meb.gov.tr/html/19816_0.html*). Sectoral experts are responsible for archiving in institutions/organizations.

Central archiving is carried out by TurkStat. EFs, AD, calculation tables, CRF and NIR outputs, etc. regarding the emission inventory are stored on TurkStat main server. Sectoral experts transfer EFs, AD and calculation tables used in emission calculations to TurkStat within 6 weeks following the date of submission of the Annual Inventory to UNFCCC Secretariat.

1.3. Brief Description of the Process of Inventory Preparation

Main steps in the annual inventory preparation process are summarized below.

Table 1.3 Time schedule for preparation of the "t-2" annual inventory submission

	Activity	Start date	Deadline
1.	Inventory planning by GHG Inventor WG (Creating Inventory Improvement Plan, recalculation, etc.)	01.05.XX-1	30.09.XX-1
2	Reviewing emission calculation methods, EFs, AD sources, etc. by GHG Inventor WG	15.09.XX-1	30.11.XX-1
3.	Collection of AD and QC of the data by the institutions involved	01.11.XX-1	31.12.XX-1
4.	Calculation of all emissions from electricity production, transportation, F-gas, emissions and removal from LULUCF by the related Institutions, and transfer to TurkStat.	15.12.XX-1	15.02.XX
5.	Calculation of emissions under the responsibility of TurkStat	15.12.XX-1	15.02.XX
6.	QC of the calculated emissions	15.12.XX-1	15.02.XX
7.	AD and emission entry to CRF reporter by sectoral experts	15.02.XX	15.03.XX
8.	Performing key source, trend and uncertainty analysis by TurkStat	15.02.XX	15.03.XX
9.	Preparation of Emission Inventory Report by the institutions involved and compilation by TurkStat	15.02.XX	31.03.XX
10.	Approval of National GHG Emission Inventory by Inventory Focal Point	01.04.XX	10.04.XX
11.	Release of the National GHG Inventory as news release on TurkStat webpage.	01.04.XX	30.04.XX
12.	Reporting of Inventory to UNFCCC Secretariat by TurkStat	10.04.XX	15.04.XX
13.	Documentation and archiving processes	15.04.XX	30.05.XX

1.4. Brief General Description of Methodologies and Data Sources

The National GHGs are calculated by using 2006 IPCC Guidelines. CO_2 emissions from energy are calculated by using Tier 2 (T2) approach except for biomass and other fossil fuels. CH_4 and N_2O emissions from all subcategories of energy are calculated by using Tier 1 (T1). For the emissions from coke production, due to plant specific data are gathered, Tier 3 (T3) methodology are used.

For industrial process and other product use, T2 methodology was used for the CO_2 emissions from cement production, ammonia (NH_3) production, iron and steel production and aluminum production. For the emissions from rest T1 methodology was used. For the PFCs emissions from aluminum production, T3 methodology is used.

For agriculture sector; T1 methodology was used for all categories and gases.

For LULUCF; T2 methodology was used for the emissions/removals from forestland and grassland while T1 methodology was default methodology was used for the emissions from harvested wood product (HWP).

In waste sector; for the CO_2 emissions from open burning of waste, which is only CO_2 emission source for waste sector is calculated by using T2 method. For CH_4 emissions from solid waste disposal, T2 methodology was used while T1 was used for the rest of CH_4 emission source category. For N_2O emissions, T1 methodology was used for all categories.

Data sources of inventory are listed below.

Table 1.4 Activity data sources for GHG emissions inventory

Sector	Category	Activity data source
Energy	Energy – 1 (excluding 1.A.1 – Energy industry and 1.A.3 – Transportation)	MENR
	Public electricity and heat production – 1.A.1.a	MENR
	Petroleum Refining – 1.A.1.b	TÜPRAŞ
	Manufacture of solid fuels and other energy industries – 1.A.1.c	Integrated iron and steel plants
	Transportation – 1.A.3	TurkStat MENR MTMAC
Industrial Process	Industrial Process – 2	TurkStat
	Cement Manufacturing - 2.A.1	TurkStat & TCMA
	Lime Manufacturing - 2.A.2 Lime Stone and Dolomite Use - 2.A.3	TurkStat & TLA
	Ammonia Production (2.B.1)	Plants
	Nitric Acid Production (2.B.2)	Plants
	Iron and Steel (2.C.1)	Plants
	Aluminum Manufacturing - 2.C.3	TurkStat & ETİ Aluminum Co. Inc.
	Halocarbon and SP6 consumption - 2.F	MCT, TurkStat
	Chemicals manufacturing and processing – 3.C	TurkStat
Agriculture	Agriculture – 3	TurkStat
Land Use, Land Use Change and Forestry	LULUCF - 4	MFWA, MFAL
Waste	Waste – 5	TurkStat

1.5. Brief Description of Key Source Categories

The 2006 IPCC Guidelines for National GHG Inventories (IPCC 2006) recommend as good practice the identification of key categories of emissions and removals. The intent is to help inventory agencies prioritize their efforts to improve overall estimates. A key category is defined as "one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of GHG in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions and removals" (IPCC 2006); this term is used in reference to both source and sink categories.

For the 1990–2014 GHG inventory, level and trend key category assessments were performed according to the recommended IPCC approach found in Volume 1, Section 4.3.1, of the 2006 IPCC Guidelines. The details of key source analysis are given in Annex 1.

Based on the key source analysis including LULUCF, the followings are determined as key source in 2014.

- 1.A.1.a. Public electricity and heat production (CO_2)
- 1.A.1.b. Petroleum refining (CO_2)
- 1.A.1.c. Manufacture of solid fuels and other energy industries (CO_2)
- 1.A.2.a. Iron and Steel Production (CO_2)
- 1.A.2.b. Non-Ferrous Metals (CO_2)
- 1.A.2.c. Chemicals (CO_2)
- 1.A.2.d. Food Processing, Beverages and Tobacco (CO_2)
- 1.A.2.f. Non-metallic minerals (CO_2)
- 1.A.2.g. Other Industries (CO_2)
- 1.A.3.a. Domestic aviation (CO_2)
- 1.A.3.b. Road transportation (CO_2)
- 1.A.4.b. Residential (CO_2)
- 1.A.4.c. Agriculture/forestry/fishing (CO_2)
- 1.B.1. Coal mining (CH_4)
- 1.B.2.b. Natural Gas (CH_4)
- 2.A.1. Cement production (CO_2)
- 2.A.2. Lime production (CO_2)
- 2.A.4. Other Process Uses of Carbonates(CO_2)
- 2.C.1. Iron and steel production (CO_2)
- 2.C.3. Aluminum production (PFCs)
- 2.F. Product uses as substitutes for ozone depleting substances (ODS) (HFCs)
- 3.A. Enteric fermentation (CH_4)
- 3.B. Manure management (CH_4)
- 3.B. Manure management (N_2O)
- 3.D. Agricultural Soils (N_2O)
- 4.A. Forest Land (CO_2)
- 4.C Grass Land (CO_2)
- 4.D. Wetlands (CO_2)

- 4.G. Harvested Wood Products (CO_2)
- 5.A.1. Managed waste disposal sites (CH_4)
- 5.A.2. Unmanaged waste disposal sites (CH_4)
- 5.D.1. Domestic wastewater (CH_4)
- 5.D.1. Domestic wastewater (N_2O)

1.6. General Uncertainty Evaluation

The general procedures for uncertainty analysis based on the expert judgment are as follows;

- Uncertainties of each activity are allocated by using EFs and AD uncertainties.
- Emissions are estimated for each (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) gases,
- The uncertainties for industrial processes data are estimated by TurkStat,
- The uncertainties of F gases data are estimated by MoEU,
- The uncertainties of agricultural activities data are estimated by TurkStat,
- The uncertainties of waste data are estimated by TurkStat,
- The uncertainties for sectoral energy usage data are estimated by MENR,
- The uncertainties of transport sectors data are estimated by MTMAC.
- The uncertainties of forest land sectors data are estimated by MFWA.

Quantitative estimates of the uncertainties in the emissions are calculated using direct sectoral expert judgment based on the data collection matters considering completeness, accuracy and other parameters. The total uncertainty is 11.34%, mainly caused by the highly uncertain data of CO_2 uptake by forest. The details of uncertainty analysis are given in Annex 2.

1.7. General Assessment of Completeness

The inventory is considered to be largely complete with only a few minor sources not estimated, due to either a lack of available information. These sources are considered to be insignificant, when compared with the inventory as a whole. The categories given in Annex 5 were not estimated due to insufficient data or methodology.

2. TRENDS IN GREENHOUSE GAS EMISSIONS

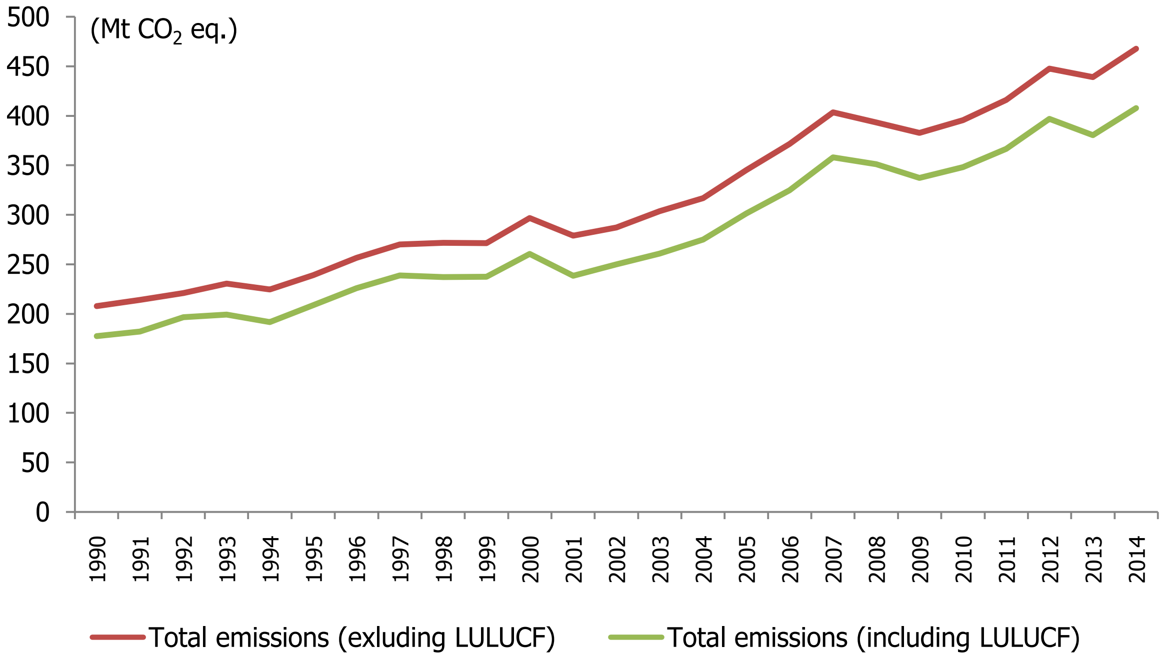
2.1. Emission Trends for Aggregated Greenhouse Gas Emissions

Total GHG emissions, excluding the LULUCF sector, were 467.6 Mt CO_2 eq. in 2014. This represents an increase of 259.8 Mt CO_2 eq. (125%) on total emissions in 1990 and an increase of 28.7 Mt CO_2 eq. (6.5%) in 2013.

Net GHG emissions, including the LULUCF sector, were 407.7 Mt CO_2 eq. in 2014. This represents an increase of 230.1 Mt CO_2 eq. (129.6%) on net emissions in 1990 and an increase of 27.3 Mt CO_2 eq. (7.2%) in 2013.

Figure 2.1 presents total and net GHG emissions from 1990 to 2014. The fluctuations in the emission trend are mainly due to the trends in the economic activites which can be seen through Gross Domestic Product (GDP) at market prices (constant 2005 USD (United States Dollar)) as shown in Figure 2.2. Population data is one of the main drivers of the emission trends in national inventories and given in Figure 2.3.

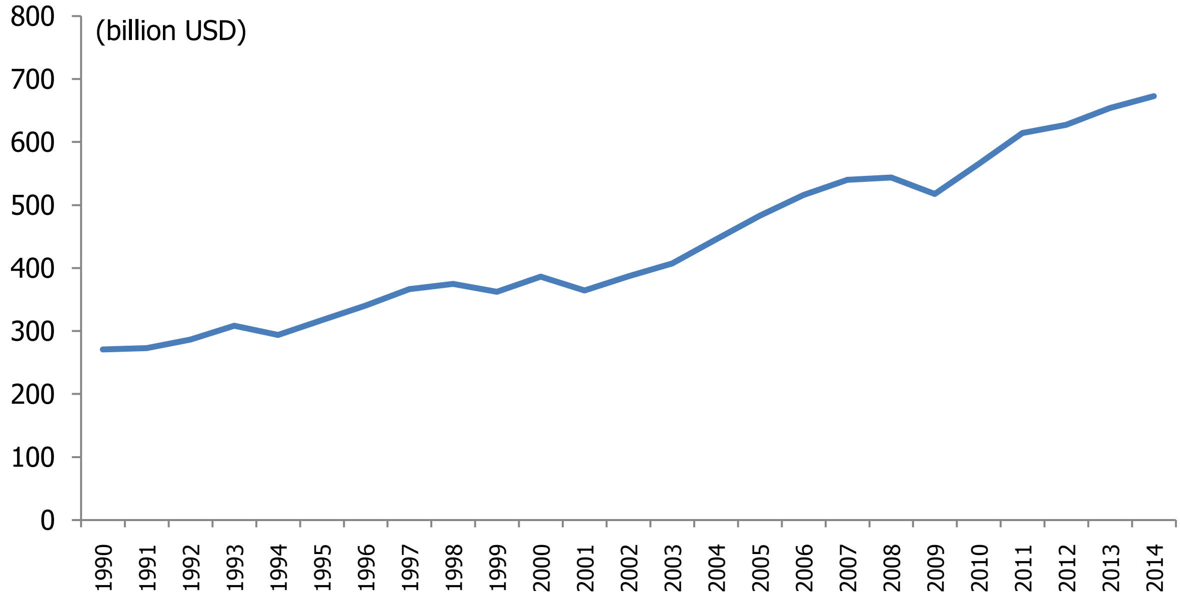
Figure 2.1 Emission trend for aggregated GHG emissions, 1990-2014



There is positive trend in the total emissions over the period 1990-2014. However, economic recession had directly caused reduction in the total GHG emissions in 1994, 1999, 2001, 2008 and 2009. In these years, total emissions are decreased 2.6%, 0.1%, 6.1%, 2.6% and 2.7% as compared to the previous years emissions respectively. Although there is no economic recession, total emissions are slightly decreased by 1.9% in 2013. This is mainly result of a change in the share of solid fuels for electricity generation as shown in Figure 2.11.

The fluctuations in the emission trend are mainly due to the trends in the GDP at market prices (constant 2005 USD) as shown in Figure 2.2.

Figure 2.2 GDP, 1990-2014



GDP can be thought as the main driver of the GHG emissions in Turkey. It has nearly the same pattern as total GHG emissions for the period 1990-2014. While it was about 271 billion USD in 1990, it reached 673 billion USD with 2005 constant prices. Although economic crisis in 1994, 2001, 2009 caused 4.7%, 5.7%, 4.8% decrease in GDP, Turkish economy grew about 149% for the period 1990-2014.

Population data is another main driver of the emission trends in national inventories and the population trend of Turkey is given in Figure 2.3.

Figure 2.3 Mid-year population, 1990-2014

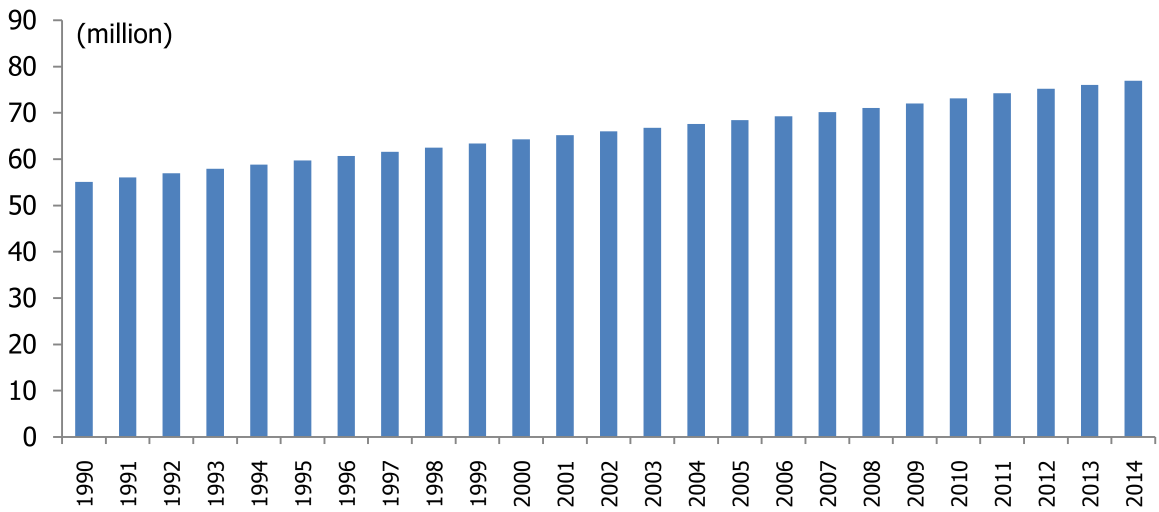


Figure 2.3 shows the mid-year population of Turkey with increase about 39.5% for the period 1990-2014. While it was 55.1 million in 1990, it reached 76.9 million in 2014. Moreover figure 2.4 shows GHG emission per capita.

As seen in Figure 2.4, GHG emission per capita shows an increasing trend and it is parallel to the Turkey's total emissions trend.

Figure 2.4 Total GHG emissions per capita, 1990-2014

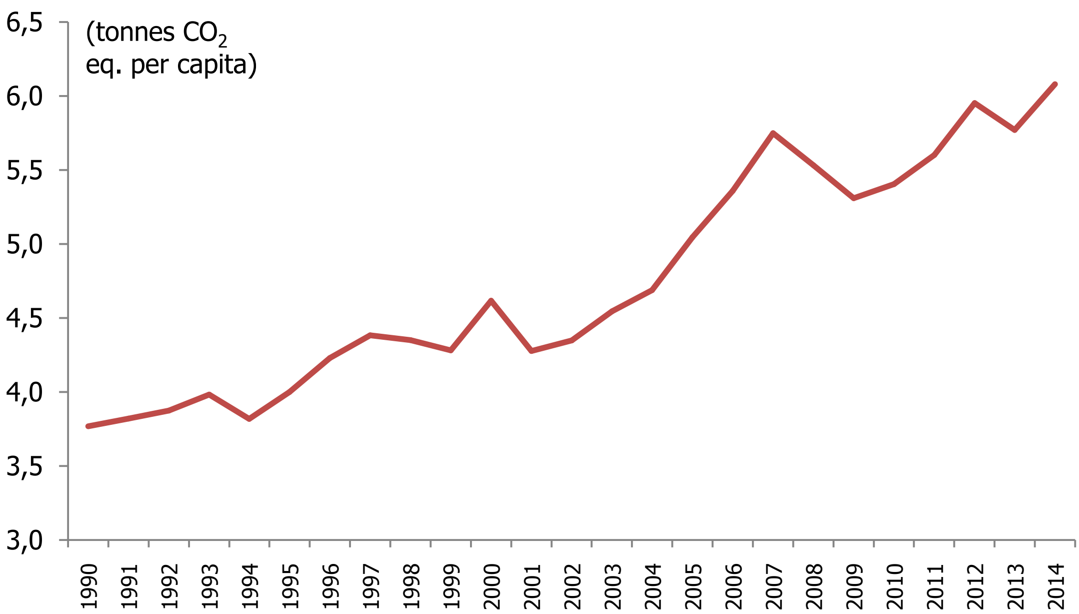


Table 2.1 gives summary data for GHG emissions for some selected years between 1990 and 2014.

Table 2.1 Aggregated GHG emissions by sectors

(Mt CO_2 eq.)

Sector	1990	1995	2000	2005
Total (excluding LULUCF)	**207.77**	**239.04**	**296.81**	**345.23**
Energy	132.48	160.05	214.36	252.65
Industrial processes and product use	23.12	26.99	28.41	37.78
Agriculture	41.23	39.77	39.65	37.94
Waste	10.94	12.23	14.39	16.86
Land use, land-use change and forestry	-30.23	-30.17	-36.21	-43.76
Compared to 1990 (%)	-	15.05	42.85	66.16
Sector	**2010**	**2012**	**2013**	**2014**
Total (excluding LULUCF)	**395.28**	**447.45**	**438.82**	**467.55**
Energy	286.05	321.32	310.04	339.10
Industrial processes and product use	51.78	62.40	63.21	62.81
Agriculture	39.33	45.77	49.32	49.52
Waste	18.12	17.96	16.25	16.11
Land use, land-use change and forestry	-47.19	-50.57	-58.42	-59.88
Compared to 1990 (%)	90.25	115.36	111.20	125.03

In overall 2014 emissions excluding LULUCF, the energy sector had the largest portion with 72.5%. The energy sector was followed by the IPPU with 13.4%, the agricultural activities with 10.6% and the waste with 3.5%. Total GHG emissions in 2014 increased by 6.5% compared to year 2013, and 125% to 1990.

2.2. Emission Trends by Gas

Total CO_2 emissions (excluding LULUCF) increased by 160.5% from 1990 to 2014. CH_4 emissions (excluding LULUCF) increased by 30.4% and N_2O emissions (excluding LULUCF) increased by 41%.

Total CO_2 emissions (including LULUCF) increased by 176.6% from 1990 to 2014. There are no significant changes in other GHGs by taking into account the LULUCF sector. CH_4 emissions (including LULUCF) increased by 30.4% and N_2O emissions (including LULUCF) increased by 41%.

As shown in Figure 2.5, the CO_2 emissions show a general increasing trend, while N_2O and CH_4 emissions are not changing considerably.

Figure 2.5 Emission trend of main GHGs, 1990-2014

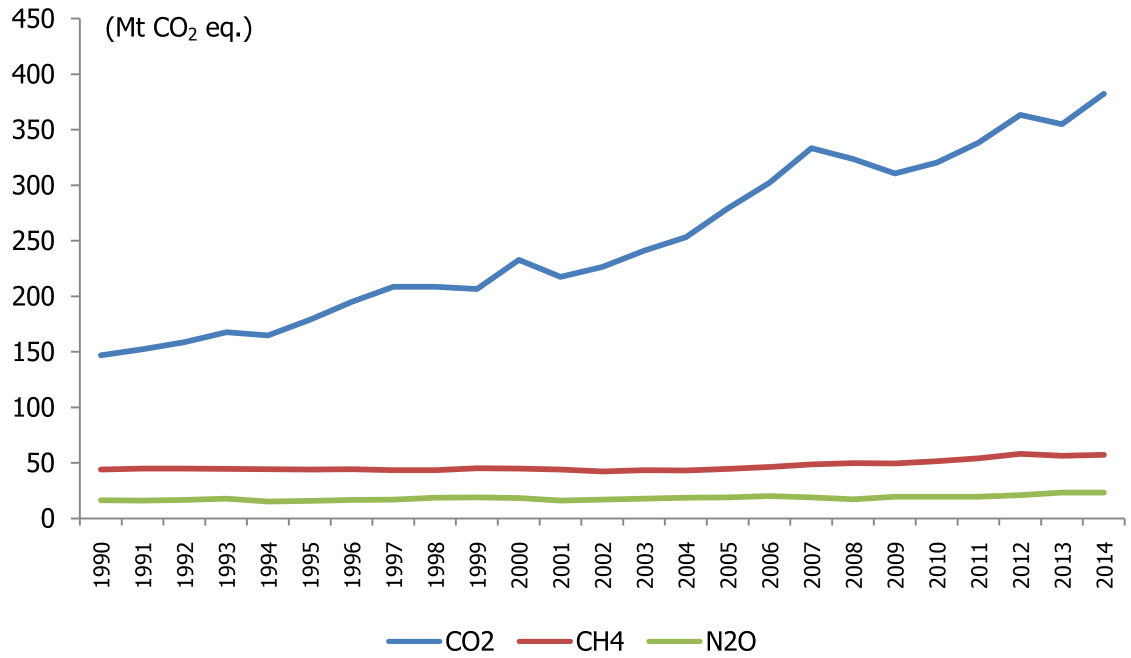


Table 2.2 gives summary data for GHG emissions by gas for some selected years between 1990 and 2014.

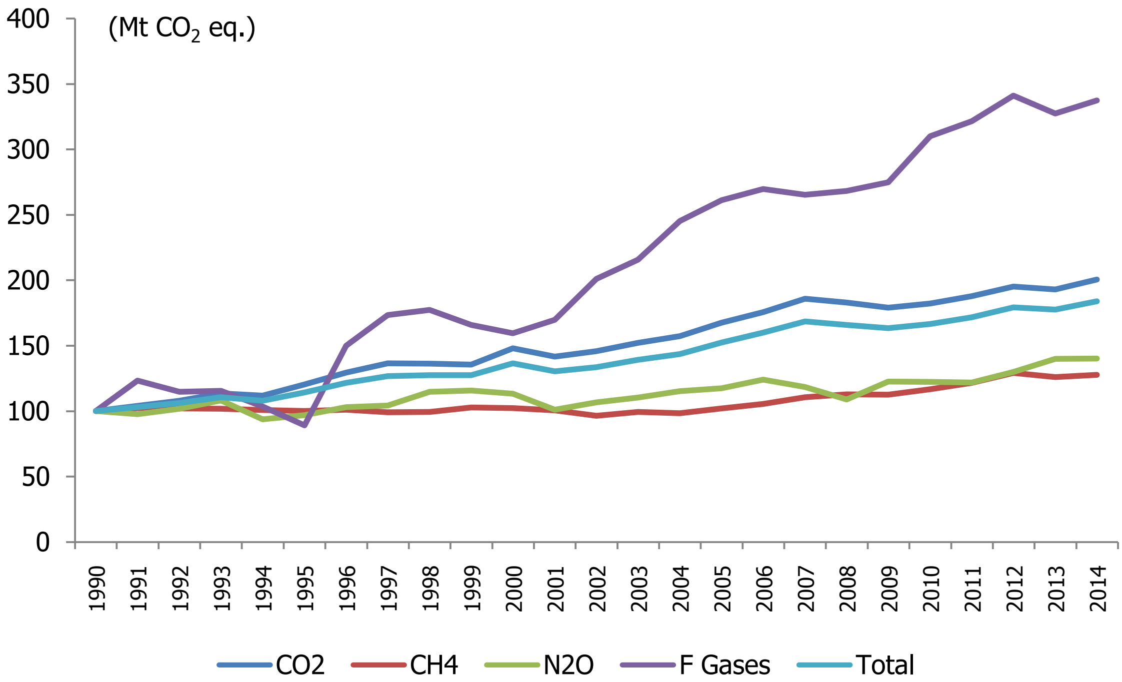
Table 2.2 Aggregated GHG emissions excluding LULUCF

(Mt CO_2 eq.)

Gas	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2013**	**2014**
Total	**207.77**	**239.04**	**296.81**	**345.23**	**395.28**	**447.45**	**438.82**	**467.55**
CO_2	146.75	178.81	232.55	279.13	320.36	363.13	354.96	382.21
CH_4	43.82	43.88	44.82	44.59	51.42	58.03	56.18	57.14
N_2O	16.51	15.75	18.43	18.98	19.62	21.12	23.21	23.28
HFCs	NO	NO	0.12	1.15	3.05	4.26	4.47	4.92
PFCs	0.69	0.59	0.59	0.56	NE	NE	NE	NE
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO	NO	NO
SF_6	NE	NE	0.31	0.82	0.84	0.93	NE	NE
NF_3	NO	NO	NO	NO	NO	NO	NO	NO

Figure 2.6 shows that those all GHGs together for 1990-2014 period. It can easily be seen from this graph that all gases are showing increasing trend since 1990 generally. The largest contributor is CO_2 at 82% of the total emission in 2014. Second one is CH_4 with 12%. N_2O contributes 5% and HFCs is following with 1%.

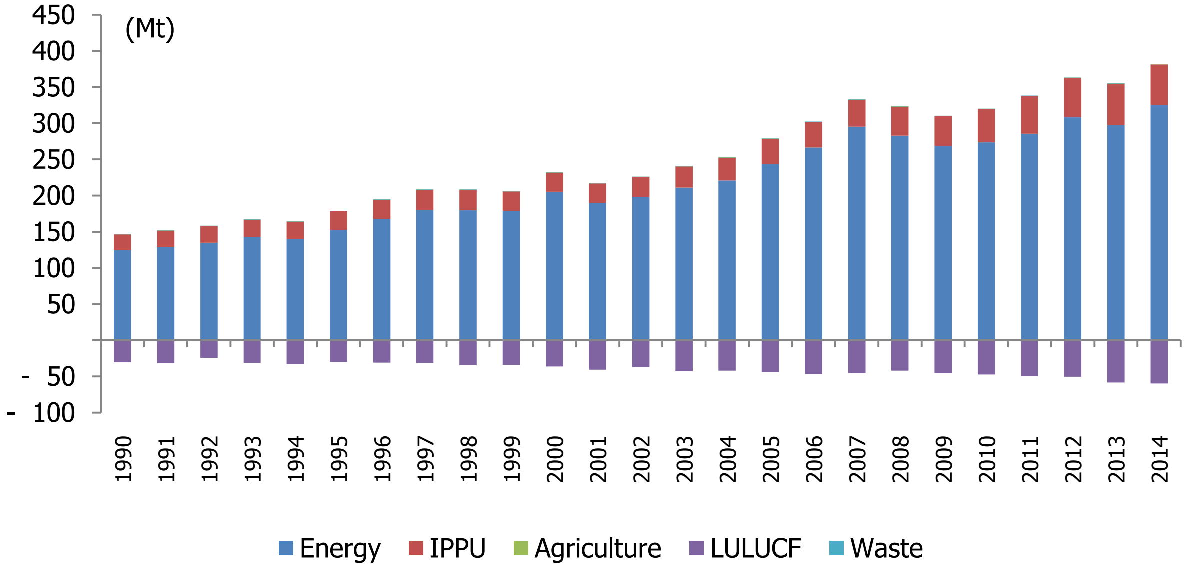
Figure 2.6 Emission trend of all GHGs, 1990-2014



Carbon Dioxide

In 2014, CO_2 emissions are 382.2 Mt (excluding LULUCF), 7.7% above the 2013 level and 160.5% above the 1990 level. Figure 2.7 illustrates the trend in CO_2 emissions. It is seen that CO_2 emissions are dominated by the energy sector which is the main driver for the rising trend in emissions. This situation is caused by growing industrial sector and population in Turkey. In 2014 excluding the LULUCF, energy sector is responsible for 85.2% of the total CO_2 emissions while IPPU is responsible for 14.6%. Agriculture and waste sectors do not cause significant amount of CO_2 emission.

Figure 2.7 CO_2 emissions by sector, 1990-2014

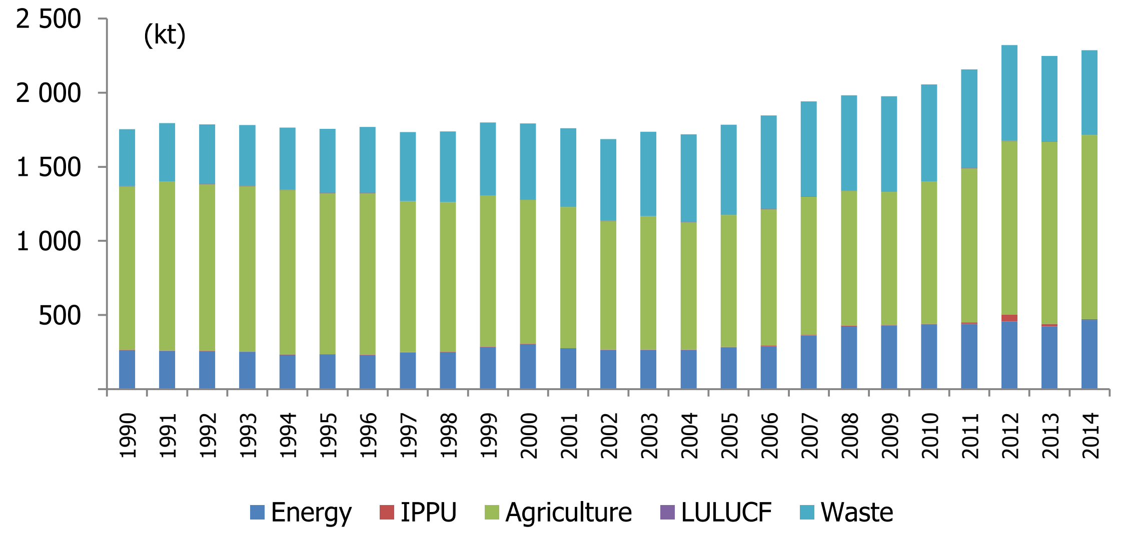


Methane

The trend in emissions of CH_4 is broken down by source in figure 2.8. CH_4 is the second most significant GHG after CO_2 in Turkey since 1990. Emissions of CH_4 have increased 30.4% since the base year 1990 and have risen by 1.7% compared to 2013. In 2014, CH_4 emissions were 2 286 kt.

The major sectors of CH_4 are enteric fermentation from agriculture, solid waste disposal from waste source and fugitive emissions in energy sector. Emissions from Industrial processes and LULUCF are not significant sources of CH_4 in comparison with other sector. Generally all sectors have risen since 1990.

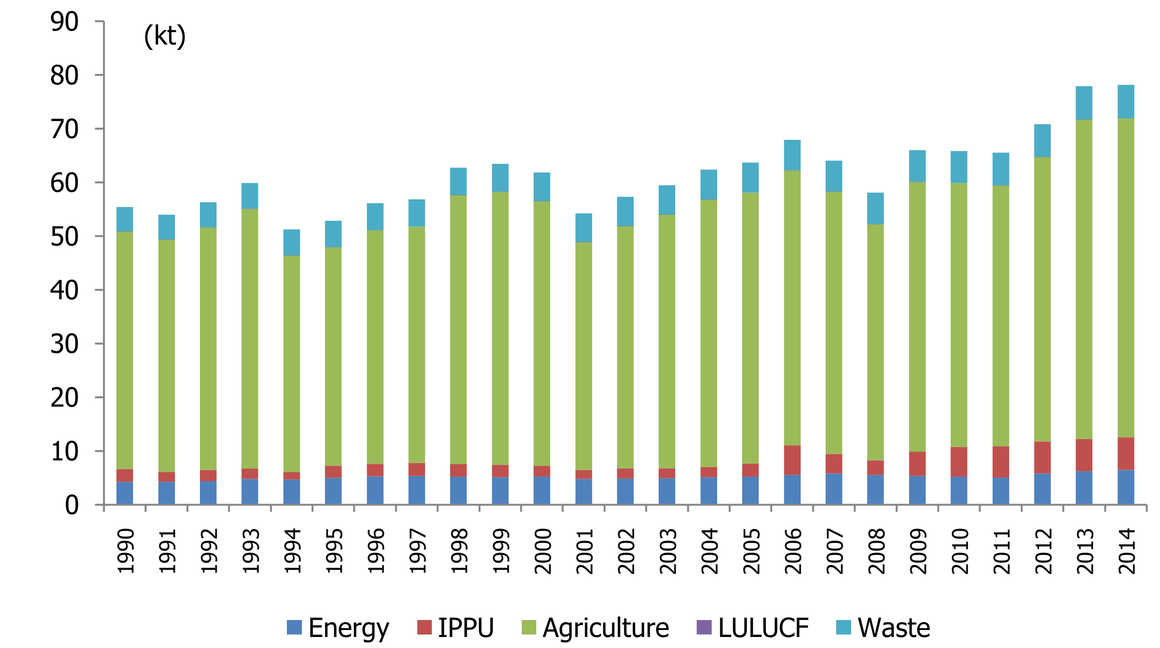
Figure 2.8 CH_4 emissions by sector 1990-2014



Nitrous Oxide

In 2014, N_2O emissions are 78.1 kt and it is almost the same level with 2013 level (77.9 kt) but 41% above the 1990 level. As it is seen from the figure 2.9, agriculture sector is the main contributor of N_2O emissions in all the years and the share is 76% in 2014. IPPU has a minor share for the N_2O emissions by 7.8% however it is remarkable that IPPU originated N_2O emissions increased by 160% since 1990 due to increasing nitric acid production of Turkey thereafter. Energy sector is responsible for 8.3% and waste sector is responsible for 8% of all N_2O emisssions.

Figure 2.9 N_2O emissions by sector 1990-2014



Florinated Gases

The F gases are only caused by the IPPU sector. In 2014, 4 917 kt of F gases released to the atmosphere. It is seen from Table 2.3 that total F gases emissions increased by 610% since 1990. The main contributor of total F gas emissions is HFCs emissions and it is mainly due to increasing demand of Turkey's refrigerant and air conditioning sector.

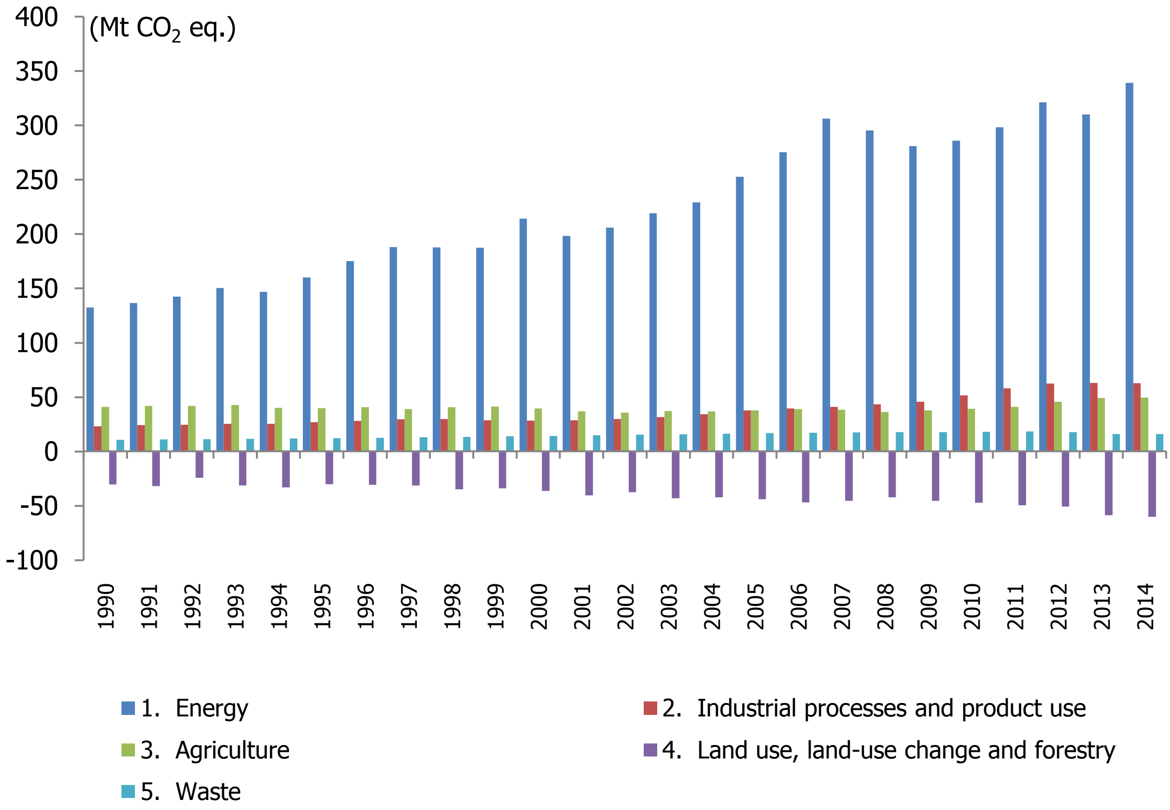
Table 2.3 Florinated gases emissions by sector 1990-2014

(kt CO_2 eq.)

Year	HFCs	PFCs	SF6
1990	NO	692.77	NE
1991	NO	854.54	NE
1992	NO	781.92	NE
1993	NO	786.58	NE
1994	NO	693.65	NE
1995	NO	592.88	NE
1996	NO	597.28	356.64
1997	NO	593.33	582.97
1998	NO	593.87	629.28
1999	NO	591.07	493.03
2000	115.66	591.38	308.03
2001	232.00	592.20	294.26
2002	417.19	595.92	454.81
2003	628.80	595.33	457.37
2004	909.37	600.78	672.14
2005	1 146.88	559.97	819.20
2006	1 424.19	450.06	869.18
2007	1 713.19	NE,NO	908.29
2008	1 896.14	NE,NO	804.29
2009	2 111.28	NE,NO	766.49
2010	3 054.34	NE,NO	835.48
2011	3 432.69	NE,NO	906.49
2012	4 256.86	NE,NO	926.43
2013	4 470.25	NE,NO	NE,IE
2014	4 916.55	NE,NO	NE,IE

2.3. Emission Trends by Sector

Figure 2.10 GHG emission trend by sectors, 1990-2014



1990-2014: All sectors have an increasing trend from 1990 to 2014 included IPPU (171.6%), energy (156.0%), LULUCF (98.1%), waste (47.2%) and agriculture (20.1%).

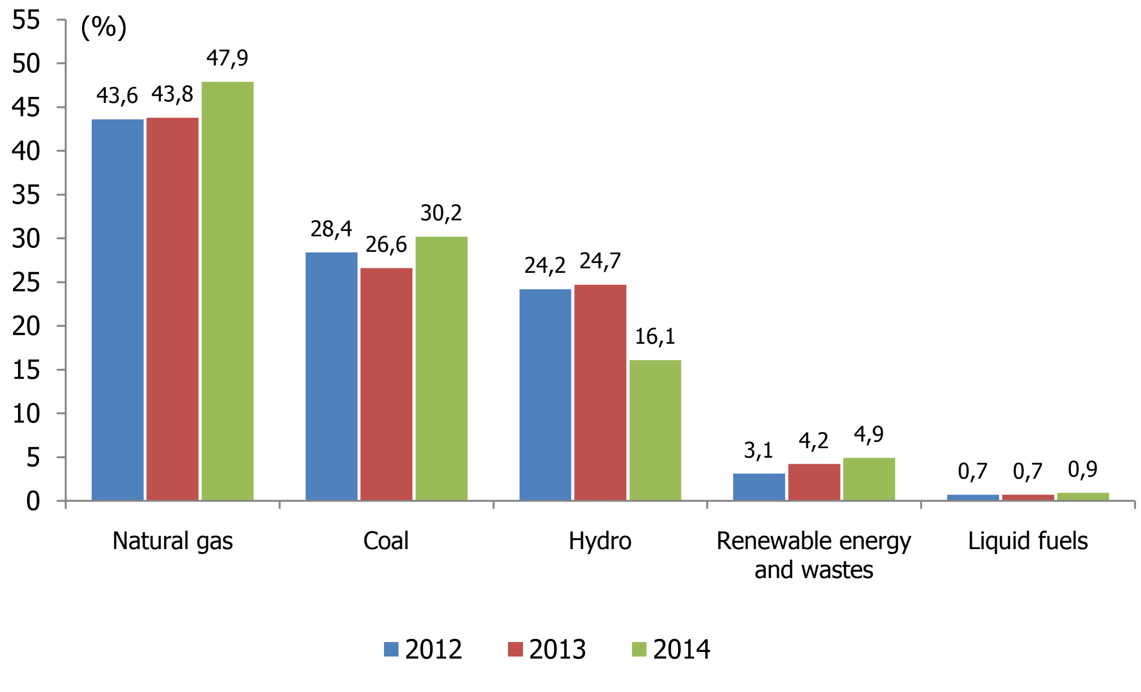
The main reasons of the increase for all sectors are population growth, a growing economy and an increase in energy demand.

The main reasons of the rise in removals for LULUCF are improvements in sustainable forest management, afforestation, rehabilitation of degraded forests, reforestations on forest land and conversion of coppices to productive forests in forest land remaining forest land, efficient forest fire management and protection activities, conversions to perennial croplands from annual croplands and grasslands, and conversions to grasslands from annual croplands. The main reasons for the decrease in removals are related to drought and biomass burning as wildfire (e.g. year 2008; 29 749 ha forest area burned), deforestation, conversions to wetlands (flooded land) and settlements.

2013-2014: There are both increasing and decreasing trends in the annual change for each sector from 2013 to 2014. The sectors having increasing trends are energy (9.4%), LULUCF (2.5%), and agriculture (0.4%). The sectors having decreasing trends are waste (0.8%) and IPPU (0.6%).

The increase in energy sector is mainly originating from electricity and heat production in 2014. As shown in Figure 2.11 electricity production from renewable energy sources (especially in hydraulic power generation) is decreased so it is compensated by solid fuel in 2014.

Figure 2.11 Electricity generation and shares by energy resources, 2012-2014



The decrease in emissions from waste sector is mainly due to the increase in methane recovery processes particularly in recent years. The detailed reasons behind the emission trends and main drivers for all sectors are discussed by each sub-sector in the related chapters.

While Table 2.4 provides contribution of sectors to the net GHG emissions by sectors for some selected years between 1990 and 2014, Table 2.5 shows the same shares for the GHG emissions without LULUCF.

Table 2.4 Contribution of sectors to the net GHG emissions

(%)

Sectors	1990	1995	2000	2005	2010	2012	2013	2014
Energy	74.62	76.63	82.26	83.81	82.18	80.96	81.50	83.18
IPPU	13.02	12.92	10.90	12.53	14.88	15.72	16.62	15.41
Agriculture	23.22	19.04	15.22	12.58	11.30	11.53	12.97	12.15
Waste	6.16	5.85	5.52	5.59	5.21	4.53	4.27	3.95
LULUCF	-17.03	-14.44	-13.90	-14.52	-13.56	-12.74	-15.36	-14.69

Table 2.5 Contribution of sectors to the GHG emissions without LULUCF

(%)

Sectors	1990	1995	2000	2005	2010	2012	2013	2014
Energy	63.76	66.96	72.22	73.18	72.37	71.81	70.65	72.53
IPPU	11.13	11.29	9.57	10.94	13.10	13.95	14.41	13.43
Agriculture	19.84	16.64	13.36	10.99	9.95	10.23	11.24	10.59
Waste	5.27	5.11	4.85	4.88	4.58	4.01	3.70	3.45

Energy

As in most countries, the energy system in Turkey is largely driven by the fuel combustion, followed by fugitive emissions from fuels and then CO_2 transport and storage. In 2014, emissions from the energy sector are 72.5% of total emissions, excluding LULUCF. Emissions in CO_2 eq. from the energy sector are reported in Table 2.6 and showed in Figure 2.12.

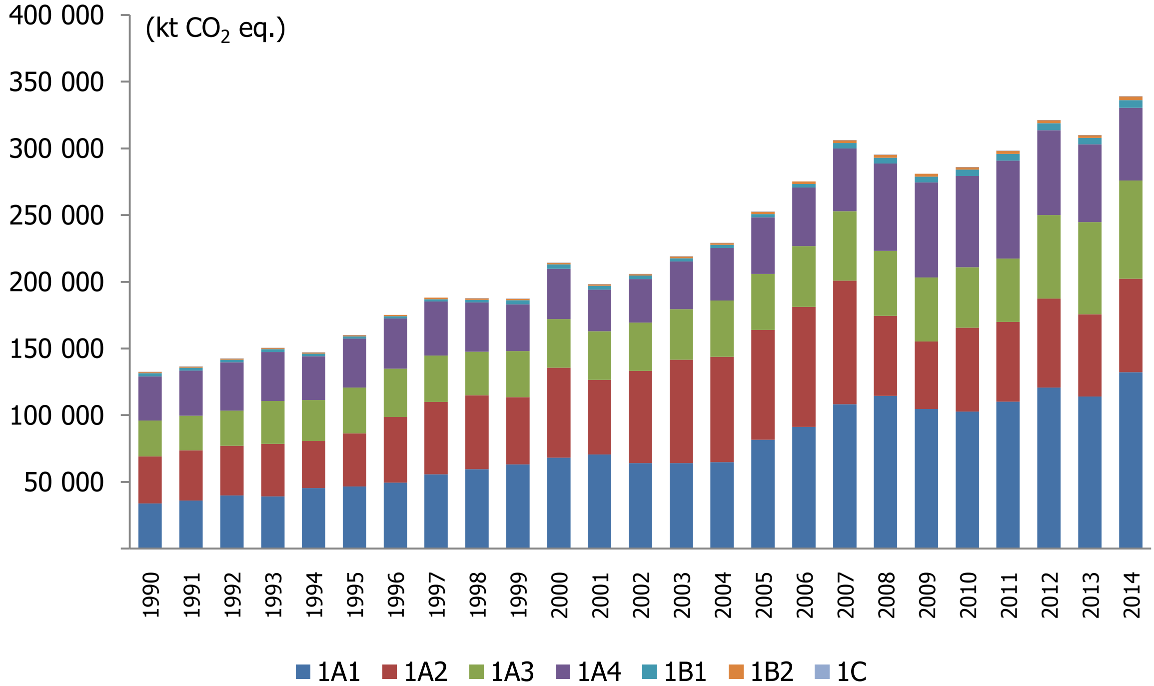
CO_2 emissions are 96% of the total energy sector emissions, showed an increase by 161.2% from 1990 to 2014. CH_4 emissions are just 3.4% of the total, increased by 77.3% in comparison with the 1990. N_2O emissions, with minimal contribution to total emissions of energy sector, show 51% increase in proportion to year 1990.

Table 2.6 Total emissions from the energy sector by source

(kt CO_2 eq.)

	1990	1995	2000	2005	2010	2012	2013	2014
Total	**132 477**	**160 055**	**214 365**	**252 652**	**286 049**	**321 315**	**310 037**	**339 105**
Fuel combustion	129 154	157 353	209 658	248 370	279 355	313 505	303 048	330 385
Energy industries	33 937	46 457	68 192	81 703	102 609	120 669	113 904	132 248
Manufacturing industries and construction	35 141	39 997	67 442	82 181	62 867	66 790	61 821	70 085
Transport	27 004	34 152	36 508	42 106	45 468	62 632	68 997	73 700
Other sectors	33 072	36 747	37 516	42 380	63 411	63 414	58 326	54 351
Fugitive emissions from fuels	3 324	2 701	4 707	4 282	6 694	7 810	6 989	8 719
Solid fuels	2 432	1 688	3 421	2 497	4 640	5 304	4 813	5 843
Oil and natural gas	891	1 013	1 286	1 784	2 054	2 507	2 176	2 876
CO_2 transport and storage	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13

Figure 2.12 Trend of total emissions from energy sector, 1990-2014



GHG emissions of energy sector, in CO_2 eq., show an increase by 156% from 1990 to 2014. Generally, an upward trend is noted from 1990-2014.

IPPU

Emissions from industrial process and product use sector has a share of 13.4% of Turkey's total emissions excluding LULUCF in 2014. CO_2 emissions in year 2014, are 89% of total IPPU emissions. N_2O has 3% share in IPPU emissions and increased by 160%. Whereas, CH_4 has a minor impact.

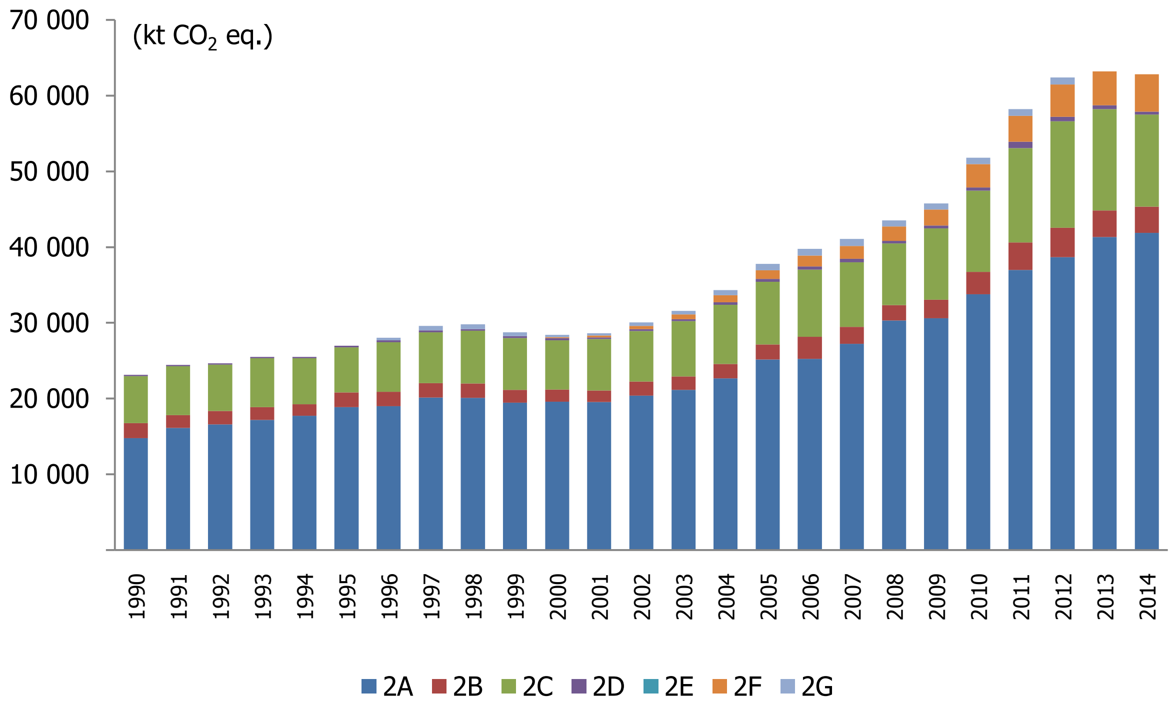
Emissions by each subsector of IPPU is tabulated in Table 2.7 for the 1990-2014 period. Figure 2.13 shows the trend for the IPPU related emissions by cumulating its subsectors.

Table 2.7 Total emissions from the industrial process and product use sector by source

(kt CO_2 eq.)

	1990	1995	2000	2005	2010	2012	2013	2014
Total	23 124	26 986	28 410	37 780	51 785	62 405	63 213	62 810
Mineral industry	14 796	18 869	19 570	25 157	33 795	38 683	41 323	41 884
Chemical industry	1 956	1 943	1 624	1 985	2 942	3 892	3 532	3 469
Metal industry	6 196	5 973	6 520	8 269	10 736	14 056	13 359	12 151
Non-energy products from fuels and solvent use	177	200	272	404	423	592	528	388
Product uses as substitutes for ozone depleting substances	NO	NO	116	1 147	3 054	4 257	4 470	4 917
Other product manufacture and use	NE	NE	308	819	835	926	NE,IE	NE,IE

Figure 2.13 Trend of total emissions from IPPU sector, 1990-2014



IPPU related emissions increased by 172 % from 1990 to 2014. Due to the growth of population and the production especially for the recent decade, emissions from IPPU sector are increased.

Agriculture

Enteric fermentation is by far the largest source of GHG emissions of agriculture in Turkey since 1990. The agriculture sector includes emissions from the enteric fermentation, manure management, rice cultivation, agricultural soils, field burning of agricultural residues and urea application. In 2014, the agriculture sector accounted for 10.6% of total emissions in Turkey.

Enteric fermentation and agricultural soils dominate the trends in this sector between 1990 and 2014 as seen in Table 2.8 and they have an increase by 10.2% and 44.6% compared to 1990 respectively.

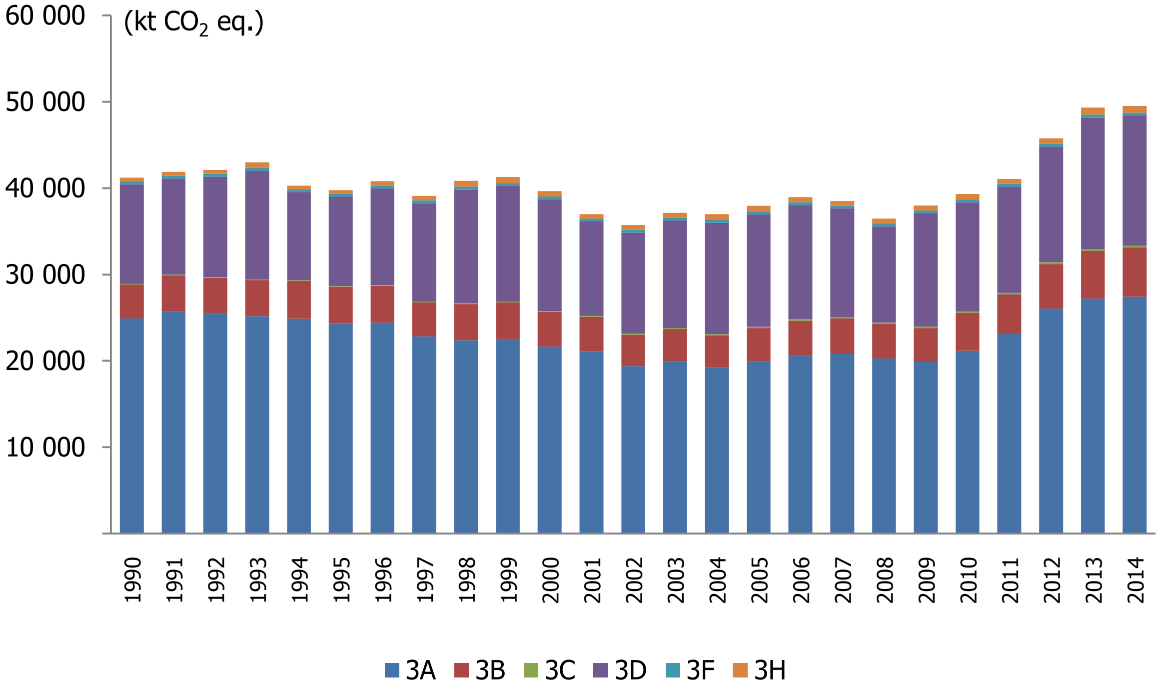
Most important portion in each gas is CH_4 with 62.7%, then comes N_2O with 35.7% share in agriculture sector emissions. CO_2 has the lowest contribution with 1.6%.

Table 2.8 Total emissions from agriculture sector by source

(kt CO_2 eq.)

	1990	1995	2000	2005	2010	2012	2013	2014
Total	**41 227**	**39 773**	**39 650**	**37 936**	**39 329**	**45 770**	**49 320**	**49 522**
Enteric fermentation	24 888	24 366	21 647	19 911	21 159	26 051	27 196	27 434
Manure management	3 937	4 202	4 028	3 881	4 401	5 155	5 540	5 692
Rice cultivation	91	86	100	147	171	206	191	191
Agricultural soils	11 524	10 388	12 914	13 013	12 622	13 385	15 218	15 090
Field burning of agricultural residues	3 324	2 701	4 707	4 282	6 694	7 810	6 989	8 719
Urea application	327	306	343	371	331	333	368	327

Figure 2.14 Trend of total emissions from agriculture sector, 1990-2014



LULUCF

GHG emissions of LULUCF sector from sources and removals by sinks are estimated and reported for categories of managed lands: forest land, cropland, grassland, wetlands, settlements, harvested wood products, other land and others.

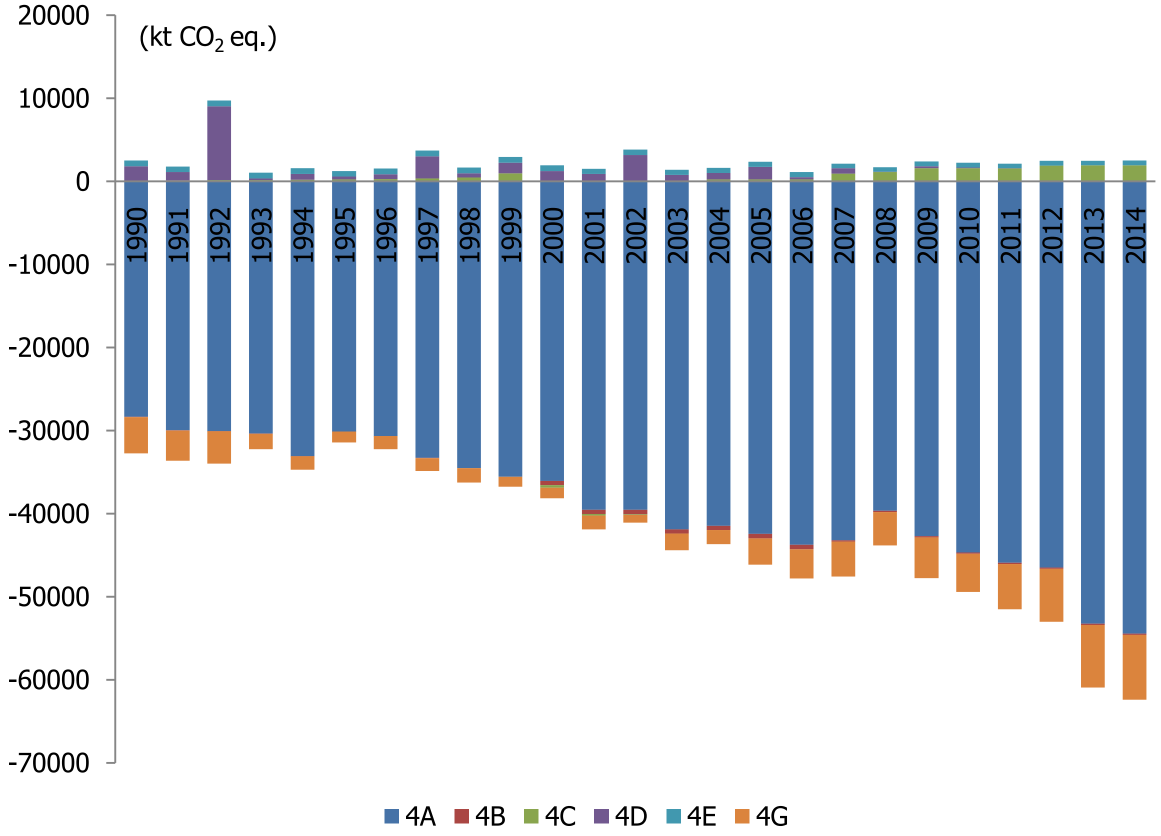
In 2014, total CO_2 eq. emissions and removals of the LULUCF sector has increased 2% compared to 2013. Table 2.9 reports emissions and removals from the LULUCF sector by source.

Table 2.9 Total emissions and removals from the LULUCF sector by source

(kt CO_2 eq.)

	1990	1995	2000	2005	2010	2012	2013	2014
Total	**- 30 229**	**- 30 168**	**- 36 215**	**- 43 765**	**- 47 194**	**- 50 570**	**- 58 421**	**- 59 880**
Forest land	- 28 323	- 30 098	- 36 060	- 42 447	- 44 684	- 46 481	- 53 261	- 54 458
Cropland	- 48	- 16	- 509	- 517	- 146	- 143	- 137	- 131
Grassland	84	228	- 304	236	1 590	1 883	1 916	1 948
Wetlands	1 742	341	1 233	1 499	61	NO,NE	NO,NE	NO,NE
Settlements	683	683	683	629	571	571	571	571
Harvested wood products	- 4 368	- 1 306	- 1 257	- 3 164	- 4 585	- 6 400	- 7 509	- 7 809

Figure 2.15 Trend of total emissions from the LULUCF sector, 1990-2014



LULUCF emissions or removals, in CO_2 equivalent, are variable over the reporting period 1990-2014 as seen in Figure 2.15. Generally decreases in removals were influenced by fires and drought in the relevant areas. Moreover, rises are originated mainly from forest management, afforestation, rehabilitation of degraded forests, reforestations on forest land and etc.

Waste

The waste sector includes GHG emissions from the treatment and disposal of wastes, open burning, waste water treatment and discharge. Waste incineration emissions are included in inventory however it is reported under energy sector. Waste sector GHG emissions are tabulated in Table 2.10. Total waste emissions for the year 2014 3.4% of total GHG emissions (without LULUCF). Considering emissions by gas, the most important GHG is CH_4 which accounts for 88.5% of the total and shows a decrease of 49% from 1990 to 2014. N_2O levels have increased by 38% whereas CO_2 decreased by 96.7%; these gases account for 11.5% and 0.001%, respectively.

Table 2.10 Total emissions from the waste sector by source

(kt CO_2 eq.)

	1990	1995	2000	2005	2010	2012	2013	2014
Total	10 945	12 226	14 386	16 863	18 120	17 962	16 250	16 114
Solid waste disposal	6 730	7 652	9 712	12 086	13 359	13 214	11 822	11 893
Biological treatment of solid waste	21	17	26	31	25	30	17	18
Incineration and open burning of waste	81	79	67	39	28	22	12	1
Waste water treatment and discharge	4 114	4 478	4 580	4 708	4 707	4 695	4 399	4 203

Figure 2.16 Trend of total emissions from the waste sector, 1990-2014

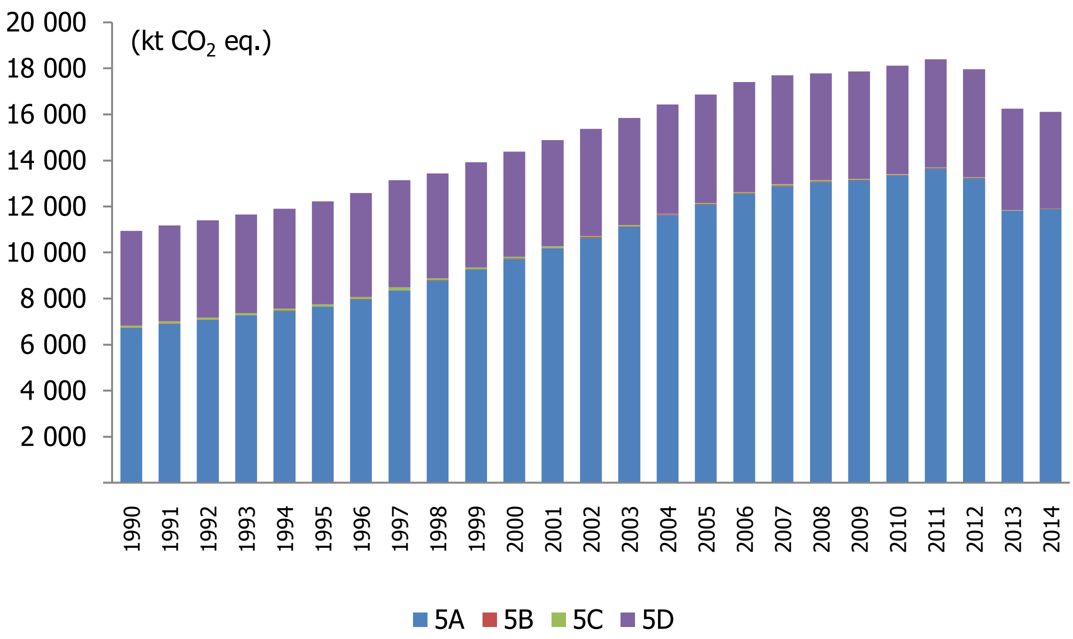


Figure 2.16 shows trends in waste sector between 1990-2014. The trend is mainly driven by solid waste disposal with 73.8% of the emissions were from, followed by 26.1% from waste water treatment and discharge, 0.11% from biological treatment of solid waste and 0.01% from open burning of waste. Total emissions, in CO_2 equivalent, decreased by 1% from 2013 to 2014.

2.4. Emission Trends for Indirect Greenhouse Gases

Emission trends of NO_X, CO, NMVOC and SO_2 from 1990 to 2014 are given in Table 2.11.

Table 2.11 Total emissions for indirect greenhouse gases, 1990-2014

(kt)

Gas	1990	1995	2000	2005	2010	2012	2013	2014
NO_X	562.04	699.99	836.12	874.20	937.35	1 081.68	1 037.92	1 051.37
CO	2 022.98	2 007.97	1 995.70	1 896.33	2 544.70	3 302.45	2 539.55	2 465.64
NMVOC	834.29	907.95	952.97	917.68	974.78	1 032.35	986.68	955.72
SO_2	1 747.16	1 886.45	2 329.56	2 103.57	2 557.75	2 712.98	1 940.23	2 144.51

1990-2014: All gases have an increasing trend from 1990 to 2014 included NO_X (87.1%), SO_2 (22.7%), CO (21.9%) and NMVOC (14.6%).

2013-2014: There are both increasing and decreasing trends in the annual change for each gases from 2013 to 2014. The gases having increasing trends are SO_2 (10.5%) and NO_X (1.3%). The gases having decreasing trends are NMVOC (3.1%) and CO (2.9%).

3. ENERGY (CRF Sector 1)

3.1. Sector Overview

The energy sector includes emissions from the combustion of fossil fuels (1.A.1 energy industries; 1.A.2 manufacturing industries and construction; 1.A.3 transport; and 1.A.4 other sectors; as well as fugitive emissions from fossil fuels (1.B).

Energy sector is the major source of Turkish anthropogenic GHG emissions. In overall 2014 GHG emissions (excluding LULUCF), the energy sector had the largest portion with 72.5%.

Energy sector CO_2 emissions constituted 85.2% of total CO_2 emissions in 2014. The non-CO_2 emissions from energy-related activities represented a very small portion of total national emissions on the basis of CO_2 eq. (with 2.5% for CH_4 and 0.4% for N_2O) in 2014.

Total emissions from the energy sector for 2014 were estimated to be 339.1 Mt CO_2 eq. (Table 3.1). Energy industries were the main contributor, accounting for 39% of emissions from the energy sector. It is followed by transport sector with 21.7%, manufacturing industries with 20.7% and other sector with 16% (Table 3.2).

Energy sector GHG emissions increased by 156% between 1990 and 2014. Annual emissions from 2013 to 2014 increased by 9.4% (29.07 Mt CO_2 eq.).

Table 3.1 Energy sector emissions by gas, 1990-2014

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	124 597	264	4.3	132 477
1991	128 899	259	4.3	136 642
1992	134 898	256	4.4	142 624
1993	142 726	253	4.8	150 489
1994	139 796	232	4.7	147 004
1995	152 710	234	5.0	160 055
1996	167 871	231	5.3	175 232
1997	180 310	248	5.3	188 106
1998	179 868	250	5.3	187 696
1999	178 721	286	5.1	187 393
2000	205 192	305	5.2	214 365
2001	189 989	275	4.8	198 303
2002	197 876	265	4.9	205 962
2003	211 019	265	5.0	219 129
2004	221 028	265	5.1	229 177
2005	244 079	280	5.3	252 652
2006	266 328	290	5.5	275 228
2007	295 318	362	5.8	306 116
2008	283 057	424	5.5	295 311
2009	268 549	430	5.4	280 889
2010	273 530	438	5.2	286 049
2011	285 634	441	5.1	298 163
2012	308 133	458	5.8	321 315
2013	297 608	423	6.2	310 037
2014	325 471	468	6.5	339 105

Table 3.2 Energy sector GHG emissions, 1990-2014

(kt CO_2 eq.)

		Fuel combustion					Fugitive emissions from fuels			
Year	Energy	Fuel combustion total	Energy industries	Manufacturing industries and construction	Transport	Other sectors	Total fugitive emissions	Solid fuels	Oil and natural gas	CO_2 transport and storage
1990	132 477	129 154	33 937	35 141	27 004	33 072	3 324	2 432	891	0.13
1991	136 642	133 430	35 890	37 874	25 706	33 960	3 211	2 151	1 060	0.13
1992	142 624	139 555	39 798	37 306	26 398	36 053	3 069	2 022	1 046	0.13
1993	150 489	147 445	39 159	39 290	32 182	36 813	3 044	2 047	997	0.13
1994	147 004	144 219	45 379	35 184	30 676	32 980	2 785	1 808	977	0.13
1995	160 055	157 353	46 457	39 997	34 152	36 747	2 701	1 688	1 013	0.13
1996	175 232	172 594	49 319	49 217	36 313	37 745	2 637	1 570	1 067	0.13
1997	188 106	185 187	55 577	54 420	34 726	40 464	2 919	1 767	1 152	0.13
1998	187 696	184 513	59 425	55 422	32 813	36 852	3 183	2 028	1 155	0.13
1999	187 393	183 139	63 219	50 192	34 655	35 073	4 254	3 038	1 215	0.13
2000	214 365	209 658	68 192	67 442	36 508	37 516	4 707	3 421	1 286	0.13
2001	198 303	194 007	70 620	55 882	36 501	31 004	4 296	3 005	1 291	0.13
2002	205 962	201 964	64 124	68 986	36 282	32 573	3 998	2 665	1 333	0.13
2003	219 129	215 196	64 059	77 594	37 879	35 665	3 933	2 433	1 500	0.13
2004	229 177	225 314	64 721	79 100	42 105	39 389	3 863	2 323	1 540	0.13
2005	252 652	248 370	81 703	82 181	42 106	42 380	4 282	2 497	1 784	0.13
2006	275 228	270 699	91 136	90 012	45 492	44 059	4 529	2 591	1 938	0.13
2007	306 116	299 841	108 222	92 515	52 177	46 927	6 274	4 078	2 196	0.13
2008	295 311	288 617	114 351	60 176	48 569	65 521	6 694	4 429	2 265	0.13
2009	280 889	274 455	104 501	50 863	47 984	71 107	6 434	4 385	2 049	0.13
2010	286 049	279 355	102 609	62 867	45 468	68 411	6 694	4 640	2 054	0.13
2011	298 163	290 758	110 211	59 630	47 461	73 456	7 405	5 024	2 381	0.13
2012	321 315	313 505	120 669	66 790	62 632	63 414	7 810	5 304	2 507	0.13
2013	310 037	303 048	113 904	61 821	68 997	58 326	6 989	4 813	2 176	0.13
2014	339 105	330 385	132 248	70 085	73 700	54 351	8 719	5 843	2 876	0.13

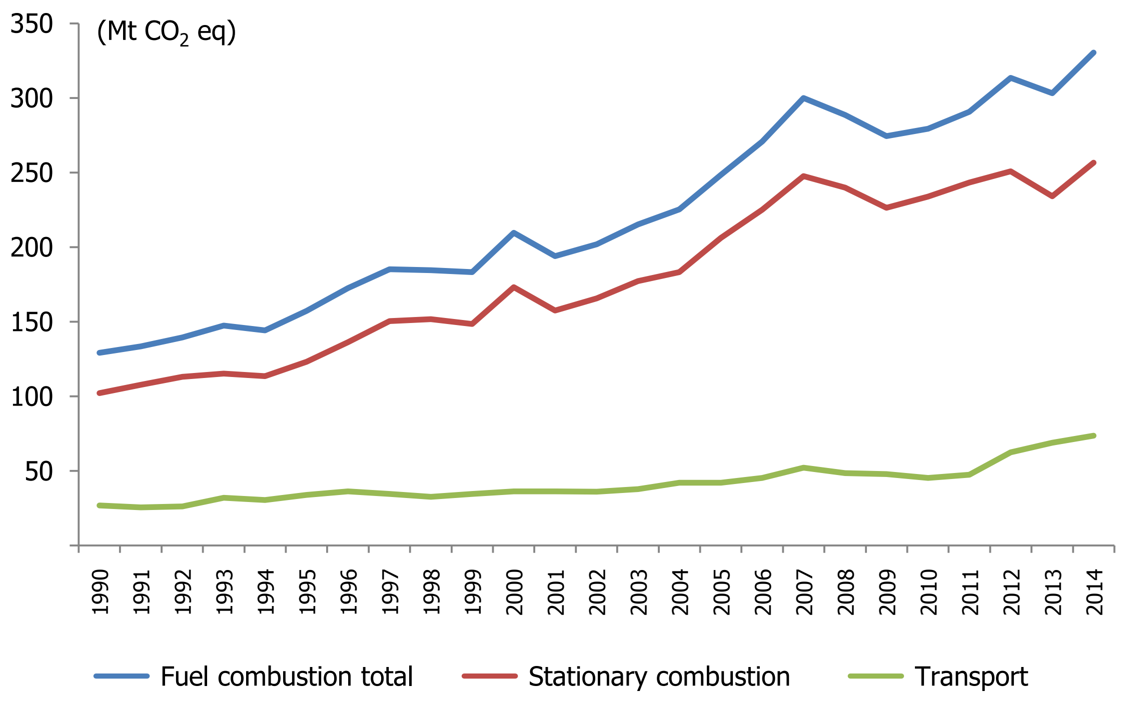
Energy sector GHG emissions mainly coming from stationary combustion. Total emissions from stationary combustion were 256.7 Mt CO_2 eq. in 2014, equal to 54.9% of total national GHG emissions (excluding LULUCF).

The energy industries subsector includes fuel combustion in electricity generation, petroleum refining, and manufacture of solid fuels. Electricity and heat production (1.A.1.a) contributed 125.1 Mt CO_2 eq. which is 48.7% of stationary combustion in 2014. The manufacturing industries and construction subsector (1.A.2) emissions were 70.1 Mt CO_2 eq. in 2014 while it was 54.4 Mt CO_2 eq. from other sectors (1.A.4).

GHG emissions from stationary combustion increased by 151.3% (154.5 Mt CO_2 eq.) between 1990 and 2014, and increased by 9.7% (22.6 Mt CO_2 eq.) between 2013 and 2014.

Although GHG emissions of Turkey demonstrated an increasing trend between 1990 and 2014, a decrease was observed in emissions in 1994, 1999, 2001, 2008 and 2009 due to the economic crisis at those years. The decrease in 2013 emissions was mainly due to the decrease in solid fuel consumption in electricity and heat production sector and residential sector.

Figure 3.1 GHG emissions from fuel combustion, 1990-2014



In 2014, transport contributed 73.7 Mt CO_2 eq., which is 15.8% of total GHG emissions (excluding LULUCF). The major source of transport emissions in Turkey is road transportation. It accounts for 91% of transport emissions. It is followed by domestic aviation while other sources are far smaller: domestic aviation with 5.5% and domestic navigation with 1.8%. Pipeline transport contribution was 0.9% and railway contribution was 0.8%.

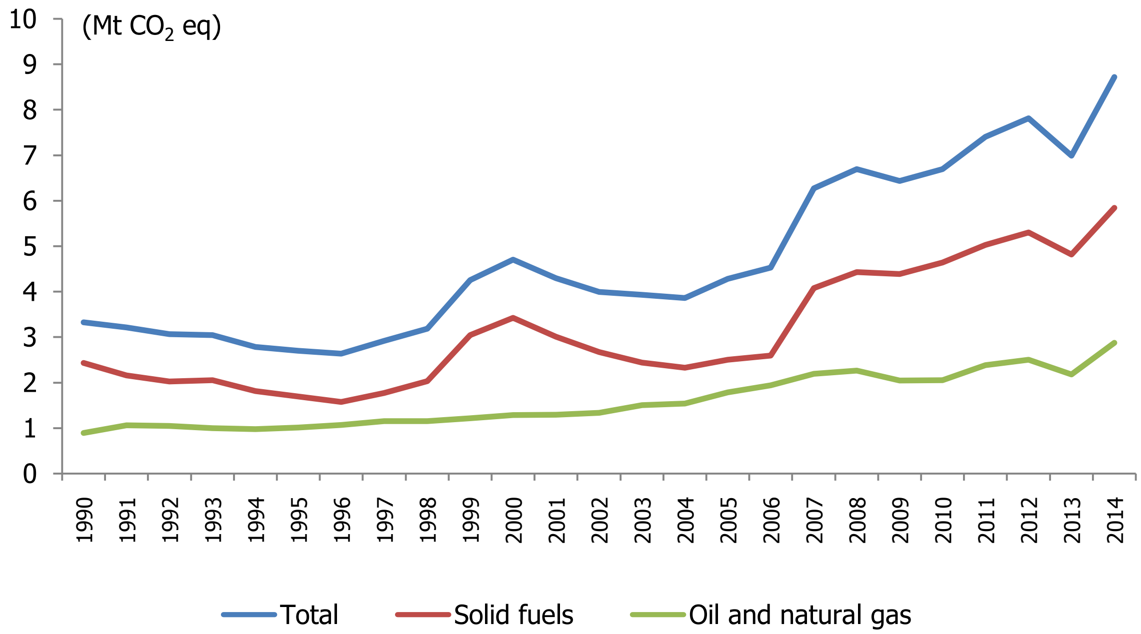
Fuel used in international aviation and marine bunkers is reported separately from the national total. In 2014, international bunker GHG emissions were 13.3 Mt CO_2 eq.

Emissions from transport sector increased 172.9% in 2014 compared to 1990. In the same period increase in road transportation emissions was 170.4%, in domestic aviation it was 343.2% and in domestic navigation it was 165.2%. Emissions from railway transport decreased by 22.1% between 1990 and 2014.

Total fugitive emissions for 2014 were 8.7 Mt CO_2 eq., representing 1.9% of total GHG emissions (excluding LULUCF). Solid fuel emissions contributed 67%, oil and natural gas account for the remaining 33% of fugitive emissions.

Overall fugitive emissions increased 162.3% between 1990 and 2014, and increased by 24.8% from 2013 to 2014. From 1990 to 2014, fugitive emissions from solid fuels increased by 140.2% and oil and natural gas emissions increased by 222.7%.

Figure 3.2 Fugitive emissions, 1990-2014



2006 IPCC guidelines are used for energy sector emission estimation. The methodology for emissions from stationary energy sectors is a mix of T1, T2 and T3 approaches. In transport sector, T1 and T2 approaches have been used. Fugitive emissions were estimated by T1 approach (Table 3.3).

Table 3.3 Summary of methods and emission factors used in energy sector

	CO_2		CH_4		N_2O	
GHG sources and sink categories	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**
1. Energy	T1,T2,T3	CS,D	T1,T2	D	T1,T2	D
A. Fuel combustion	T1,T2,T3	CS,D	T1,T2	D	T1,T2	D
1. Energy industries	T2,T3	CS,D	T2	D	T2	D
2. Manufacturing industries and construction	T1,T2	CS,D	T1	D	T1	D
3. Transport	T1,T2	CS,D	T1,T2	D	T1,T2	D
4. Other sectors	T1,T2	CS,D	T1	D	T1	D
B. Fugitive emissions from fuels	T1	D	T1	D	T1	D
1. Solid fuels	NA	NA	T1	D	NA	NA
2. Oil and natural gas	T1	D	T1	D	T1	D
C. CO_2 transport and storage	T1	D	-	-	-	-

Country specific carbon contents of liquid, solid and gaseous fuels are used for CO_2 emissions estimation. For CH_4 and N_2O emissions, 2006 IPCC default emissions factors are used.

3.2. Fuel Combustion (Sector 1.A)

The major source of GHGs in Turkey is the fossil fuel combustion. The emissions from fossil fuel combustion are calculated by TurkStat with cooperation with the MENR and the MTMAC. The emissions from electricity generation were calculated by MENR and the emissions from transport were calculated by MTMAC, and the other energy sub-sectors were calculated by TurkStat. 2006 IPCC guidelines were used in emissions estimation for all energy subcategories.

The emissions from fuel combustion excepting energy industries are calculated by using the energy-balance tables produced by the MENR. Energy balance tables are prepared in both the original mass units as kt and energy units as ktoe.

The emissions from public electricity and heat production (1A1a) are calculated on the basis of plant specific fuel consumption and net calorific values (NCVs) with country specific carbon contents of fuels. For petroleum refining sector, fuel data, NCV and carbon content of fuels were compiled directly from the refineries. In the same way for manufacture of solid fuels (1A1c) categories, plant specific AD and plant specific carbon content were used in the emission estimation.

Emissions from manufacturing industry and construction and other sectors were estimated by using energy balance tables and country specific carbon contents of fuels.

Transportation sector consists of road transportation, domestic civil aviation, railways, domestic navigation and pipeline transportation. Data availability in road transportation, navigation sector and railways allows mostly T1 methodology in the estimations. Country specific carbon content of diesel oil and residual fuel oil are used for CO_2 emission estimations but for gasoline and liquefied petroleum gas (LPG) 2006 IPCC default emission factors are used. CO_2 emissions from diesel oil were 78% of total road transportation, and 21.6% from LPG and gasoline. T2 methodology was used for the calculation of emissions from civil aviation. Also T2 methodology was used for the calculation of CO_2 emissions from pipeline transportation

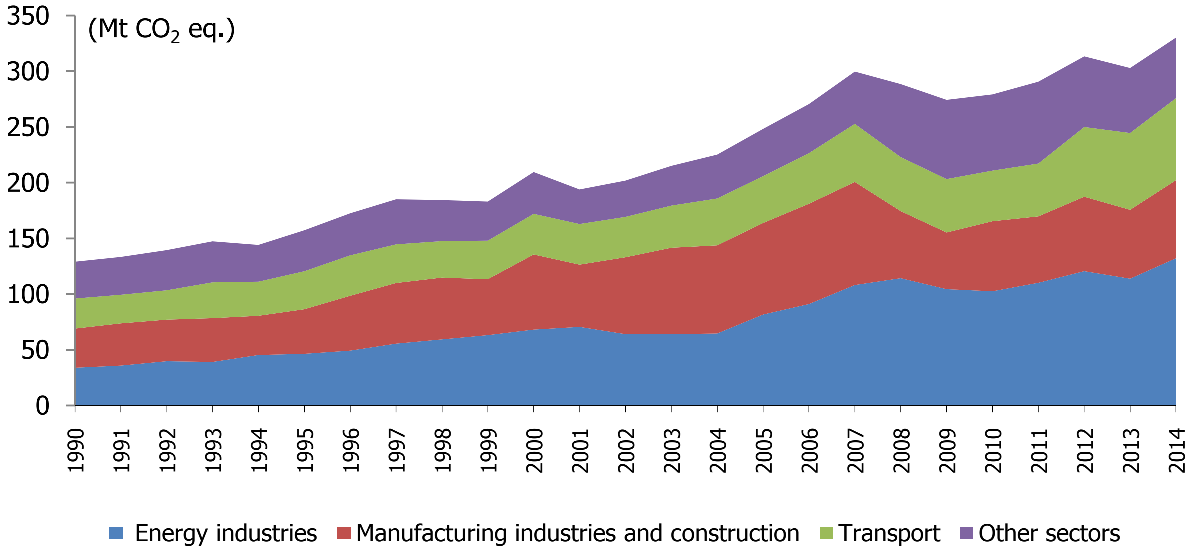
CO_2, CH_4 and N_2O emissions from fuel combustion were calculated for the period 1990-2014.

Table 3.4 Emissions from fuel combustion, 1990-2014

(kt)

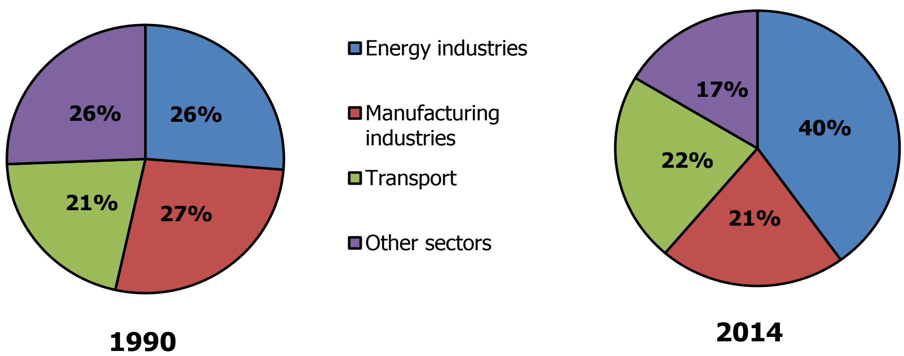
Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	124 376	140	4.3	129 154
1991	128 636	141	4.3	133 430
1992	134 644	144	4.4	139 555
1993	142 495	141	4.8	147 445
1994	139 577	130	4.7	144 219
1995	152 501	135	5.0	157 353
1996	167 662	134	5.3	172 594
1997	180 103	140	5.3	185 187
1998	179 674	131	5.3	184 513
1999	178 543	123	5.1	183 139
2000	205 024	123	5.2	209 658
2001	189 834	110	4.8	194 007
2002	197 727	111	4.9	201 964
2003	210 874	114	5.0	215 196
2004	220 888	116	5.1	225 314
2005	243 937	115	5.3	248 370
2006	266 193	114	5.5	270 699
2007	295 185	117	5.8	299 841
2008	282 922	162	5.5	288 617
2009	268 411	178	5.4	274 455
2010	273 374	177	5.2	279 355
2011	285 484	150	5.1	290 758
2012	307 989	151	5.8	313 505
2013	297 462	149	6.2	303 048
2014	325 325	125	6.5	330 385

Figure 3.3 CO_2 emissions from fuel combustion, 1990-2014



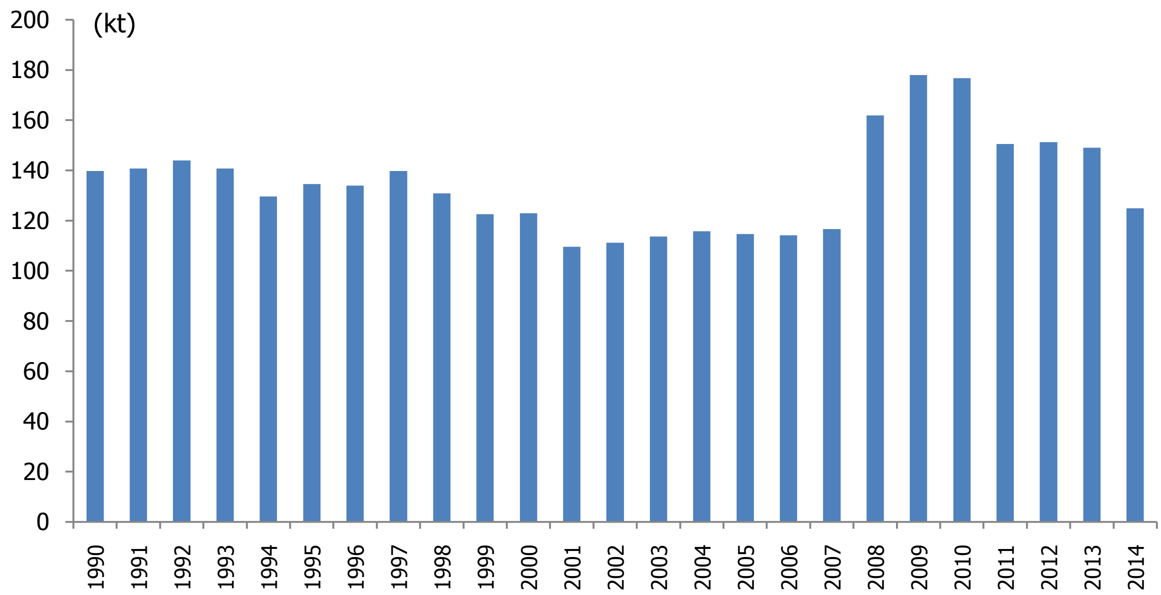
Energy industry has the highest share in total CO_2 emission from fuel combustion in 2014. It is followed by transport, manufacturing industries and other sectors (Figure 3.4).

Figure 3.4 CO_2 emissions from fuel combustion by sectors, 1990 and 2014



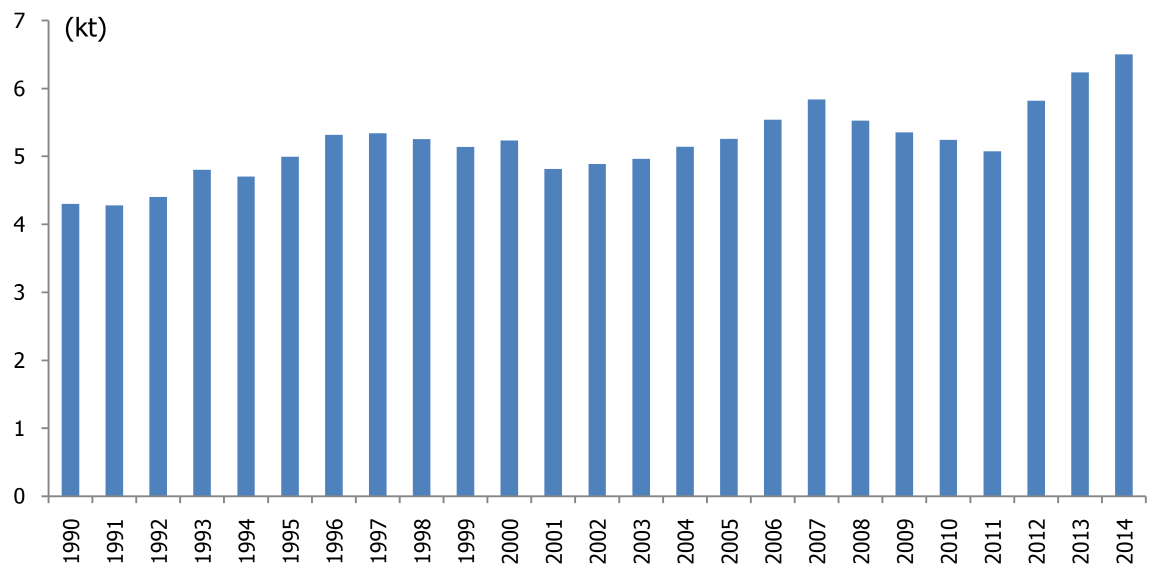
Trends in CH_4 emission from fuel combustion is given in Figure 3.5.

Figure 3.5 CH_4 emissions from fuel combustion, 1990-2014



Trends in N_2O emission from fuel combustion is given in Figure 3.6.

Figure 3.6 N_2O emissions from fuel combustion, 1990-2014



3.2.1. Comparison of the sectoral approach with reference approach

The IPCC Reference Approach is a top down inventory based on production, imports, exports, stock change and international bunker consumption of fuels.

IPCC 2006 methodology is used for reference approach CO_2 estimation. The estimation based on the apparent consumption of fuels in the country. The apparent consumption of primary fuels have been calculated using the following formula:

Apparent consumption= Domestic production + imports - exports - change (increase/decrease) in stocks- international bunkers

Apparent consumption of secondary fuels have been calculated using the following formula:

Apparent consumption= imports - exports - change (increase/decrease) in stocks- international bunkers

The apparent consumption are need to be adjusted for feedstock's and non energy use of fuels. Also the amount of fuel used for iron and steel production and NH_3 production of which emissions are allocated under IPPU sector should be deducted. Process emissions from blast furnaces and steel production, which are included in category 2.C Metal Production and process emissions from ammonia-production which are included in category 2.B.1 Ammonia Production are deducted from Reference Approach.

Domestic production, import, export, stock change and international bunkers have been taken from national energy balance tables for all primary fuels and petroleum products except non energy use of fuels and feedstock's. The national energy balance tables provide non energy use of fuels and feedstock's in aggregated form but not in fuel type detail. However, the Reference approach requires non energy use of fuels and feedstock's in a more disaggregated level. Therefore gross delivery amounts of non energy use of fuels are taken from dataset sent to IEA via Oil Questionnaire. Energy conversion factors have been calculated using primary energy supply amounts for solid and gaseous fuels, and final energy consumption figures provided in the national balance tables in both original mass units (kt) and energy units (ktoe). Dividing ktoe amounts by kt amounts and converting the results to TJ/kt average conversion factors are obtained. Conversion factors used for reference approach are given below.

Table 3.5 Conversion factors (Reference approach)

Fuel types	Unit	1990	1995	2000	2005	2010	2011	2012	2013	2014
Crude Oil	TJ/kt	43.06	43.17	43.65	43.56	43.67	43.67	43.54	43.82	45.25
Gasoline	TJ/kt	44.80	44.80	44.80	44.80	44.80	44.80	44.80	44.80	44.80
Jet Kerosene	TJ/kt	44.59	44.59	44.59	44.59	44.59	44.59	44.59	44.59	44.59
Other Kerosene	TJ/kt	43.75	43.75	43.75	43.75	43.75	43.75	43.75	43.75	43.75
Gas / Diesel Oil	TJ/kt	43.33	43.33	43.33	43.33	43.33	43.33	43.33	43.33	43.33
Residual Fuel Oil	TJ/kt	40.19	40.19	40.19	40.19	40.19	40.19	40.19	40.19	40.19
LPG	TJ/kt	47.31	47.31	47.31	47.31	47.31	47.31	47.31	47.31	47.31
Naphtha	TJ/kt	45.01	45.01	45.01	45.01	45.01	45.01	45.01	45.01	45.01
Bitumen	TJ/kt	40.19	40.19	40.19	40.19	40.19	40.19	40.19	40.19	40.19
Lubricants	TJ/kt	40.19	40.19	40.19	40.19	40.19	40.19	40.19	40.19	40.19
Petroleum Coke	TJ/kt	31.82	32.27	32.24	32.24	31.55	31.36	31.72	32.84	31.86
Refinery Feedstocks	TJ/kt	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00
Other Oil	TJ/kt	40.19	40.19	40.19	40.19	40.19	40.19	40.19	40.19	40.19
Coking Coal	TJ/kt	31.43	28.92	26.79	26.98	25.35	26.60	27.04	26.29	26.91
Other Bit. Coal	TJ/kt	31.43	28.92	26.79	26.98	25.35	26.60	27.04	26.29	26.91
Sub-bit. Coal	TJ/kt	18.00	18.00	18.00	18.00	18.41	19.54	22.72	22.72	20.41
Lignite	TJ/kt	8.91	8.47	8.14	6.90	9.30	9.30	9.44	10.00	9.91
Coke Oven/Gas Coke	TJ/kt	30.58	29.61	29.31	29.31	26.53	28.66	28.10	28.85	28.22
Coal Tar	TJ/kt	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00
Natural Gas (Dry)	TJ/MSm^3	34.35	34.35	34.35	34.35	34.56	34.56	34.57	34.54	34.54

The same country specific carbon content of liquid, solid and gaseous fuels were used as sectoral approach. For biomass and other fossil fuels 2006 IPCC guidelines default carbon contents were used.

Table 3.6 CO_2 emissions from fuel combustion, 1990-2014

(kt)

	Reference approach					Sectoral approach				
Year	Liquid fuels (excluding international bunkers)	Solid fuels (excluding international bunkers)	Gaseous fuels	Other fossil fuels	Total	Liquid fuels (excluding international bunkers)	Solid fuels (excluding international bunkers)	Gaseous fuels	Other fossil fuels	Total
1990	71 055	56 178	5 932	NO	133 164	61 053	56 574	6 750	NO,IE	124 376
1991	56 452	53 035	7 444	NO	116 931	59 732	60 592	8 312	NO,IE	128 636
1992	66 908	57 353	8 239	NO	132 500	64 273	61 267	9 105	NO,IE	134 644
1993	76 375	57 993	9 409	NO	143 777	74 383	57 974	10 138	NO,IE	142 495
1994	73 678	62 268	10 559	NO	146 505	71 994	56 953	10 629	NO,IE	139 577
1995	81 581	63 279	13 160	1	158 021	79 491	59 215	13 794	1	152 501
1996	86 733	68 682	15 631	5	171 051	83 541	68 031	16 084	5	167 662
1997	86 103	77 872	19 149	9	183 133	83 305	76 757	20 032	9	180 103
1998	82 094	83 746	20 713	12	186 564	79 013	80 138	20 512	12	179 674
1999	79 954	78 240	25 688	17	183 899	80 176	72 784	25 566	17	178 543
2000	92 405	81 769	30 735	42	204 952	86 764	86 284	31 933	42	205 024
2001	81 503	65 885	33 042	41	180 471	83 264	72 103	34 426	41	189 834
2002	86 502	76 262	33 460	34	196 258	85 095	75 617	36 982	34	197 727
2003	87 498	82 420	41 054	48	211 020	86 156	79 969	44 701	48	210 874
2004	90 847	79 192	43 211	48	213 298	89 495	83 892	47 454	48	220 888
2005	84 456	87 183	53 805	79	225 524	91 228	91 302	61 328	79	243 937
2006	82 735	102 502	61 611	89	246 937	88 405	107 093	70 606	89	266 193
2007	85 022	114 998	72 924	174	273 117	92 900	120 827	81 285	174	295 185
2008	79 423	115 089	75 067	190	269 769	86 599	118 013	78 120	190	282 922
2009	72 058	123 115	70 315	329	265 817	81 921	116 703	69 458	329	268 411
2010	76 645	113 693	74 698	472	265 509	79 434	122 317	71 151	472	273 374
2011	81 585	124 468	83 634	586	290 273	82 143	117 783	84 972	586	285 484
2012	87 709	137 506	90 332	856	316 403	89 603	129 664	87 866	856	307 989
2013	91 311	124 164	86 877	1 214	303 567	95 440	113 776	87 032	1 214	297 462
2014	98 788	133 009	96 298	1 284	329 379	96 131	131 867	96 043	1 284	325 325

Figure 3.7 CO_2 emissions, 1990-2014

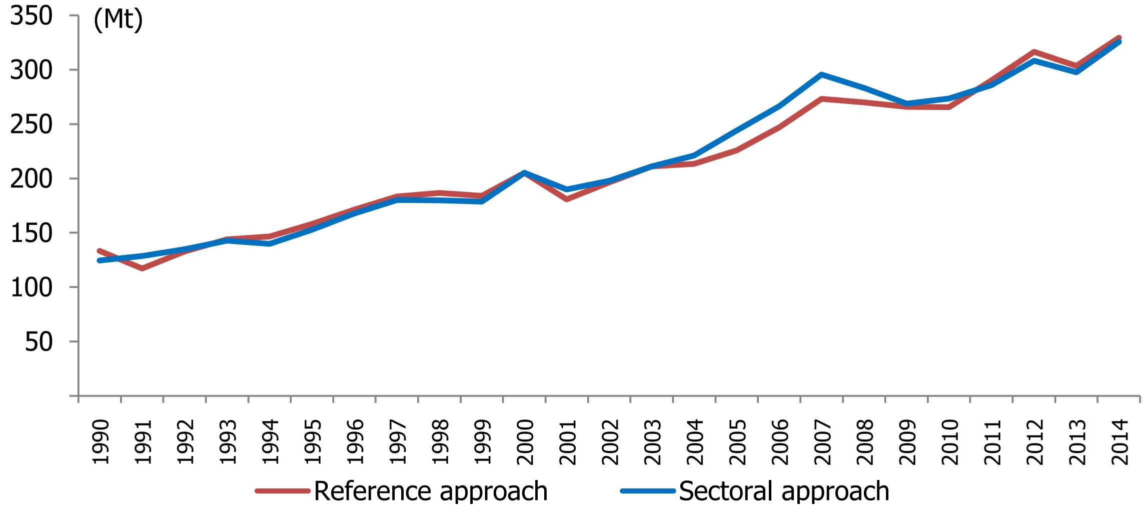


Table 3.7 Comparison of CO_2 from fuel combustion

(%)

Year	Liquid fuels (excluding international bunkers)	Solid fuels (excluding international bunkers)	Gaseous fuels	Other fossil fuels	Total
1990	16.38	-0.70	-12.12	NO,IE	7.07
1991	-5.49	-12.47	-10.45	NO,IE	-9.10
1992	4.10	-6.39	-9.51	NO,IE	-1.59
1993	2.68	0.03	-7.19	NO,IE	0.90
1994	2.34	9.33	-0.66	NO,IE	4.96
1995	2.63	6.86	-4.60	0.00	3.62
1996	3.82	0.96	-2.82	0.00	2.02
1997	3.36	1.45	-4.41	0.00	1.68
1998	3.90	4.50	0.98	0.00	3.83
1999	-0.28	7.50	0.48	0.00	3.00
2000	6.50	-5.23	-3.75	0.00	-0.04
2001	-2.12	-8.62	-4.02	0.00	-4.93
2002	1.65	0.85	-9.52	0.00	-0.74
2003	1.56	3.06	-8.16	0.00	0.07
2004	1.51	-5.60	-8.94	0.00	-3.44
2005	-7.42	-4.51	-12.27	0.00	-7.55
2006	-6.41	-4.29	-12.74	0.00	-7.23
2007	-8.48	-4.82	-10.29	0.00	-7.48
2008	-8.29	-2.48	-3.91	0.00	-4.65
2009	-12.04	5.49	1.23	0.00	-0.97
2010	-3.51	-7.05	4.99	0.00	-2.88
2011	-0.68	5.68	-1.57	0.00	1.68
2012	-2.11	6.05	2.81	0.00	2.73
2013	-4.33	9.13	-0.18	0.00	2.05
2014	2.76	0.87	0.27	0.00	1.25

Explanation of differences:

While converting to common energy units, the reference approach multiplies the apparent fuel consumption by a single conversion factor. On the other hand each fuel has different heat content. Sectoral approach uses sector specific heat value provided in the energy balance tables.

In sectoral approach fuel consumption and NCVs of 1A1 category have been collected directly from the end users (from electricity producers, refineries and coke producers). It brings differences between the sectoral and reference approaches due to the plant level NCVs is differ from average NCVs used in energy balance tables.

Big differences (more than 5%) have been highlighted especially in 1990, 1991, 2005, 2006, and 2007. The differences are mainly related to gaseous fuels and sometimes liquid fuels. No obvious reasons for those differences have been found and still been investigated.

3.2.2. International bunker fuels

3.2.2.1. International aviation

The fuel type used in international aviation is jet kerosene. Table 3.8 shows the trend in emissions of CO_2, CH_4, N_2O from international aviation between 1990 and 2014.

GHG emissions from international aviation have an increasing trend in relation to growth in international aviation sector. CO_2 emissions were 9.9 Mt in 2014 while it was 0.6 Mt in 1990. In 2014, CH_4 and N_2O emissions were 69 tonnes and 278 tonnes respectively.

Emissions from international aviation were calculated using the T1 methodology given in 2006 IPCC guideline. Energy balance tables were used for AD.

Table 3.8 Emissions and fuel for international aviation, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq (kt)	Aviation bunkers (TJ)
1990	552	0.004	0.015	556	7 718
1991	716	0.005	0.020	722	10 011
1992	804	0.006	0.022	811	11 246
1993	977	0.007	0.027	986	13 671
1994	788	0.006	0.022	795	11 025
1995	807	0.006	0.023	814	11 290
1996	1 003	0.007	0.028	1 011	14 024
1997	1 368	0.010	0.038	1 380	19 139
1998	1 523	0.011	0.043	1 536	21 300
1999	1 514	0.011	0.042	1 526	21 168
2000	1 599	0.011	0.045	1 612	22 359
2001	1 592	0.011	0.045	1 606	22 271
2002	2 649	0.019	0.074	2 671	37 044
2003	2 762	0.019	0.077	2 786	38 632
2004	2 977	0.021	0.083	3 002	41 630
2005	3 330	0.023	0.093	3 358	46 570
2006	3 014	0.021	0.084	3 040	42 160
2007	3 731	0.026	0.104	3 762	52 177
2008	4 991	0.035	0.140	5 034	69 810
2009	5 255	0.037	0.147	5 299	73 493
2010	5 858	0.041	0.164	5 908	81 937
2011	6 769	0.047	0.189	6 827	94 671
2012	7 684	0.054	0.215	7 750	107 473
2013	8 661	0.061	0.242	8 734	121 129
2014	9 922	0.069	0.278	10 007	138 775

3.2.2.2. International navigation

The fuel type used in international navigation is diesel oil and residual fuel oil. Table 3.9 shows the trend in emissions of CO_2, CH_4 and N_2O from international navigation between 1990 and 2014.

GHG emissions from international navigation have an increasing trend in relation to growth in international navigation sector. CO_2 emissions were 3.3 Mt in 2014 while it was 0.4 Mt in 1990. In 2014, CH_4 and N_2O emissions were 294 tonnes and 84 tonnes respectively.

Emissions from international navigation were calculated using the T1 and T2 methodology given in 2006 IPCC guideline. Country specific carbon content is used for CO_2 emission estimation. 2006 IPCC default EFs are used for CH_4 and N_2O emissions. Energy balance tables were used for AD.

Table 3.9 Emissions and fuel for international navigation, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Navigation bunkers (TJ)
1990	379	0.035	0.010	383	5 035
1991	424	0.039	0.011	428	5 622
1992	348	0.032	0.009	351	4 626
1993	313	0.029	0.008	316	4 148
1994	351	0.033	0.009	355	4 656
1995	588	0.055	0.016	594	7 819
1996	395	0.037	0.011	399	5 248
1997	503	0.047	0.013	508	6 658
1998	509	0.047	0.013	514	6 689
1999	895	0.083	0.024	904	11 810
2000	1 280	0.118	0.034	1 293	16 861
2001	749	0.069	0.020	757	9 848
2002	1 691	0.156	0.045	1 709	22 334
2003	1 967	0.183	0.052	1 987	26 127
2004	3 171	0.294	0.084	3 204	41 988
2005	3 380	0.312	0.089	3 414	44 586
2006	3 129	0.287	0.082	3 161	41 059
2007	2 356	0.212	0.061	2 379	30 323
2008	2 326	0.211	0.060	2 349	30 114
2009	2 854	0.257	0.074	2 883	36 737
2010	2 408	0.217	0.062	2 432	31 058
2011	1 952	0.176	0.050	1 971	25 160
2012	2 619	0.237	0.068	2 645	33 786
2013	2 893	0.261	0.075	2 922	37 316
2014	3 261	0.294	0.084	3 293	41 958

3.2.3. Feedstocks and non-energy use of fuels

AD and emissions associated with the non-energy use of fuels are not reported within the fuel combustion subsector. In accordance with the 2006 IPCC Guidelines, they are reported under the IPPU sector.

Based on 2006 IPCC guidelines;

Coke where used as a reductant in the integrated coke/iron and steel production, and hard coal (other bituminous coal), natural gas used and other carbonaceous fuels used in the integrated coke/iron and steel production and electric arc furnaces (EAF) have been reported in 2.C.1 Iron and Steel Production. So those fuels have been deducted from total CO_2 emissions in the reference approach.

Natural gas used in Ammonia production — reported in 2.B.1;

Also, lubricants, bitumen, solvents reported as non energy use fuels are considered in the reference approach and carbon stored is subtracted from total CO_2 emissions.

In the national energy balance tables, feedstock and non-energy use of fuels are given separately and those consumption are not included in fuel consumptions. Naphta is given as feedstock in the national energy balance tables. Fuels used for non energy purposes are lubricants, bitumen, solvents etc. but they are not given separately in the national energy balance tables. They are given as aggregated form under "other petroleum products". In the sectoral approach feedstock and non-energy use of fuel are not considered since they are not included in sectoral fuel consumption in the national energy balance tables.

On the other hand feedstock and non-energy use of fuels are reported by the MENR to the IEA in detail manner. For this reason mainly data sent to IEA via petrol questionnaire were used as AD. Only Naphta was used from national energy balance tables.

Non energy use of fuels was considered for CO_2 emissions estimation in the reference approach.

3.2.4. Energy industries (Category 1.A.1)

Source Category Description:

This source category includes the emission from the public electricity and heat production, petroleum refining and manufacture of solid fuels in Turkey. This category is one of the main emission sources in Turkey. The share of GHG emissions as CO_2 eq. from energy industries in total fuel combustion was 40% in 2014 while it was 26.3% in 1990.

Table 3.10 GHG emissions from energy industries, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	33 820	0.46	0.35	33 937	364 970
1991	35 767	0.47	0.37	35 890	384 683
1992	39 657	0.54	0.43	39 798	423 471
1993	39 021	0.54	0.42	39 159	418 700
1994	45 216	0.61	0.50	45 379	484 192
1995	46 294	0.66	0.49	46 457	501 856
1996	49 144	0.70	0.53	49 319	531 065
1997	55 379	0.80	0.59	55 577	602 916
1998	59 213	0.84	0.64	59 425	638 881
1999	63 003	0.90	0.65	63 219	702 588
2000	67 961	1.03	0.69	68 192	783 869
2001	70 389	1.05	0.69	70 620	812 157
2002	63 927	0.96	0.58	64 124	752 596
2003	63 869	0.95	0.56	64 059	774 460
2004	64 525	0.93	0.58	64 721	780 581
2005	81 458	1.13	0.73	81 703	980 485
2006	90 864	1.30	0.80	91 136	1 093 114
2007	107 898	1.57	0.96	108 222	1 303 275
2008	114 005	1.64	1.02	114 351	1 373 309
2009	104 191	1.51	0.91	104 501	1 276 401
2010	102 303	1.50	0.90	102 609	1 258 901
2011	109 894	1.44	0.94	110 211	1 308 045
2012	120 299	1.72	1.10	120 669	1 495 435
2013	113 561	1.65	1.01	113 904	1 428 726
2014	131 838	1.81	1.23	132 248	1 665 533

Methodological Issues:

2006 IPCC guidelines T2 and T3 approaches were used for emission calculation in energy industries. The emissions from public electricity and heat production (1A1a) are calculated on the basis of plant specific fuel consumption and NCVs with country specific carbon contents of fuels. For petroleum refining sector, fuel data, NCV and carbon content of fuels were compiled directly from the refineries. For manufacture of solid fuels (1A1c) category, plant specific AD and carbon content were used in the emission estimation.

Emissions from CRF category 1A1a, have been estimated by the MENR by using 2006 IPCC T2 and T3 approaches. Plant-specific net NCVs were used to calculate heat values that led to emissions. Fuel consumption and NCVs of fuels are compiled from every single unit by the Ministry. Carbon contents of fuels were calculated by using fuel analysis reports and oxidation rates were calculated by using ash and slag analysis reports for solid fuels, and stack gas analysis reports for liquid and gaseous fuels. CO_2 emissions from liquid, solid and gaseous fuels used in public electricity and heat production (1A1a) were calculated by using country specific carbon content of fuels and oxidation rates. For biomass and other fossil fuels on the other hand, default carbon contents and oxidation rates were used given in the 2006 IPCC guidelines. CH_4 and N_2O emissions from CRF category 1A1a, have been estimated by using plant specific fuel consumption and NCVs with IPCC default EFs.

Emissions from petroleum refining (CRF 1A1b) were calculated according to 2006 IPCC T2 approach by TurkStat. Fuel consumption, NCVs and carbon content of fuels were compiled directly from refineries. CO_2 emissions from 1A1b were calculated by using average carbon contents of fuels used in the refineries with IPCC default oxidation rates. CH_4 and N_2O emissions from CRF category 1A1b, have been estimated by using refineries total fuel consumption and average NCVs for refineries with IPCC default EFs.

Emissions from manufacture of solid fuels (CRF 1A1c) were calculated according to 2006 IPCC T3 approach by TurkStat. Coke production in integrated iron and steel production plants have been considered in this category. Plant specific fuel consumption, NCVs and carbon content of fuels were compiled from each plant. CO_2 emissions from 1A1c were calculated by using plant specific AD, carbon contents of fuels and IPCC default oxidation rates. CH_4 and N_2O emissions from CRF category 1A1c, have been estimated by using plant specific fuel consumption and IPCC default EFs for NCVs.

Recalculation:

There is no recalculation in energy industry category.

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

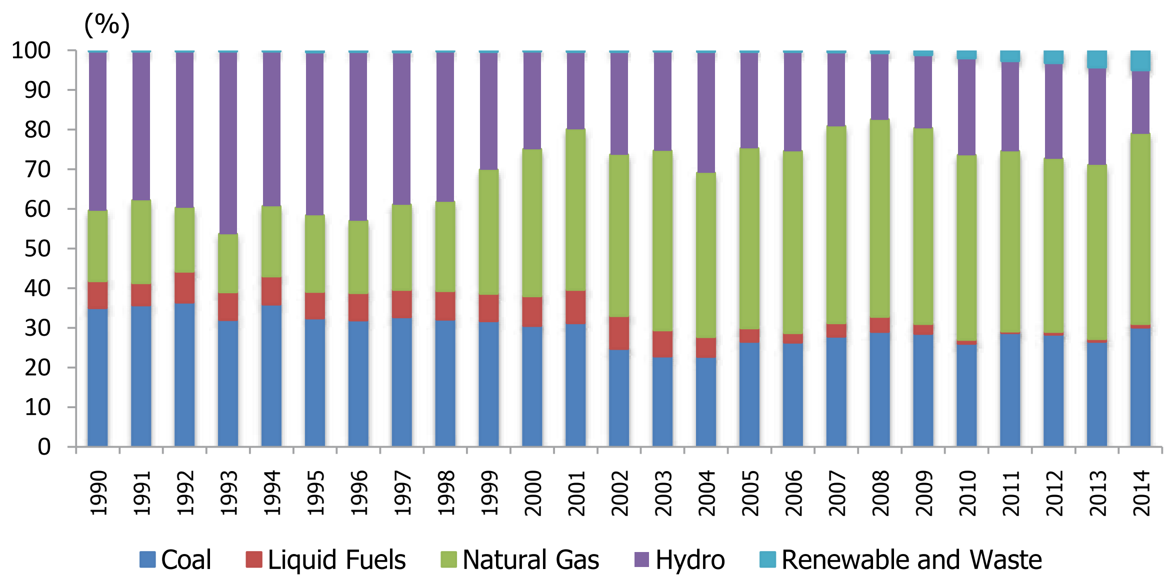
Source Category Description:

The source category public electricity and heat production was a key category in terms of emission level of CO_2 from liquid, solid and gaseous fuels in 2014. This category was also a key category in terms of emission trend of CO_2 from solid fuels. The data under public electricity and heat production category, include electricity and heat production of all electricity generation installations in operation excluding autoproducers. Autoproducers are the facilities that produce electricity that they use for their own purposes. Their AD are taken under the related industry subcategory they belong to in order to avoid double counting for the whole time series. For 1.A.1.a sector AD are gathered from every single plant via questionnaires.

In 2014, electricity production kept its major role in GHG emissions. Total installed capacity reached to 69.52 GW with 4.4% increase from the previous year and more than four times higher than 1990 values. The total net electricity consumption has increased in 2014 compared to the previous year. In the year 2014, net consumption was 257.22 TWh meanwhile in 2013 this figure realized as 246.35 TWh. Above mentioned installed capacities and consumption amounts belong to electricity production companies and autoproducers as well. On the other hand, in order to avoid double counting, GHGs arising from the activities of autoproducers are excluded and evaluated under the industrial sector they operate in. Natural gas had a very high share of 47.9% in all electricity production, which was followed by coking coal (15.3%), Turkey lignite (14.5%) hydro and geothermal (17%), other renewables (4%), oil (0.9%) and bitumen (0.4%). Due to drought that even exceeded the summertime, electricity production from hydropower plants decreased almost by 32%. In order to compensate this supply lack, electricity production from solid fossil fuels has increased. To visualize; amount of electricity production from Turkey lignite has increased from 30.26 TWh to 36.61 TWh, whereas this change was from 32.7 TWh to 38.6 TWh for coking coal. Electricity production from natural gas has increased as well, namely from 105.1 TWh to 120.5 TWh.

In 2014 electricity production from fossil fueled thermal power plants has accounted for 200.4 TWh of a total of 251.9 TWh production whilst in 2013 electricity production from fossil fueled thermal power plants had accounted for 171.8 TWh of a total of 240 TWh production Fossil fueled thermal share in electricity production raised from 71% in 2013 to 80% in 2014.

Figure 3.8 Energy mix of category 1.A.1.a, 1990-2014



There was an accelerated increase in wind installed capacity from 2 759.6 MW in 2013 to 3629.7 in the year 2014. Renewable Law which came into force in 2005 later revised in 2011 provided some supporting mechanism for purchasing electricity from solar, biomass, geothermal, wind and hydraulic energy. In the year 2014 solar power plants of 40.2 MWs were installed. The role of voluntary carbon market is important to mention, as many of the wind projects in the country generate and sell the voluntary carbon credits.

Electricity generation from animal and yard waste has increased by 28% compared to the previous year, reaching to 288.1MWs of installed power, generating 1 432.6 GWh of power in 2014.

In 2014, Turkey's Total Primary Energy Supply (TPES) was 5 188 994 TJ, a 2.9% increase compared to 2013. Oil had a share of 1 357 695 TJ while hard coal and natural gas accounted for 846 571 TJ and 1 683 889 TJ respectively.

Figure 3.9 Electricity generation and shares by energy resources, 2013-2014

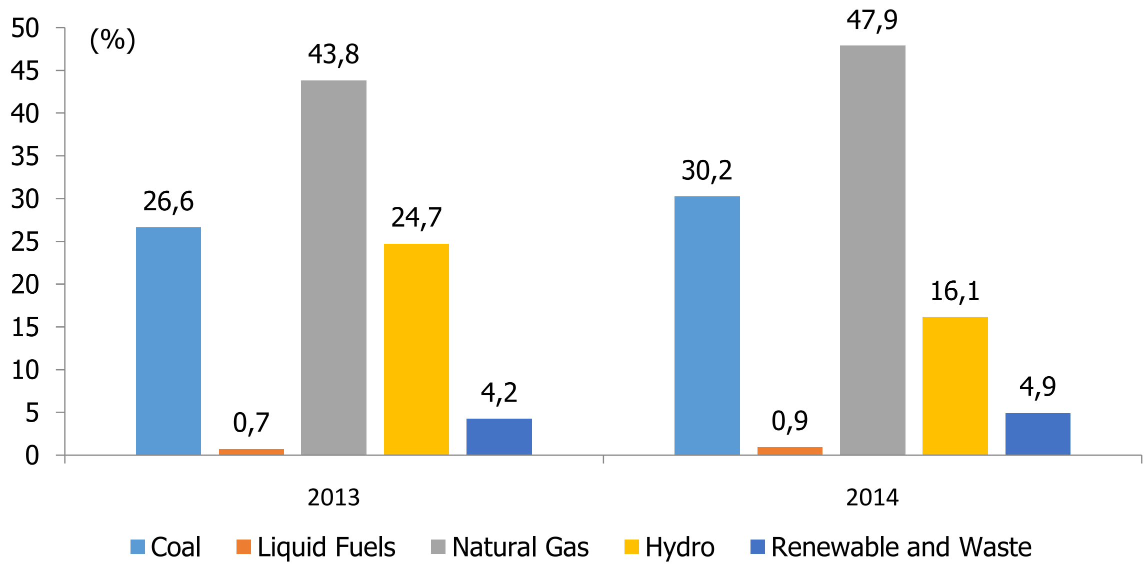
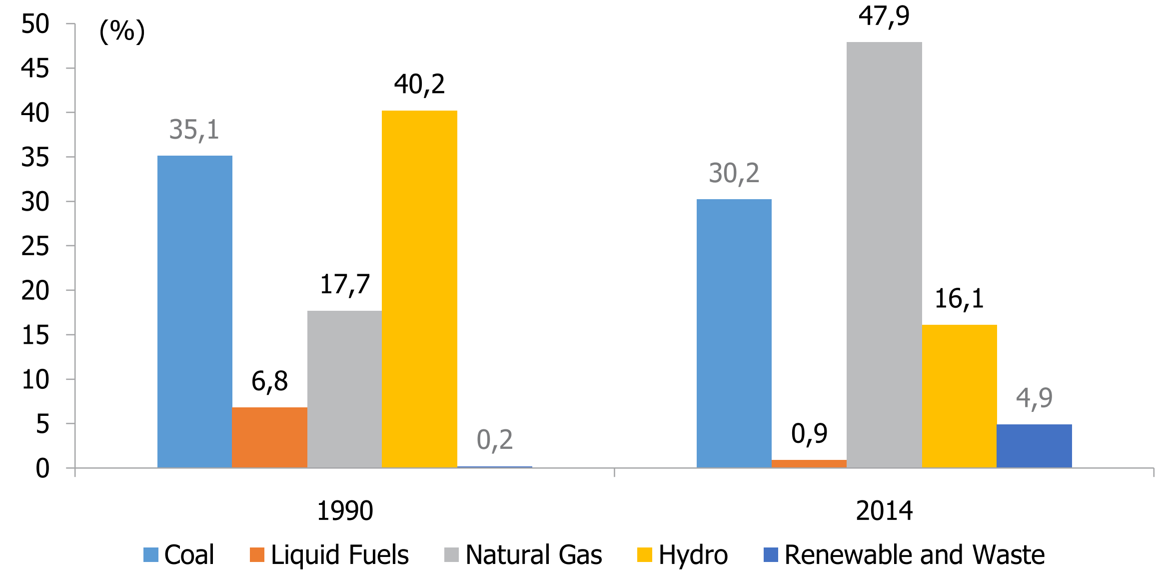


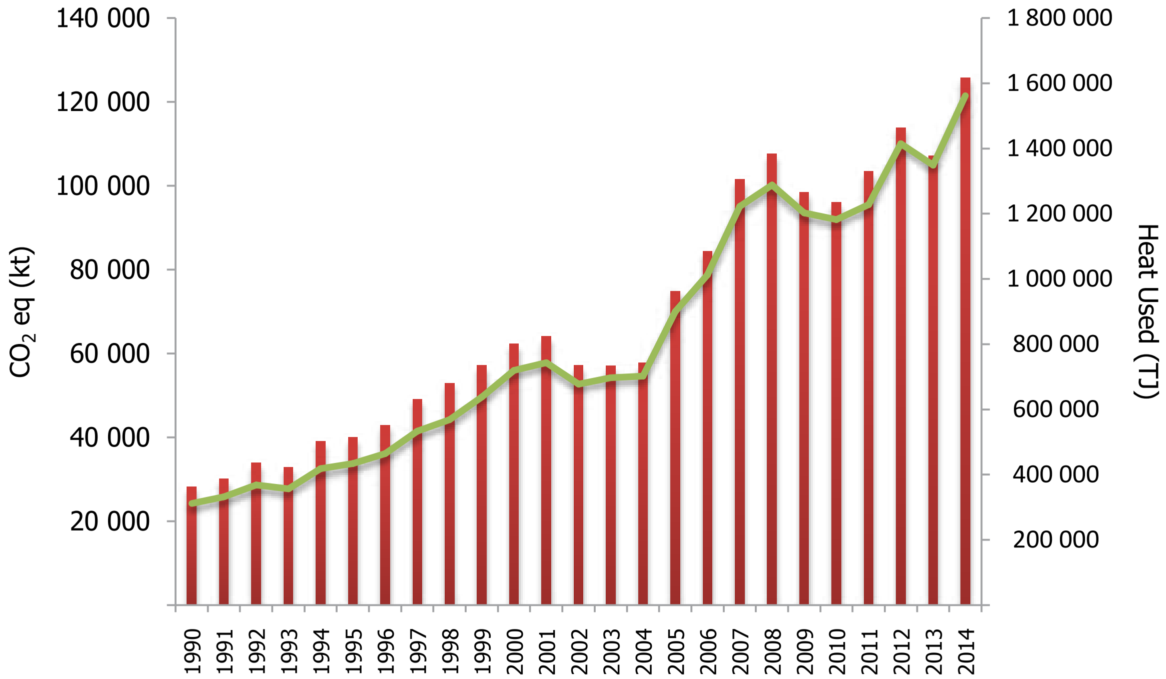
Figure 3.10 Electricity generation and shares by energy resources, 1990 and 2014



Primary energy (domestic) production in 2014 provided 25% of overall energy supply. Import dependency of the country decreased to 75% from previous years' 79.8%.

The production of solid fossil fuels, excluding animal & yard waste, has decreased to 684 918.6 TJ in 2014 from 760 320 TJ in 2013. The m ain domestic energy source remains as Turkey lignite with a production increased by about 8% from 57.52 Mt in 2013 to 62.57 Mt in 2014.

Figure 3.11 Heat used and emissions, 1990-2014



Public electricity and heat production category is one of the main emission sources in Turkey. The share of GHG emissions as CO_2 eq. from public electricity and heat production in total fuel combustion was 35.2% in 2013 while it was 22% in 1990.

Table 3.11 Emissions from category 1A1a, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	28 153	0.34	0.33	28 260	311 311
1991	29 960	0.35	0.35	30 074	331 462
1992	33 790	0.42	0.41	33 922	368 148
1993	32 754	0.41	0.39	32 882	356 162
1994	38 854	0.47	0.47	39 006	417 681
1995	39 805	0.51	0.46	39 957	433 555
1996	42 650	0.56	0.50	42 813	464 099
1997	48 919	0.65	0.57	49 104	533 284
1998	52 679	0.68	0.61	52 879	568 646
1999	56 966	0.76	0.62	57 171	637 921
2000	62 033	0.88	0.66	62 252	719 790
2001	63 891	0.89	0.66	64 110	743 106
2002	56 961	0.79	0.55	57 144	677 258
2003	56 873	0.78	0.53	57 050	697 006
2004	57 609	0.76	0.55	57 791	701 449
2005	74 647	0.97	0.70	74 879	899 938
2006	84 100	1.14	0.78	84 360	1 012 092
2007	101 197	1.40	0.93	101 509	1 222 128
2008	107 283	1.48	1.00	107 617	1 288 101
2009	98 110	1.37	0.89	98 410	1 202 311
2010	95 800	1.38	0.88	96 098	1 182 183
2011	103 085	1.33	0.93	103 395	1 228 020
2012	113 420	1.60	1.08	113 782	1 414 352
2013	106 845	1.54	1.00	107 181	1 348 891
2014	125 335	1.70	1.21	125 739	1 562 105

Methodological Issues:

Activity Data

For source category 1.A.1.a (Public electricity and Heat Production Sector), power plants that produced electricity in the inventory year are examined first with the help of Activity Report of Turkish Electricity Transmission Company (TEİAŞ). Then communication information log is revised. Questionnaires are sent to related electricity production facilities attached to official letter. In these questionnaires there are data cells to be filled by facilities, about electricity production, amount of fuel used, NCV of the fuel used, number of working hours in the related year, content of the original fuel, and content of ash and slag etc. After the completion of first stage of data gathering, sector experts check whether there are data omissions, and then whether the data submitted is sound. Cross checks including fuel capacity factor controls, and examining outliers give some opinion about data reliability. Suspicious data are corrected by getting contact with production facility through e-mails and/or telephone calls.

Once sector experts are assured about data reliability, data entry to the overall calculation table begins. After entering data of every single plant that produced electricity in the related year, heat content of fuels is calculated with plant specific data collected from electricity generation installations. The amount of main fuel used is multiplied by plant specific NCVs to obtain heat values in terms of TJ. Thus plant specific activity data were obtained.

Table 3.12 Emission factors used for CO_2 according to fuel types in 2014

Fuel Type	EF (t/TJ)
Sub-Bituminous Coal	97.43
Biogas	54.60
Natural gas	58.29
Industrial Waste	143.00
Fuel Oil	77.79
Coking Coal	97.44
Turkey Lignite	107.63
Diesel Oil	73.19
Animal Waste	112.00

Heat content of fuels for source category 1.A.1.a was calculated with the plant specific data collected from electricity generation installations, via questionnaires. The amount of main fuel used was multiplied by plant specific NCVs to obtain heat values in terms of TJ. Thus plant specific AD were obtained. The average NCVs are given in the Table 3.13.

Table 3.13 Average NCVs of fuels used in category 1A1a (TJ/kt)

Fuel Type	Weighted average	Default
Sub-Bituminous Coal	21.70	18.90
Biogas	24.29	50.40
Natural gas	50.00	48.00
Residual Fuel Oil	40.59	40.40
Coking Coal	23.70	28.20
Turkey Lignite	7.19	11.90
Diesel Oil	42.60	43.00

The multipliers of EF, namely carbon content and oxidation rates were calculated through fuel analysis and ash-slag analysis reports. For Turkey lignite and coking coal, coal analysis reports were examined.

The mass fraction of carbon in sample was divided by its NCV in order to find carbon content of related solid fuel. For liquid fuels the same procedure was applied through residual fuel oil characteristics and mass percentage of carbon. On the other hand, for natural gas, volumetric fractions of gas concentrations were obtained through gas chromatography analysis. Using density of the gases and some stoichiometry carbon mass amount coming from each gas was calculated and summed up to reach an overall carbon amount. The calculated mass of carbon was then divided by the NCV of examined sample. Oxidation rate of solid fuels was calculated by using the mass percentage of carbon in ash-slag analysis reports. For liquid and gaseous fuels CO measured in the stack gas was used in order to calculate unoxidised carbon's mass percentage and then oxidation rate of related fuel. Some of the analysis reports and calculation steps were shared in Annex 3. For whole time series, analysis reports were used to calculate carbon contents and oxidation rates of the fuels. For some years, however, there was no available data. To cover data gaps, recommendations of Good Practice Guidance (2000) were followed to carry out interpolations and extrapolations. After above mentioned calculations, EFs of solid fuels were obtained for every single year. On the other hand, that of liquid and gaseous fuels was obtained as one unique value for whole time series. To sum up; for CO_2 emissions plant specific AD and country specific EFs were used. For CH_4 and N_2O emissions plant specific AD and default EFs were used. EFs for CO_2 were listed in Table 3.14 for whole time series on fuel basis.

Table 3.14 CO_2 emission factors, 1990-2014

(t/TJ)

Year	Turkey lignite	Coking coal	Diesel oil	Residual fuel oil	Natural gas	Wood-wood waste	Biogas	Industrial waste
1990	106.05	90.76	72.42	76.97	58.23	NO	NO	NO
1991	106.48	90.90	72.42	76.97	58.23	NO	NO	NO
1992	106.90	91.04	72.42	76.97	58.23	NO	NO	NO
1993	107.33	91.18	72.42	76.97	58.23	NO	NO	NO
1994	107.77	91.32	72.42	76.97	58.23	NO	NO	NO
1995	108.20	91.46	72.42	76.97	58.23	NO	NO	143.00
1996	108.64	91.60	72.42	76.97	58.23	NO	NO	143.00
1997	109.09	91.73	72.42	76.97	58.23	NO	NO	143.00
1998	109.54	91.87	72.42	76.97	58.23	NO	NO	143.00
1999	109.99	92.01	72.42	76.97	58.23	NO	NO	143.00
2000	107.90	92.15	72.42	76.97	58.23	NO	NO	143.00
2001	109.41	92.28	72.42	76.97	58.23	NO	NO	143.00
2002	110.94	92.42	72.42	76.97	58.23	NO	NO	143.00
2003	112.47	92.55	72.42	76.97	58.23	NO	NO	143.00
2004	114.01	92.69	72.42	76.97	58.23	NO	NO	143.00
2005	115.63	92.82	72.42	76.97	58.23	NO	NO	143.00
2006	117.13	92.80	72.42	76.97	58.23	111.83	NO	143.00
2007	116.59	93.11	72.42	76.97	58.23	111.83	NO	143.00
2008	116.08	93.42	72.42	76.97	58.23	111.83	NO	143.00
2009	115.56	93.73	72.42	76.97	58.23	111.83	NO	143.00
2010	115.09	94.04	72.42	76.97	58.23	111.83	NO	143.00
2011	115.12	93.91	72.42	76.97	58.23	111.83	NO	143.00
2012	115.12	93.78	72.42	76.97	58.23	111.83	54.63	143.00
2013	115.10	93.65	72.42	76.97	58.23	111.83	54.63	143.00
2014	107.63	97.44	73.19	77.79	58.29	111.83	54.63	143.00

Comparability and Accuracy through Nomenclature Change:

Local lignite of Turkey differs much in its NCV from that of Energy Statistics Handbook and general fuel literature. It is even lower than the lowest of all reporting Parties. Analysis reports support this NCV data of local lignite. Its average carbon content is 30.6 kg/GJ, approaches the upper limit of 2006 IPCC Guideline (31.3 kg/GJ). In order to recharacterise our local lignite, we renamed it as "Turkey lignite" to separate it from literature lignite and therefore avoid misleading comparisons.

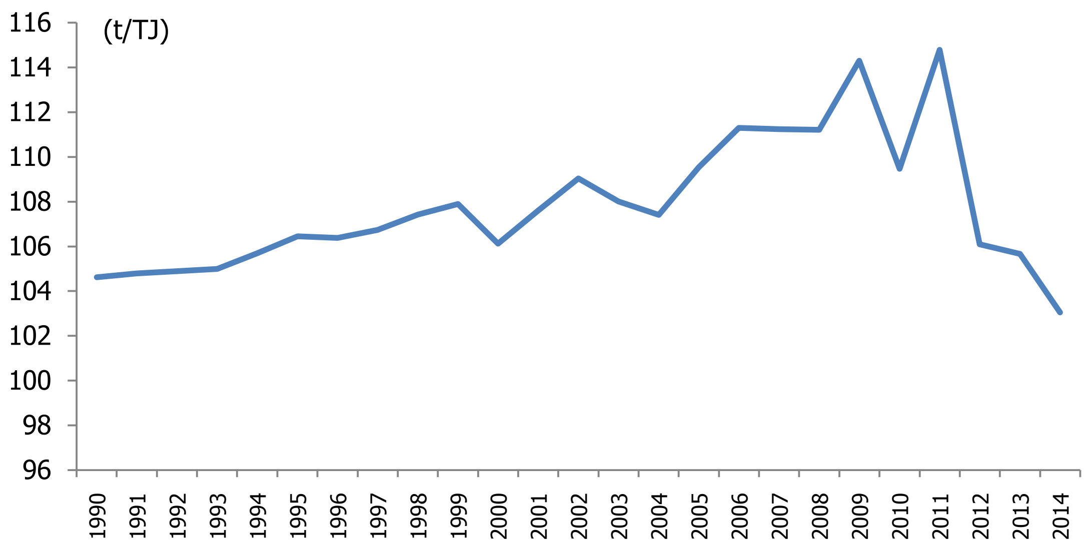
Carbon Capture and Storage in 1.A.1.a, if applicable

CO_2 capture from flue gases and CO_2 storage is not occurring in Turkey, except pilot scaled research fields.

Implied Emission Factor (IEF) Trends and Comments

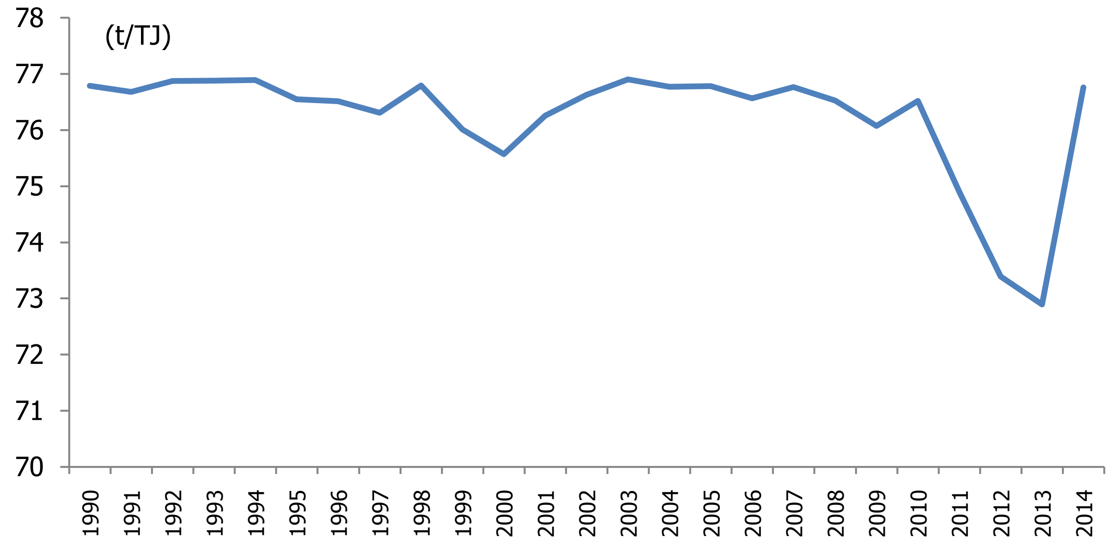
IEFs were examined in the following graphs to see time series consistency for solid, liquid, gaseous fuels and biomass respectively.

Figure 3.12 IEFs of solid fuels used for category 1A1a, 1990-2014



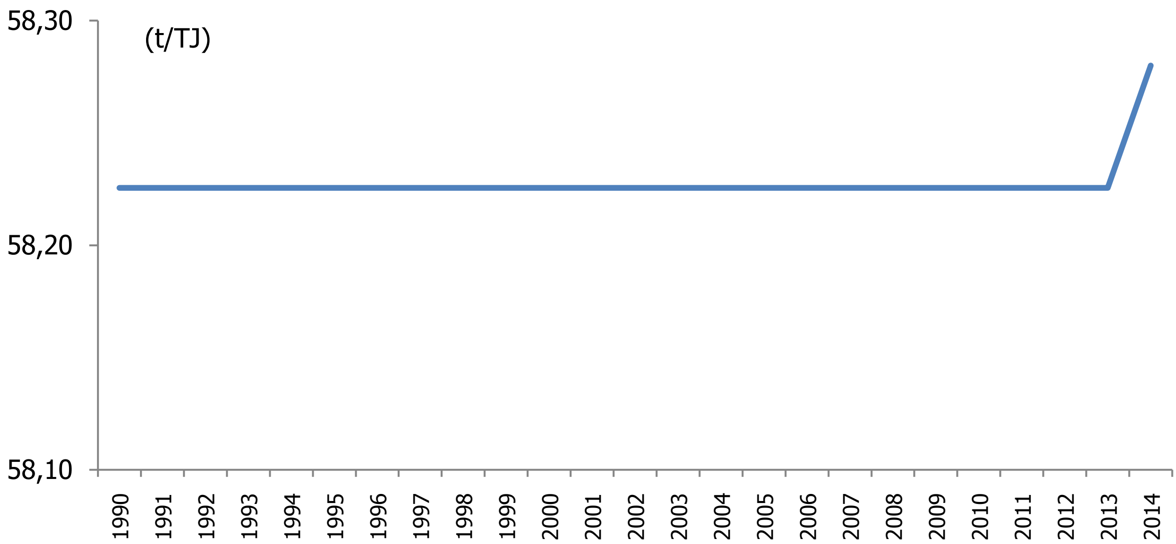
IEFs of CO_2 ranges from 104 to 114 t/TJ. It is mainly because of local Turkey lignite and its share in solid fuels. Different from literature lignite of statistics manual, Turkey's lignite has a very low NCV, about one fifth of that of literature. Also its share in the solid fuels affects the overall IEF causing a dramatic rise and fall like its trend through the years 2009-2011.

Figure 3.13 IEFs of liquid fuels used for category 1A1a, 1990-2014



Liquid fuel mix has dramatically changed from the year 2010 to 2014. This fuel mix change is the main reason for the decrease in IEF between the years 2010-2013. Fueloil share has reached to about 3.5 times of diesel oil in 2014. That is why in 2014 IEF returned to its previous value that approaches that of the year 2010.

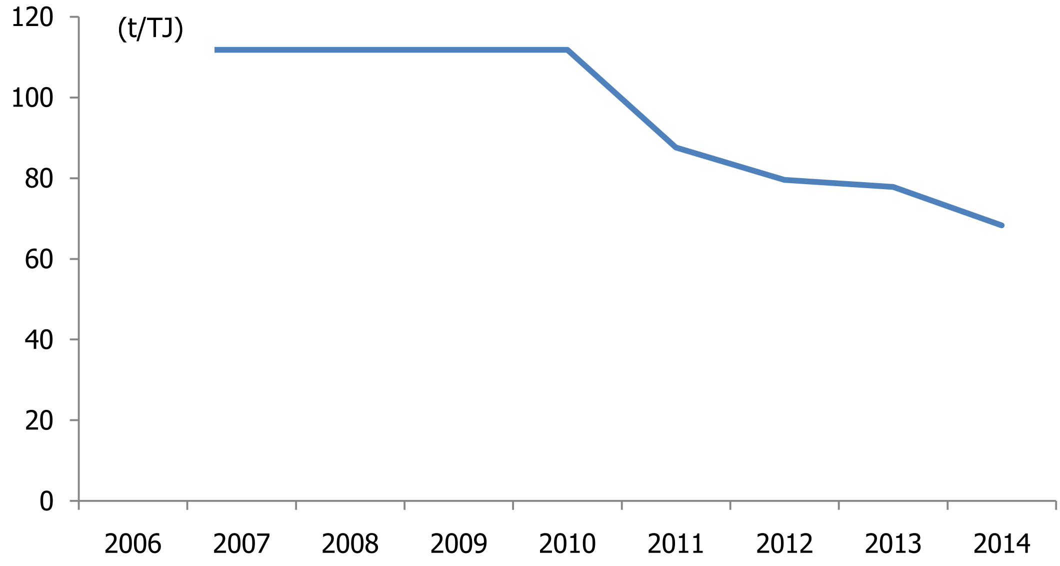
Figure 3.14 IEFs of gaseous fuels used for category 1A1a,1990-2014



IEFs of gaseous fuels do not change considerably over time[1].

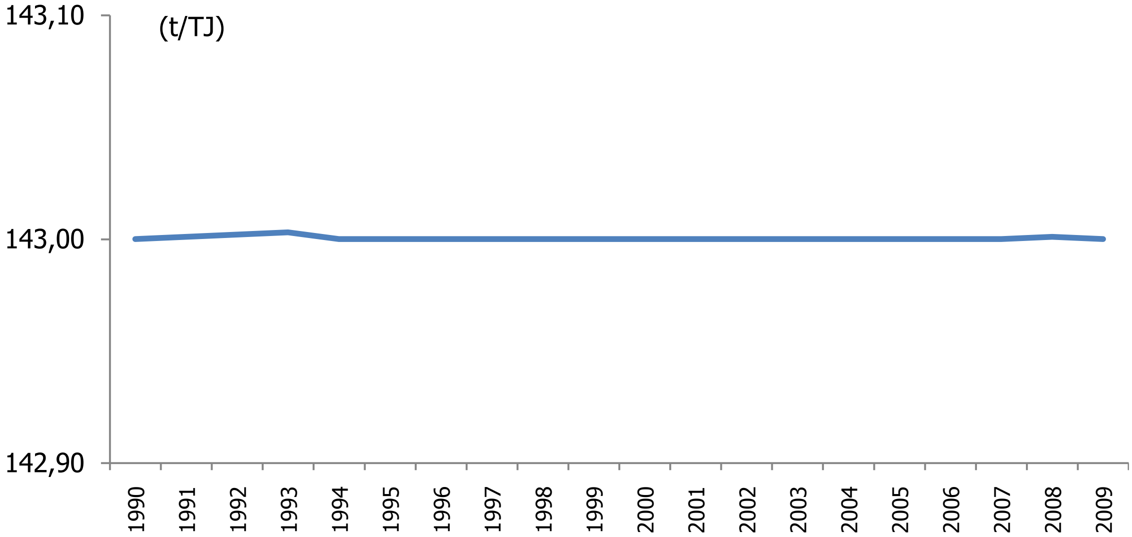
[1] Almost all of the natural gas fuelled power stations have combined heat and power generation status. Therefore we had aimed to enter all of gaseous fuels under 1.A.1.a.ii sub category. However CRF Reporter gave error and child node "gaseous

Figure 3.15 IEFs of biomass used for category 1A1a, 1990-2014



Starting from the year 2011 biogas is also used in electricity production besides wood/wood waste. Therefore the overall CO_2 IEF decreases to 87.6 t/TJ and then to 68.32 t/TJ in 2014. A similar change is seen for CH_4 and N_2O IEFs too.

Figure 3.16 IEFs of waste fuels used for category 1A1a, 1990-2014



fuels" under 1.A.1.a.ii did not work. It is seen in grey as if we have deleted it. It cannot be deleted for days either. We could not solve the problem by conducting through bug reports. So that we decided to place the child node under 1.A.1.a.i instead.

We used "Other Fossil Fuels" node to report data of industrial wastes that consist of clinic and hazardous wastes. The content of the waste makes changes in the IEF accordingly, but again IEF seems to be stable.

Uncertainties and Time-Series Consistency:

AD have been compiled from all public electricity and heat production facilities by MENR via survey. As a result of this survey, missing AD corresponded to %0.1 of total electricity production that was published in Activity Report of TEİAŞ . AD uncertainties were determined by experts of MENR as 3% for liquid, solid, gaseous fuels. For industrial waste, it was determined as 1.76% again from the bias in electricity production declaration between data reported in Activity Report of TEİAŞ and that of producer company. For biomass, since TEİAŞ gathers data of biomass fuelled power plants' data aggregated with renewable and waste, the amount of AD uncertainty was determined according to electricity row of General Energy Balance Tables and questionnaires from the field. Heat values (TJ) from General Energy Balance Tables plus data from questionnaires were together compared with electricity production number of Activity Report of TEİAŞ that was converted into TJs. The resulting uncertainty amount for biomass appeared to be 48.5%. The share of biomass in AD of electricity production in terms of TJs was 0.63%. Taking this ratio into consideration, its effect to overall uncertainty will be slight.

CO_2 emission factors uncertainties:

Solid fuels: Turkey lignite and coking coal have been used as solid fuels in 1A1a category and combined uncertainty for solid fuels was calculated as 3.354102.

Liquid fuels: Residual fuel oil and diesel oil have been used as liquid fuels in 1A1a category and combined uncertainty for liquid fuels was calculated as 4.123105.

Gaseous Fuels: Natural gas has been used as gaseous fuels in 1A1a category and uncertainty for gaseous fuels was calculated as 1.415097.

Biomass: Default EF in 2006 IPCC Guideline on page 1.26 in the landfill gas distribution figure the most frequent EF is 47 000 kg/TJ. Default value that we used for biomass is 54 600 kg/TJ. Bias in between is 13.91%that was taken as uncertainty for biogas. Default EF in 2006 IPCC Guideline on page 1.27 in the wood/wood waste distribution figure the most frequent EF is 103 000 kg/TJ. Default value that we used for wood/wood waste is 112 000 kg/TJ. Bias in between is 8% that was taken as uncertainty for wood/wood waste. These two biomass fuel's uncertainty was combined using weighted average according to generated heat amount. So, the combined uncertainty for biomass is 12.81%. For industrial waste(mainly composed of hazardous and clinic waste) default EF was taken from 2006

IPCC Guideline. On the other hand, there was no default uncertainty value for industrial waste EF throughout the guideline.

EFs uncertainty for CH_4 and N_2O was considered as 100% (mid value in the range of the abovementioned section of guideline).

Recalculation:

For this inventory year there conducted no recalculation for 1.A.1.a sector.

3.2.4.2. Petroleum refining (Category 1.A.1.b)

Source Category Description:

All petroleum refineries were covered in CRF category 1A1b. Autoproducers within the refineries were also included in the category. Petroleum refining was a key category in terms of emission level of CO_2 from liquid and gaseous fuels in 2014. This category was also a key category in terms of emission trend of CO_2 from liquid fuels. The share of GHG emissions as CO_2 eq. from petroleum refining in total fuel combustion was 1.4% in 2014 while it was 2.5% in 1990.

Table 3.15 Emissions from petroleum refining, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ	Share in fuel combustion sector %	Fuel combustion total (kt)
1990	3 228	0.110	0.021	3 237	44 089	2.5	129 154
1991	3 118	0.106	0.020	3 126	42 699	2.3	133 430
1992	3 304	0.109	0.020	3 313	45 990	2.4	139 555
1993	3 825	0.125	0.023	3 835	53 507	2.6	147 445
1994	4 159	0.136	0.025	4 170	58 174	2.9	144 219
1995	4 305	0.140	0.026	4 317	60 275	2.7	157 353
1996	4 197	0.139	0.026	4 208	58 284	2.4	172 594
1997	4 352	0.141	0.026	4 363	61 166	2.4	185 187
1998	4 433	0.146	0.027	4 445	61 641	2.4	184 513
1999	4 119	0.137	0.026	4 130	56 968	2.3	183 139
2000	4 066	0.136	0.026	4 077	56 104	1.9	209 658
2001	4 449	0.148	0.028	4 461	61 562	2.3	194 007
2002	4 838	0.158	0.029	4 851	67 823	2.4	201 964
2003	4 938	0.160	0.030	4 951	69 429	2.3	215 196
2004	5 019	0.161	0.030	5 032	71 039	2.2	225 314
2005	4 994	0.154	0.028	5 006	72 393	2.0	248 370
2006	4 990	0.153	0.027	5 002	72 973	1.8	270 705
2007	4 969	0.154	0.028	4 981	72 918	1.7	299 841
2008	5 076	0.149	0.026	5 088	76 621	1.8	288 617
2009	4 385	0.130	0.023	4 395	65 876	1.6	274 455
2010	4 246	0.109	0.017	4 254	67 634	1.5	279 355
2011	4 336	0.102	0.015	4 343	70 772	1.5	290 758
2012	4 431	0.102	0.015	4 438	71 719	1.4	313 505
2013	4 189	0.096	0.014	4 195	69 431	1.4	303 048
2014	4 506	0.100	0.013	4 512	79 770	1.4	330 385

The increase since 2013 is 317 kt CO_2 eq. (7.6% of increase). The main reason for increasing emissions in this sector is due to increasing liquid fuel (13.03%) and gas fuel consumption (2.27%).

Methodological Issues:

Emissions from petroleum refining (CRF 1A1b) were calculated according to 2006 IPCC T2 approach by TurkStat. Fuel consumption, NCVs and carbon content of fuels were compiled directly from refineries. CO_2 emissions from 1A1b were calculated by using average carbon contents of fuels used in the refineries. IPCC default oxidation rate was used. CH_4 and N_2O emissions from CRF category 1A1b, have been estimated by using refineries total fuel consumption and average NCVs for refineries and IPCC default EFs.

Uncertainties and Time-Series Consistency:

All refineries are covered in the inventory. AD uncertainty both liquid and gaseous fuels for refineries is considered 2% as indicated in table 2.15 of 2006 IPCC guideline Vol.2. Since AD for refineries have been taken directly from the refineries uncertainty level for survey data were considered and to be conservative the maximum uncertainty value was used.

EFs uncertainty was taken from 2006 IPCC guideline Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A1b category was performed on the basis of QA/QC plan. It was first confirmed with refinery authorities that AD also included the autoproducers consumption in the refinery. Calorific values provided by the refinery checked with national average NCVs of fuels to ensure the use of NCVs in emission estimation. Also carbon content of fuels provided by the refinery checked with IPCC default values to ensure they are in the range.

Planned Improvement:

Uncertainty level is planned to be determined in cooperation with refineries authorities.

3.2.4.3. Manufacture of solid fuels and other energy industries (Category 1.A.1.c)

Source Category Description:

All coke production facilities were covered in CRF category 1A1c. This category was a key category in terms of emissions level and emission trend of CO_2 from solid fuel in 2014. The share of GHG emissions as CO_2 eq. from manufacture of solid fuels category in total fuel combustion was 0.8% in 2014 while it was 1.9% in 1990.

Table 3.16 Emissions from category 1A1c, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ	Share in fuel combustion sector %	Fuel combustion total (kt)
1990	2 439	0.010	0.001	2 440	9 570	1.9	129 154
1991	2 689	0.011	0.001	2 690	10 522	2.0	133 430
1992	2 563	0.009	0.001	2 563	9 333	1.8	139 555
1993	2 442	0.009	0.001	2 443	9 031	1.7	147 445
1994	2 204	0.008	0.001	2 204	8 338	1.5	144 219
1995	2 183	0.008	0.001	2 184	8 026	1.4	157 353
1996	2 297	0.009	0.001	2 298	8 682	1.3	172 594
1997	2 109	0.008	0.001	2 109	8 466	1.1	185 187
1998	2 101	0.009	0.001	2 101	8 593	1.1	184 513
1999	1 918	0.008	0.001	1 919	7 699	1.0	183 139
2000	1 863	0.008	0.001	1 863	7 974	0.9	209 658
2001	2 049	0.007	0.001	2 050	7 489	1.1	194 007
2002	2 128	0.008	0.001	2 129	7 515	1.1	201 964
2003	2 057	0.008	0.001	2 058	8 025	1.0	215 196
2004	1 897	0.008	0.001	1 898	8 093	0.8	225 314
2005	1 817	0.008	0.001	1 818	8 154	0.7	248 370
2006	1 773	0.008	0.001	1 774	8 050	0.7	270 705
2007	1 732	0.008	0.001	1 733	8 229	0.6	299 841
2008	1 646	0.009	0.001	1 646	8 587	0.6	288 617
2009	1 696	0.008	0.001	1 697	8 214	0.6	274 455
2010	2 257	0.009	0.001	2 257	9 084	0.8	279 355
2011	2 473	0.009	0.001	2 473	9 253	0.9	290 758
2012	2 448	0.009	0.001	2 449	9 364	0.8	313 505
2013	2 527	0.010	0.001	2 528	10 404	0.8	303 048
2014	2 670	0.011	0.001	2 671	10 864	0.8	330 385

Compared to 2013, there is 143 kt CO_2 eq. (5.7% of increase) increase in total emissions from manufacture of solid fuels and other energy industries sector. The main reason for increasing emissions in this sector is due to increasing Coke oven gas (3.27%) and blast furnace gas consumption (2.83%).

Methodological Issues:

Emissions from manufacture of solid fuels (CRF 1A1c) were calculated according to 2006 IPCC T3 approach by TurkStat. Coke production in integrated iron and steel production plants have been considered in this category. Coke oven gas and blast furnace gas have been used for coke production. Plant specific fuel consumption, NCVs and carbon content of fuels were compiled from each plant. CO_2 emissions from 1A1c were calculated by using plant specific AD, carbon contents of fuels and IPCC default oxidation rates. CH_4 and N_2O emissions from CRF category 1A1c, have been estimated by using plant specific fuel consumption and NCVs and IPCC default EFs.

Uncertainties and Time-Series Consistency:

All coke production facilities were covered in the inventory. AD uncertainty both solid and gaseous fuels for coke plants were considered 2% as indicated in Table 2.15 of 2006 IPCC guideline Vol.2. Since AD have been taken directly from the coke plants uncertainty level for survey data were considered and to be conservative the maximum uncertainty value was used.

EFs uncertainty was taken from 2006 IPCC guideline Vol.2 page 2.18. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A1c category was performed on the basis of QA/QC plan. Calorific values provided by the coke plants checked with national average NCVs of fuels to ensure the use of NCVs in emission estimation. Also carbon content of fuels provided by the coke plants compared with IPCC default values.

Planned Improvement:

Work on the carbon balance in integrated iron and steel production plants in cooperation with sector experts will be continued. Meanwhile, Carbon content of coke oven gas and blast furnace gas is out of 2006 IPCC default values. The reason behind it will be investigated in cooperation with expert from integrated iron&steel facilities.

3.2.5. Manufacturing industries and construction (Category 1.A.2)

Source Category Description:

This source category consists of manufacturing industries sectors. IPCC categorizes manufacturing industry as iron and steel, nonferrous metal, chemicals, pulp, paper and print, food processing, beverages and tobacco, non-metallic minerals and other industry. In the national energy balance tables, pulp, paper and print sector were presented separately from 2011 on it was presented under "other industries (1.A.2.g)" category. Food processing category includes only sugar industry for 1990-2010 periods. From 2011 on and food processing industry were covered but beverages and tobacco industry were not still separated and were considered under the section "other industries (1.A.2.g)" category.

CO_2 and CH_4 emissions from iron and steel category were included under 2.C.1 iron and steel production category and also under 1.A.2.a category only N_2O emissions were included and CO_2 and

CH_4 emissions were included under 2.C.1 in 2013 submission. Moreover, emissions from autoproducers within the integrated iron & steel facilities were allocated under 1A2g category. In 2014 inventory all emission sources within the integrated iron & steel facilities examined in detail with the collaboration of experts from the companies and in technical assistance of Italian inventory experts. Based on the output of that sector analysis, CO_2 and CH_4 were reallocated under IPPU and Energy sector in appropriate manner. CO_2, CH_4 and N_2O emissions from all fuels, except hard coal and coke were reallocated under Energy sectors. The emission from hard coal and coke used in blast furnaces were considered under IPPU. Moreover Emissions from autoproducers in 1A2a category were separated from 1A2g emissions and included under 1A2a category. Therefore all GHG emissions for 1990-2013 periods were recalculated for 1A2a and 1A2g.

The New Electricity Market Law No. 6446 (the "New Law") has been enacted by the Turkish Parliament on 14 March 2013 and published in the Official Gazette numbered 28603 on 30 March 2013. The New Law makes certain substantial changes in the current electricity market system, such as types of licenses, introduction of a pre-licensing mechanism and extended deadlines for certain incentives. According to new law, Auto-production, as a license type, will be abolished as of the New Law. Pursuant to the New Law, an auto-production license shall be converted into a generation license within six months following the effective date of the New Law without the requirement for payment of a license issuance fee.

Energy Market Regulatory Authority (EMRA) Board Decree No. 4952-18 sets forth the general principles regarding termination of current auto-production licenses and issuance of generation licenses for the relevant entities. Pursuant to these principles, the EMRA Board issued another Decree No. 4969, providing that as of 1 May 2014, 260 of 274 auto-production licenses have terminated and generation licenses have issued to the auto-production license holder.

Since auto producers became electricity Generation Company, they produce more electricity and/or heat than their own use and sell electricity and/or heat. On this account, electricity generations increase and due to his fact our national GHG emission has increased in manufacturing industry.

All autoproducers within manufacturing industry were covered under related subcategories of 1.A.2. Since only N_2O emissions was given under 1.A2.a iron and steel production, autoproducers within iron & steel industry were included under "other industries (1.A.2.g)" category in 2013 submission. This submission reallocation has been made that 1A2a and 1A2g were separated and provided under the related category for all inventory years 1990-2014.

Emissions from waste incineration with energy recovery were included under related subcategories of 1.A.2 (cement and petrochemical industry).

The share of GHG emissions as CO_2 eq. from manufacturing industry in total fuel combustion was 21.2% in 2014 while it was 27.2% in 1990. Non-metallic minerals, other industries and iron and steel were the main emission sources. The share of GHG emissions as CO_2 eq. was 38.45% from non-metallic mineral industry, 23.10% from other industries and 20.16% from iron and steel industry in manufacturing industry for the year 2014.

Table 3.17 Fuel combustion emissions from manufacturing industry, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ	Share in fuel combustion sector (%)	Fuel combustion total (kt)
1990	34 975	2.23	0.37	35 141	392 773	27.2	129 154
1991	37 694	2.44	0.40	37 874	425 409	28.4	133 430
1992	37 141	2.22	0.37	37 306	432 472	26.7	139 555
1993	39 126	2.20	0.37	39 290	463 361	26.6	147 445
1994	35 039	1.93	0.32	35 184	417 596	24.4	144 219
1995	39 836	2.17	0.36	39 997	484 527	25.4	157 353
1996	48 999	2.98	0.48	49 217	582 681	28.5	172 594
1997	54 177	3.33	0.54	54 420	647 087	29.4	185 187
1998	55 161	3.60	0.57	55 422	657 865	30.0	184 513
1999	49 972	3.02	0.49	50 192	609 922	27.4	183 139
2000	67 128	4.22	0.70	67 442	815 022	32.2	209 658
2001	55 657	2.94	0.51	55 882	703 241	28.8	194 007
2002	68 687	3.98	0.67	68 986	853 885	34.2	201 964
2003	77 257	4.53	0.75	77 594	966 939	36.1	215 196
2004	78 759	4.59	0.76	79 100	993 134	35.1	225 314
2005	81 855	4.38	0.73	82 181	1 065 831	33.1	248 370
2006	89 629	5.23	0.85	90 018	1 147 958	33.3	270 699
2007	92 112	5.53	0.89	92 515	1 184 324	30.9	299 841
2008	59 964	2.89	0.47	60 176	800 655	20.8	288 617
2009	50 662	2.81	0.44	50 863	637 645	18.5	274 455
2010	62 636	3.20	0.51	62 867	763 280	22.5	279 355
2011	59 411	3.16	0.47	59 630	782 352	20.5	290 758
2012	66 562	3.13	0.50	66 790	842 858	21.3	313 505
2013	61 609	2.88	0.47	61 821	743 705	20.4	303 048
2014	69 855	3.12	0.51	70 085	820 718	21.2	330 385

Manufacturing industries and construction produced an estimated 70.01 Mt CO_2 eq. emissions or 21.21% of fuel combustion sector or 20.67% of energy sector or 15% of total national emissions (excluding *LULUCF*) in 2014. Emissions have increased by 8 264 kt CO_2 eq. (13.4%) from the 2013 level of 61 821.4 kt CO_2 eq. in 2014 (Table 3.18).

Table 3.18 Contribution of subsectors of manufacturing industries and construction, 2013-2014

1.A.2 Manufacturing industries and construction categories	Emission (kt CO_2 eq.)		Changes from 2013 to 2014		Share in manufacturing industry (%)	
	2013	2014	(kt CO_2 eq)	%	2013	2014
a. Iron and steel	10 248.20	14 132.10	3 883.90	37.9	16.58	20.16
b. Non-ferrous metals	1 026.40	1 311.10	284.70	27.7	1.66	1.87
c. Chemicals	4 398.60	4 791.10	392.40	8.9	7.12	6.84
d. Pulp, paper and print	1 228.20	1 686.70	458.60	37.3	1.99	2.41
e. Food processing, beverages and tobacco	3 056.40	5 027.60	1 971.10	64.5	4.94	7.17
f. Non-metallic minerals	23 534.40	26 948.00	3 413.50	14.5	38.07	38.45
g. Other (please specify)	18 329.20	16 188.80	- 2 140.40	-11.7	29.65	23.1
Total	61 821.40	70 085.30	8 263.90	13.4	100	100

The increase since 2013 is 3 884 kt CO_2 eq. (37.9% of increase in total emissions from *iron and steel* subcategory. The change in this subcategory from 2013 to 2014 accounts for 47.0% in total change in 1A2 category.

The increase since 2013 is 3 414 kt CO_2 eq. (14.5% of increase) in total emissions from Non-metallic minerals subcategory. The change in this subcategory from 2013 to 2014 accounts for 41.3.0% in total change in 1A2 category.

The increase since 2013 is 1 971 kt CO_2 eq. (64.5% of increase) in total emissions from food processing, beverages and tobacco subcategory. The change in this subcategory from 2013 to 2014 accounts for 23.9% in total change in 1A2 category.

Decrease is observed since 2013 as 2 140 kt CO_2 eq. (11.7% of decrease) in total emissions from other subcategory.

Table 3.19 GHG emissions from manufacturing industry, 1990-2014

(kt CO_2 eq.)

Year	Total	Iron and steel	Non-ferrous metals	Chemicals	Pulp, paper and print	Food processing, beverages and tobacco	Non-metallic minerals	Other industries
1990	35 141	1 858	1 100	4 948	IE	2 908	8 159	16 168
1991	37 874	2 037	1 031	4 518	IE	2 872	8 943	18 473
1992	37 306	2 256	1 082	4 996	IE	2 346	7 788	18 838
1993	39 290	2 255	993	4 887	IE	2 158	7 906	21 091
1994	35 184	2 045	1 324	4 311	IE	1 578	9 226	16 700
1995	39 997	1 913	1 768	5 027	IE	1 691	8 480	21 118
1996	49 217	2 070	1 367	4 944	IE	2 215	10 005	28 617
1997	54 420	1 960	1 243	5 009	IE	2 179	8 997	35 032
1998	55 422	1 857	1 157	4 131	IE	2 629	8 094	37 554
1999	50 192	1 618	1 721	3 644	IE	2 564	10 167	30 478
2000	67 442	1 662	2 035	3 911	IE	2 137	9 155	48 541
2001	55 882	1 572	2 043	5 215	IE	3 998	8 681	34 372
2002	68 986	1 474	2 208	4 739	IE	3 935	8 814	47 816
2003	77 594	1 427	1 970	4 515	IE	2 709	9 860	57 113
2004	79 100	1 120	2 269	7 047	IE	2 371	13 351	52 941
2005	82 181	823	2 287	5 703	IE	2 134	14 817	56 418
2006	90 012	526	2 638	4 916	IE	2 056	15 168	64 707
2007	92 515	422	9 257	2 258	IE	1 419	14 039	65 119
2008	60 176	1 837	244	944	IE	1 376	19 452	36 324
2009	50 863	4 035	1 075	1 665	IE	436	16 537	27 115
2010	62 867	8 240	1 379	4 195	480	628	17 867	30 078
2011	59 630	3 149	441	3 758	1 273	1 426	24 135	25 448
2012	66 790	7 592	1 555	5 144	1 161	2 835	25 842	22 661
2013	61 821	10 248	1 026	4 399	1 228	3 056	23 534	18 329
2014	70 085	14 132	1 311	4 791	1 687	5 028	26 948	16 189

Iron and steel production, chemicals, food processing, beverages and tobacco, non-metallic minerals, other industries, residential and agriculture/forestry/fisheries are a key category in terms of emission trend and level of CO_2 emissons in 2014. Moreover, Non-metallic minerals is a key category in terms of emission trend of CO_2 emissons in 2014.

Methodological Issues:

GHG emissions from 1A2 sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

MENR compiles fuel data from all electricity producers via survey. Plant specific fuel consumption and NCVs of the autoproducers were taken from MENR.

Data on waste incineration for energy recovery have been compiled by TurkStat via official letter. The list of all waste incineration facilities having waste incineration licenses was determined from the MoEU. Then the amount of waste incinerated and NCVs as MJ/kg by waste types were compiled from all facilities listed by the MoEU. Plant specific waste incineration and NCVs were used in the GHG estimation.

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from all subcategories of 1A2 and 1A4 were recalculated for 1990-2013 period.

CO_2 emissions from biomass were estimated by using 2006 IPCC default emissions factors. CH_4 and N_2O emissions from CRF category 1A2, have been estimated by using 2006 IPCC default EFs.

GHG emissions from waste incineration have been estimated by using IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD for manufacturing industry sector are completely taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were given under subcategories.

EFs uncertainty was taken from 2006 IPCC guideline Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O. The same uncertainties were used for all subcategories of 1A2.

Source-Specific QA/QC and Verification:

Quality control for 1A2 category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined.

Recalculation:

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from all subcategories of 1A2 and 1A4 were re calculated for 1990-2013 period.

Emissions from autoproducers in 1A2a category were separated from 1A2g emissions and included under 1A2a category. Therefore all GHG emissions for 1990-2013 periods were recalculated for 1A2a and 1A2g.

3.2.5.1. Iron and steel industries (Category 1.A.2.a)

Source Category Description:

Autoproducers within this category were also included in the category. The source category iron and steel was a key category in terms of emission trend of CO_2 from liquid fuels in 2014. This category was also a key category in terms of emission level of CO_2 from solid and gaseous fuels. The share of GHG emissions as CO_2 eq. from 1.A.2.a in total manufacturing industry fuel combustion was 20.2% in 2014 while it was 5.3% in 1990.

There are two different technologies used in iron and steel industry; integrated facilities and EAF. Iron and steel industry consumes energy and raw materials intensively. Currently, 3 integrated facilities and 27 EAF mills are in operation in Turkey.

Table 3.20 Fuel combustion emissions from iron and steel industry, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ	Share in fuel combustion sector (%)	Manufacturing industry total (kt)
1990	1 852	0.071	0.014	1 858	23 704	5.3	35 141
1991	2 030	0.076	0.015	2 037	26 586	5.4	37 874
1992	2 249	0.084	0.017	2 256	29 640	6.0	37 306
1993	2 247	0.087	0.017	2 255	29 017	5.7	39 290
1994	2 038	0.079	0.016	2 045	26 347	5.8	35 184
1995	1 906	0.074	0.015	1 913	24 708	4.8	39 997
1996	2 063	0.080	0.016	2 070	26 710	4.2	49 217
1997	1 953	0.076	0.015	1 960	25 327	3.6	54 420
1998	1 850	0.072	0.014	1 857	23 998	3.3	55 422
1999	1 613	0.062	0.012	1 618	20 887	3.2	50 192
2000	1 656	0.064	0.013	1 662	21 407	2.5	67 442
2001	1 567	0.060	0.012	1 572	20 287	2.8	55 882
2002	1 469	0.057	0.011	1 474	19 028	2.1	68 986
2003	1 423	0.055	0.011	1 427	18 421	1.8	77 594
2004	1 116	0.043	0.009	1 120	14 592	1.4	79 100
2005	820	0.032	0.006	823	10 809	1.0	82 181
2006	525	0.021	0.004	526	7 078	0.6	90 012
2007	421	0.017	0.003	422	5 715	0.5	92 515
2008	1 835	0.039	0.005	1 837	31 288	3.1	60 176
2009	4 025	0.060	0.027	4 035	59 185	7.9	50 863
2010	8 225	0.132	0.042	8 240	80 713	13.1	62 867
2011	3 146	0.056	0.006	3 149	55 119	5.3	59 630
2012	7 581	0.084	0.030	7 592	83 213	11.4	66 790
2013	10 237	0.099	0.030	10 248	97 981	16.6	61 821
2014	14 120	0.121	0.030	14 132	117 724	20.2	70 085

The increase since 2013 is 3 884 kt CO_2 eq. (37.9% of increase) in total emissions from *Iron and Steel* subcategory. The change in this subcategory from 2013 to 2014 accounts for 47.0% in total change in 1A2 category.

The main reason for increasing emissions in this sector is due to increasing electricity produced by auto producer.

Methodological Issues:

GHG emissions from 1A2a sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

MENR compiles fuel data from all electricity producers via survey. Plant specific fuel consumption and NCVs of the autoproducers were taken from MENR.

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions were recalculated for 1990-2013 period.

CO_2 and CH_4 emissions from iron and steel category were included under 2.C.1 iron and steel production category and also under 1.A.2.a category only N_2O emissions were included and CO_2 and CH_4 emissions were included under 2.C.1 in 2013 submission. Moreover, emissions from autoproducers within the integrated iron & steel facilities were allocated under 1A2g category. In 2014 inventory all emission sources within the integrated iron & steel facilities examined in detail with the collaboration of experts from the companies and in technical assistance of Italian inventory experts. Based on the output of that sector analysis, CO_2 and CH_4 were reallocated under IPPU and Energy sector in appropriate manner. CO_2, CH_4 and N_2O emissions from all fuels, except hard coal and coke were reallocated under Energy sectors. The emission from hard coal and coke used in blast furnaces were considered under IPPU. Moreover Emissions from autoproducers in 1A2a category were separated from 1A2g emissions and included under 1A2a category. Therefore all GHG emissions for 1990-2013 periods were recalculated for 1A2a and 1A2g.

CO_2 emissions from biomass were estimated by using 2006 IPCC default emissions factors. CH_4 and N_2O emissions were also estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 11.18% for liquid and gaseous fuels, and 14.14% for solid fuels.

EFs uncertainty was taken from 2006 IPCC guideline Vol.2 page 2.38. Uncertainty values were considered as 100% (mid value in the range) for N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A2a category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined.

Recalculation:

Country specific carbon contents of natural gas for 1990-2013 were revised. So based on revised EFs, CO_2 emissions were recalculated for 1990-2013 period.

CO_2 and CH_4 emissions from iron and steel category were included under 2.C.1 iron and steel production category and also under 1.A.2.a category only N_2O emissions were included and CO_2 and CH_4 emissions were included under 2.C.1 in 2013 submission. However, in 2014 inventory all emission sources within the integrated iron & steel facilities examined in detail with the collaboration of experts from the companies and in technical assistance of Italian inventory experts. Based on the output of that sector analysis, CO_2 and CH_4 were reallocated under IPPU and Energy sector in appropriate manner. CO_2, CH_4 and N_2O emissions from all fuels, except hard coal and coke were reallocated under Energy sectors. The emission from hard coal and coke used in blast furnaces were considered under IPPU.

In 2014 emissions from autoproducers in 1A2a category were separated from 1A2g emissions and included under 1A2a category. Therefore all GHG emissions for 1990-2013 periods were recalculated.

Planned Improvement:

Work on the carbon balance in integrated iron and steel production plants in cooperation with sector experts will be continued.

3.2.5.2. Non-ferrous metal (Category 1.A.2.b)

Source Category Description:

Autoproducers within this category were also included in the category. The source category non-ferrous metal was a key category in terms of emission trend of CO_2 from liquid fuels in 2014. The share of GHG emissions as CO_2 eq. from 1.A.2.b in total manufacturing industry fuel combustion was 1.9% in 2014 while it was 3.1% in 1990.

Table 3.21 Fuel combustion emissions from non-ferrous metals, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ	Share in fuel combustion sector (%)	Manufacturing industry total (kt)
1990	1 096	0.049	0.009	1 100	13 172	3.1	35 141
1991	1 027	0.049	0.009	1 031	12 437	2.7	37 874
1992	1 078	0.053	0.010	1 082	12 967	2.9	37 306
1993	989	0.049	0.009	993	11 835	2.5	39 290
1994	1 319	0.064	0.012	1 324	15 677	3.8	35 184
1995	1 762	0.084	0.014	1 768	22 277	4.4	39 997
1996	1 362	0.058	0.010	1 367	18 256	2.8	49 217
1997	1 239	0.061	0.011	1 243	15 841	2.3	54 420
1998	1 152	0.062	0.011	1 157	13 998	2.1	55 422
1999	1 716	0.073	0.012	1 721	23 789	3.4	50 192
2000	2 028	0.100	0.016	2 035	26 751	3.0	67 442
2001	2 036	0.101	0.016	2 043	26 815	3.7	55 882
2002	2 200	0.106	0.017	2 208	29 611	3.2	68 986
2003	1 965	0.079	0.013	1 970	27 983	2.5	77 594
2004	2 263	0.088	0.014	2 269	32 947	2.9	79 100
2005	2 281	0.085	0.013	2 287	33 724	2.8	82 181
2006	2 632	0.091	0.014	2 638	39 815	2.9	90 012
2007	9 244	0.217	0.025	9 257	157 450	10.0	92 515
2008	243	0.004	0.000	244	4 258	0.4	60 176
2009	1 073	0.026	0.003	1 075	17 689	2.1	50 863
2010	1 376	0.040	0.005	1 379	22 007	2.2	62 867
2011	440	0.011	0.002	441	7 054	0.7	59 630
2012	1 551	0.050	0.007	1 555	23 884	2.3	66 790
2013	1 024	0.030	0.005	1 026	16 080	1.7	61 821
2014	1 309	0.025	0.006	1 311	20 350	1.9	70 085

Methodological Issues:

GHG emissions from 1A2b sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

MENR compiles fuel data from all electricity producers via survey. Plant specific fuel consumption and NCVs of the autoproducers were taken from MENR.

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from all subcategories of 1A2 and 1A4 were recalculated for 1990-2013 period.

CO_2 emissions from biomass were estimated by using 2006 IPCC default emissions factors. CH_4 and N_2O emissions were also estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 21.21% for liquid, gaseous and solid fuels.

EFs uncertainty was taken from 2006 IPCC guideline Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A2b category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined.

Recalculation:

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions were recalculated for 1990-2013 period.

Planned Improvement:

There is no planned improvement for this category.

3.2.5.3. Chemicals (Category 1.A.2.c)

Source Category Description:

Autoproducers within this category were also included in the category. The source category of chemicals was a key category in terms of emission level of CO_2 from gaseous fuels in 2014. The category was also a key category in terms of emission trend of CO_2 from liquid fuels. The share of GHG emissions as CO_2 eq. from 1.A.2.c in total manufacturing industry fuel combustion was 6.8% in 2014 while it was 14.1% in 1990.

Table 3.22 Fuel combustion emissions from chemicals, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ	Share in fuel combustion sector (%)	Manufacturing industry total (kt)
1990	4 930	0.237	0.040	4 948	62 696	14.1	35 141
1991	4 505	0.178	0.031	4 518	61 825	11.9	37 874
1992	4 982	0.179	0.031	4 996	70 470	13.4	37 306
1993	4 875	0.170	0.028	4 887	70 397	12.4	39 290
1994	4 300	0.152	0.026	4 311	61 011	12.3	35 184
1995	5 014	0.174	0.030	5 027	71 444	12.6	39 997
1996	4 931	0.169	0.029	4 944	70 610	10.0	49 217
1997	4 996	0.166	0.028	5 009	72 806	9.2	54 420
1998	4 119	0.159	0.028	4 131	56 182	7.5	55 422
1999	3 633	0.140	0.025	3 644	49 420	7.3	50 192
2000	3 900	0.148	0.027	3 911	53 253	5.8	67 442
2001	5 200	0.195	0.036	5 215	70 465	9.3	55 882
2002	4 727	0.165	0.029	4 739	68 018	6.9	68 986
2003	4 504	0.143	0.025	4 515	65 218	5.8	77 594
2004	7 028	0.238	0.044	7 047	98 773	8.9	79 100
2005	5 690	0.174	0.029	5 703	84 915	6.9	82 181
2006	4 905	0.152	0.025	4 916	72 868	5.5	90 012
2007	2 256	0.047	0.005	2 258	38 692	2.4	92 515
2008	942	0.021	0.002	944	16 215	1.6	60 176
2009	1 660	0.076	0.011	1 665	24 144	3.3	50 863
2010	4 181	0.188	0.032	4 195	57 623	6.7	62 867
2011	3 750	0.125	0.016	3 758	60 108	6.3	59 630
2012	5 134	0.144	0.021	5 144	82 795	7.7	66 790
2013	4 386	0.188	0.028	4 399	64 470	7.1	61 821
2014	4 779	0.161	0.028	4 791	70 753	6.8	70 085

Methodological Issues:

GHG emissions from 1A2c sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

MENR compiles fuel data from all electricity producers via survey. Plant specific fuel consumption and NCVs of the autoproducers were taken from MENR.

Data on waste incineration for energy recovery have been compiled by TurkStat via official letter. The amount of waste incinerated and NCVs as MJ/kg by waste types were compiled from the facilities. Plant specific waste incineration and NCVs were used in the GHG estimation.

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from all subcategories of 1A2 and 1A4 were recalculated for 1990-2013 period.

CO_2 emissions from biomass were estimated by using 2006 IPCC default emissions factors. CH_4 and N_2O emissions were also estimated by using 2006 IPCC default EFs.

GHG emissions from waste incineration were estimated by using 2006 IPCC default EFs. Waste incineration was observed in chemical industry (1A2c) and non metallic mineral industry (1A2f). 2006 IPCC default EFs were used in the emission estimation. So waste data were need to be classified into waste oil, industrial waste and sewage sludge (waste as biomass). In 2013 inventory, the classification of waste into those 3 waste categories was made based on expert judgement. However, in 2014 inventory, waste oil and sewage sludge waste were re-classified based on the waste categorization of "EU Waste Statistics Regulation" and waste other than waste oil and sewage sludge was considered as industrial waste.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 15.81% for liquid, gaseous and solid fuels.

For other fossil fuels it was considered 2% as indicated in table 2.15 of 2006 IPCC guideline Vol.2. Since AD for waste incineration have been taken directly from the refineries, uncertainty level for survey data was considered and to be conservative the maximum uncertainty value was used.

EFs uncertainty was taken from 2006 IPCC guideline Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% was taken (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A2c category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined.

Recalculation:

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from all subcategories of 1A2 and 1A4 were recalculated for 1990-2013 period.

Also there is a recalculation in emissions from waste incineration for 2003-2013 periods due to reclassification of waste as explained above.

Planned Improvement:

There is no planned improvement for this category.

3.2.5.4. Pulp, paper and print (Category 1.A.2.d)

Source Category Description:

The fuel consumption for production of pulp, paper and printed products was separated in the national energy balance tables in 2011. Therefore emissions from this sector was evaluated under the 1.A.2.g other industries category before 2011. Autoproducers within this category were also included in the category. 2010 data covers only emissions from autoproducers.

The source category 1.A.2.d was not a key category. The share of GHG emissions as CO_2 eq. from 1.A.2.d in total manufacturing industry fuel combustion was 2.4% in 2014 while it was 2.1% in 2011.

Table 3.23 Fuel combustion emissions from pulp, paper and print, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ	Share in fuel combustion sector (%)	Manufacturing industry total (kt)
1990	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		35 141
1991	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		37 874
1992	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		37 306
1993	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		39 290
1994	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		35 184
1995	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		39 997
1996	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		49 217
1997	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		54 420
1998	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		55 422
1999	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		50 192
2000	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		67 442
2001	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		55 882
2002	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		68 986
2003	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		77 594
2004	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		79 100
2005	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		82 181
2006	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		90 012
2007	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		92 515
2008	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		60 176
2009	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE		50 863
2010	478	0.008	0.004	480	7 450	0.8	62 867
2011	1 267	0.080	0.013	1 273	20 076	2.1	59 630
2012	1 158	0.043	0.008	1 161	16 525	1.7	66 790
2013	1 225	0.041	0.008	1 228	18 161	2.0	61 821
2014	1 681	0.068	0.015	1 687	26 619	2.4	70 085

Methodological Issues:

GHG emissions from 1A2d sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

MENR compiles fuel data from all electricity producers via survey. Plant specific fuel consumption and NCVs of the autoproducers were taken from MENR.

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions were recalculated for 1990-2013 period.

CO_2 emissions from biomass were estimated by using 2006 IPCC default emissions factors. CH_4 and N_2O emissions were also estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 18% for liquid, gaseous and solid fuels.

EFs uncertainty was taken from 2006 IPCC guideline Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A2d category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined.

Recalculation:

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions were recalculated for 1990-2013 period.

Planned Improvement:

There is no planned improvement for this category.

3.2.5.5. Food processing, beverages and tobacco (Category 1.A.2.e)

Source Category Description:

The fuel consumption for food processing sector was separated in 2011. For 1990-2010 period only sugar industry were covered under this category. Fuel consumption for beverages and tobacco industry cannot be separated and still was considered under the section other industries (1.A.2.g). Autoproducers within this category were also included in the category.

The source category 1.A.2.e was a key category in terms of emission level of CO_2 from gaseous and solid fuels in 2014. The category was also a key category in terms of emission trend of CO_2 from solid fuels. The share of GHG emissions as CO_2 eq. from 1.A.2.e in total manufacturing industry fuel combustion was 7.2% in 2014 while it was 8.3% in 1990.

Table 3.24 Fuel combustion emissions from food processing, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ	Share in fuel combustion sector (%)	Manufacturing industry total (kt)
1990	2 891	0.238	0.037	2 908	27 656	8.3	35 141
1991	2 855	0.232	0.036	2 872	26 900	7.6	37 874
1992	2 332	0.186	0.029	2 346	22 193	6.3	37 306
1993	2 146	0.170	0.026	2 158	20 603	5.5	39 290
1994	1 569	0.123	0.019	1 578	15 214	4.5	35 184
1995	1 682	0.128	0.020	1 691	16 883	4.2	39 997
1996	2 204	0.163	0.025	2 215	22 803	4.5	49 217
1997	2 168	0.164	0.025	2 179	22 410	4.0	54 420
1998	2 614	0.210	0.033	2 629	25 684	4.7	55 422
1999	2 549	0.207	0.032	2 564	25 070	5.1	50 192
2000	2 124	0.188	0.028	2 137	20 644	3.2	67 442
2001	3 979	0.257	0.042	3 998	44 738	7.2	55 882
2002	3 917	0.242	0.040	3 935	44 355	5.7	68 986
2003	2 695	0.188	0.030	2 709	29 133	3.5	77 594
2004	2 360	0.156	0.025	2 371	26 399	3.0	79 100
2005	2 123	0.158	0.024	2 134	22 493	2.6	82 181
2006	2 046	0.143	0.022	2 056	22 788	2.3	90 012
2007	1 411	0.104	0.016	1 419	14 805	1.5	92 515
2008	1 370	0.068	0.012	1 376	17 585	2.3	60 176
2009	433	0.034	0.005	436	4 405	0.9	50 863
2010	626	0.032	0.005	628	8 758	1.0	62 867
2011	1 420	0.088	0.013	1 426	17 943	2.4	59 630
2012	2 828	0.093	0.016	2 835	41 791	4.2	66 790
2013	3 048	0.095	0.019	3 056	45 828	4.9	61 821
2014	5 012	0.169	0.037	5 028	68 273	7.2	70 085

The increase since 2013 is 1 971 kt CO_2 eq. (64.5% of increase) in total emissions from *Food processing, beverages and tobacco* subcategory. The increase in this subcategory from 2013 to 2014 accounts for 23.9% of total increase in 1A2 category.

The main reason for increasing emissions in this sector is due to increasing electricity produced by auto producer (changing share 63.9%) and also increasing consumption in solid and liquid fuels (changing share 36.1%) .

Methodological Issues:

GHG emissions from 1A2e sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

MENR compiles fuel data from all electricity producers via survey. Plant specific fuel consumption and NCVs of the autoproducers were taken from MENR.

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from all subcategories of 1A2 and 1A4 were recalculated for 1990-2013 period.

CO_2 emissions from biomass were estimated by using 2006 IPCC default emissions factors. CH_4 and N_2O emissions were also estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 18% for solid fuels, 5.00% for Liquid fuels and 14.14% for gaseous fuels.

EFs uncertainty was taken from 2006 IPCC guideline Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% was taken (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A2e category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined.

Recalculation:

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions were recalculated for 1990-2013 period.

Planned Improvement:

There is no planned improvement for this category.

3.2.5.6. Non-metallic minerals (Category 1.A.2.f)

Source Category Description:

Glass, cement and ceramic production were covered under this category. Autoproducers within this category were also included. The fuel consumption for glass and ceramic production sector was separated in 2011. For 1990-2010 period only cement industry were covered under this category and fuel consumption for glass and ceramic production were considered under the other industries (1.A.2.g) for that period. Autoproducers within this category were also included in the category.

In Turkey, some of the cement plants co-incinerate waste via securing a license from the Turkish MoEU. The license requires stack gas emissions and analyses according to the regulation prepared in accordance with the "EU incineration of waste directive 2000/76/EC". Wastes co-incinerated by license are: waste plastics, used tires, waste oils, industrial sludge, tank bottom sludge and biomass. Waste incineration has been carried out due since 2004 in cement industry. Waste incineration emissions from cement industry for the period 2004-2014 were covered under this category.

The source category non-metallic minerals was a key category in terms of emission level of CO_2 from liquid, solid, gaseous in 2014. This category was also a key category in terms of emission trend of CO_2 from solid fuels. This sector is energy intensive sector. The share of GHG emissions as CO_2 eq. from 1.A.2.f in total manufacturing industry fuel combustion was 38.5% and it was 8.2% of total fuel combustion emissions in 2014.

Table 3.25 Fuel combustion emissions from non-metallic minerals, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ	Share in fuel combustion sector (%)	Manufacturing industry total (kt)
1990	8 113	0.634	0.100	8 159	85 402	23.2	35 141
1991	8 891	0.715	0.112	8 943	96 889	23.6	37 874
1992	7 746	0.597	0.093	7 788	84 132	20.9	37 306
1993	7 869	0.516	0.082	7 906	84 467	20.1	39 290
1994	9 178	0.672	0.106	9 226	95 257	26.2	35 184
1995	8 436	0.611	0.097	8 480	86 753	21.2	39 997
1996	9 955	0.694	0.111	10 005	102 887	20.3	49 217
1997	8 947	0.701	0.109	8 997	93 117	16.5	54 420
1998	8 053	0.575	0.092	8 094	82 676	14.6	55 422
1999	10 115	0.709	0.113	10 167	106 169	20.3	50 192
2000	9 110	0.626	0.100	9 155	94 764	13.6	67 442
2001	8 639	0.582	0.093	8 681	88 686	15.5	55 882
2002	8 772	0.575	0.093	8 814	90 367	12.8	68 986
2003	9 810	0.692	0.110	9 860	100 845	12.7	77 594
2004	13 284	0.922	0.147	13 351	136 780	16.9	79 100
2005	14 745	0.988	0.158	14 817	153 000	18.0	82 181
2006	15 091	1.062	0.169	15 168	156 495	16.9	90 012
2007	13 961	1.086	0.170	14 039	143 789	15.2	92 515
2008	19 350	1.418	0.225	19 452	200 392	32.3	60 176
2009	16 452	1.182	0.187	16 537	167 143	32.5	50 863
2010	17 770	1.356	0.212	17 867	182 040	28.4	62 867
2011	24 016	1.682	0.259	24 135	261 700	40.5	59 630
2012	25 716	1.770	0.274	25 842	278 989	38.7	66 790
2013	23 416	1.671	0.259	23 534	250 861	38.1	61 821
2014	26 823	1.751	0.273	26 948	293 854	38.5	70 085

The increase since 2013 is 3 414 kt CO_2 eq. (14.5% of increase) in total emissions from Non-metallic minerals subcategory. The increase in this subcategory from 2013 to 2014 accounts for 41.3% of total increase in 1A2 category.

The main reason for increasing emissions in this sector is due to increasing consumption in solid and liquid fuels of glass, cement and ceramic sectors (93.4% change), and also increasing electricity produced by auto producer (6.6% change)

Methodological Issues:

GHG emissions from 1A2f sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

MENR compiles fuel data from all electricity producers via survey. Plant specific fuel consumption and NCVs of the autoproducers were taken from MENR.

Data on waste incineration for energy recovery have been compiled by TurkStat via official letter. The amount of waste incinerated and NCVs as MJ/kg by waste types were compiled from all waste incinerating cement plants. Plant specific waste incineration and NCVs were used in the GHG estimation.

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from all subcategories of 1A2 and 1A4 were recalculated for 1990-2013 period.

CO_2 emissions from biomass were estimated by using 2006 IPCC default emissions factors. CH_4 and N_2O emissions were also estimated by using 2006 IPCC default EFs.

GHG emissions from waste incineration were estimated by using 2006 IPCC default EFs. Waste incineration was observed in chemical industry (1A2c) and non metallic mineral industry (1A2f). 2006 IPCC default EFs were used in the emission estimation. So waste data were need to be classified into waste oil, industrial waste and sewage sludge(waste as biomass). In 2013 inventory, the classification of waste into those 3 waste categories was made based on expert judgement. However, in 2014 inventory, waste oil and sewage sludge waste were re-classified based on the waste categorization of "EU Waste Statistics Regulation" and waste other than waste oil and sewage sludge was considered as industrial waste.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 25.5% solid fuels, 27.8% for liquid fuels, and 29.2% for gaseous fuels.

For other fossil fuels it was considered 2% as indicated in table 2.15 of 2006 IPCC guideline Vol.2. Since AD for waste incineration have been taken directly from the refineries uncertainty level for survey data were considered and to be conservative the maximum uncertainty value was used.

EFs uncertainty was taken from 2006 IPCC guideline Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A2f category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined.

Recalculation:

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions were recalculated for 1990-2013 period.

Also there is a recalculation in emissions from waste incineration for 2004-2013 periods due to reclassification of waste as explained above.

Planned Improvement:

There is no planned improvement for this category.

3.2.5.7. Other industries (Category 1.A.2.g)

Source Category Description:

The manufacturing industry sectors which are not specified above are covered in this section. The source category 1.A.2.g was a key category in terms of emission level of CO_2 from liquid, solid and gaseous fuels in 2014. This category was also a key category in terms of emission trend of CO_2 from liquid and solid fuels. The share of GHG emissions as CO_2 eq. from 1.A.2.g in total manufacturing industry fuel combustion was 23.1% in 2014 while it was 46.0% in 1990. It was 4.9% of total fuel combustion emissions in 2014.

Table 3.26 Fuel combustion emissions from other industries, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ	Share in fuel combustion sector (%)	Manufacturing industry total (kt)
1990	16 093	1.005	0.168	16 168	180 142	46.0	35 141
1991	18 385	1.188	0.196	18 473	200 773	48.8	37 874
1992	18 754	1.118	0.188	18 838	213 070	50.5	37 306
1993	21 000	1.209	0.203	21 091	247 043	53.7	39 290
1994	16 635	0.844	0.146	16 700	204 090	47.5	35 184
1995	21 036	1.098	0.184	21 118	262 462	52.8	39 997
1996	28 484	1.817	0.292	28 617	341 415	58.1	49 217
1997	34 875	2.163	0.347	35 032	417 587	64.4	54 420
1998	37 373	2.524	0.397	37 554	455 327	67.8	55 422
1999	30 345	1.833	0.292	30 478	384 587	60.7	50 192
2000	48 310	3.098	0.514	48 541	598 204	72.0	67 442
2001	34 237	1.742	0.308	34 372	452 251	61.5	55 882
2002	47 603	2.830	0.477	47 816	602 506	69.3	68 986
2003	56 861	3.374	0.561	57 113	725 339	73.6	77 594
2004	52 708	3.145	0.519	52 941	683 643	66.9	79 100
2005	56 196	2.941	0.496	56 418	760 891	68.7	82 181
2006	64 430	3.760	0.614	64 707	848 914	71.9	90 012
2007	64 819	4.060	0.669	65 119	823 873	70.4	92 515
2008	36 224	1.337	0.222	36 324	530 918	60.4	60 176
2009	27 018	1.427	0.206	27 115	365 078	53.3	50 863
2010	29 979	1.447	0.209	30 078	404 689	47.8	62 867
2011	25 372	1.113	0.161	25 448	360 351	42.7	59 630
2012	22 594	0.945	0.146	22 661	315 661	33.9	66 790
2013	18 274	0.758	0.121	18 329	250 323	29.6	61 821
2014	16 131	0.822	0.124	16 189	223 145	23.1	70 085

The decrease since 2013 is 2 140 kt CO_2 eq. (11.7% of increase) in total emissions from *other industries* subcategory. The main reason for decreasing emissions in this sector is due to considerable reduction of consumption of liquid and solid fuels in Other Industry and liquid fuels in Motor Vehicle Industry whereas increase in consumption of liquid fuels in Textile and Leather sector.

Methodological Issues:

GHG emissions from 1A2g sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

MENR compiles fuel data from all electricity producers via survey. Plant specific fuel consumption and NCVs of the autoproducers were taken from MENR.

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO2 emissions from all subcategories of 1A2 and 1A4 were recalculated for 1990-2013 period.

CO_2 emissions from biomass were estimated by using 2006 IPCC default emissions factors. CH_4 and N_2O emissions were also estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 70.71% for liquid, gaseous and solid fuels.

EFs uncertainty was taken from 2006 IPCC guideline Vol.2 page 2.18. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A2g category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined.

Recalculation:

Emissions from autoproducers in 1A2a category were separated from 1A2g emissions and included under 1A2a category. Therefore all GHG emissions for 1990-2013 periods were recalculated for 1A2a and 1A2g.

Planned Improvement:

There is no planned improvement for this category.

3.2.6. Transport (Category 1.A.3)

Estimation of emissions in Transport sector are carried out in sub-categories listed below:

- Civil Aviation (1.A.3.a)
- Road Transportation (1.A.3.b)
- Railways (1.A.3.c)
- Water-borne Navigation (1.A.3.d)
- Pipeline (1.A.3.e.i)

Emissions from this sector were 173% higher in 2014 than in 1990 (Figure 3.17), and on average emissions increased by more than 7.2% annually.

In 2014 transport sector contributed to 73.7 Mt CO_2 eq. emissions. The share of GHG emissions as CO_2 eq. from transport sector in total fuel combustion was 22.3% in 2014 while it was 20.9% in 1990.

GHG emissions by transport mode are given in Table 3.28. As shown in Figure 3.18, road transportation is the major CO_2 source contributing to 91% of transport emissions in 2014. Contribution of the domestic aviation is 5.5%, domestic water-borne navigation is 1.8%, and railways are 0.8% in 2014. The share of pipeline transportation is 0.9%.

Figure 3.17 GHG emissions for transportation sector, 1990-2014

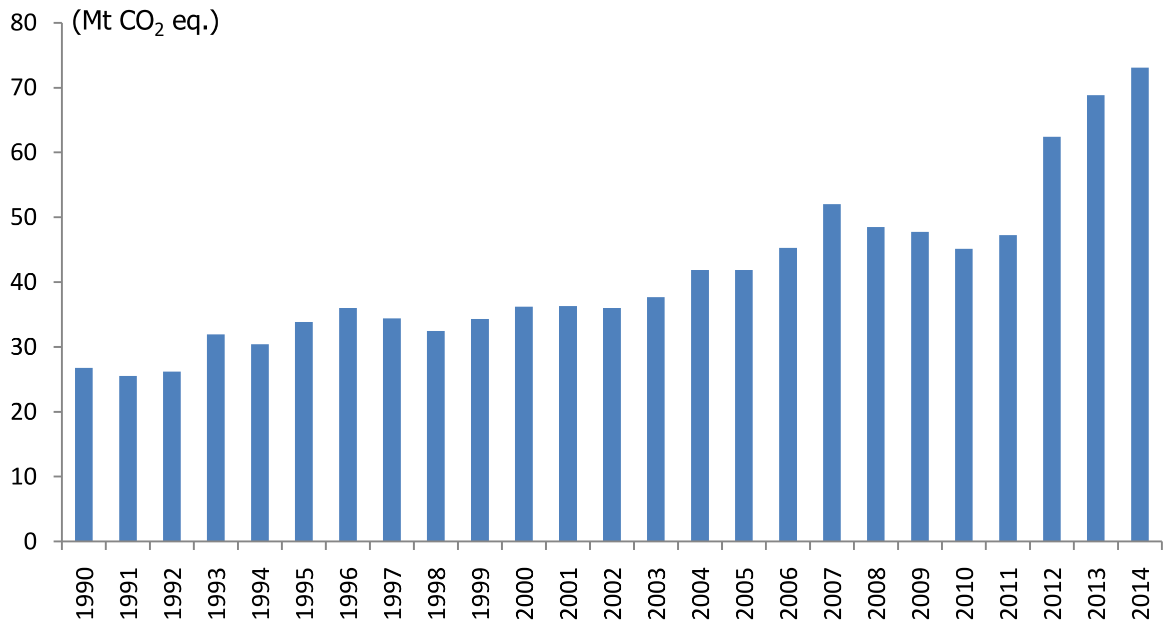


Table 3.27 GHG emissions from transport sector, 1990-2014

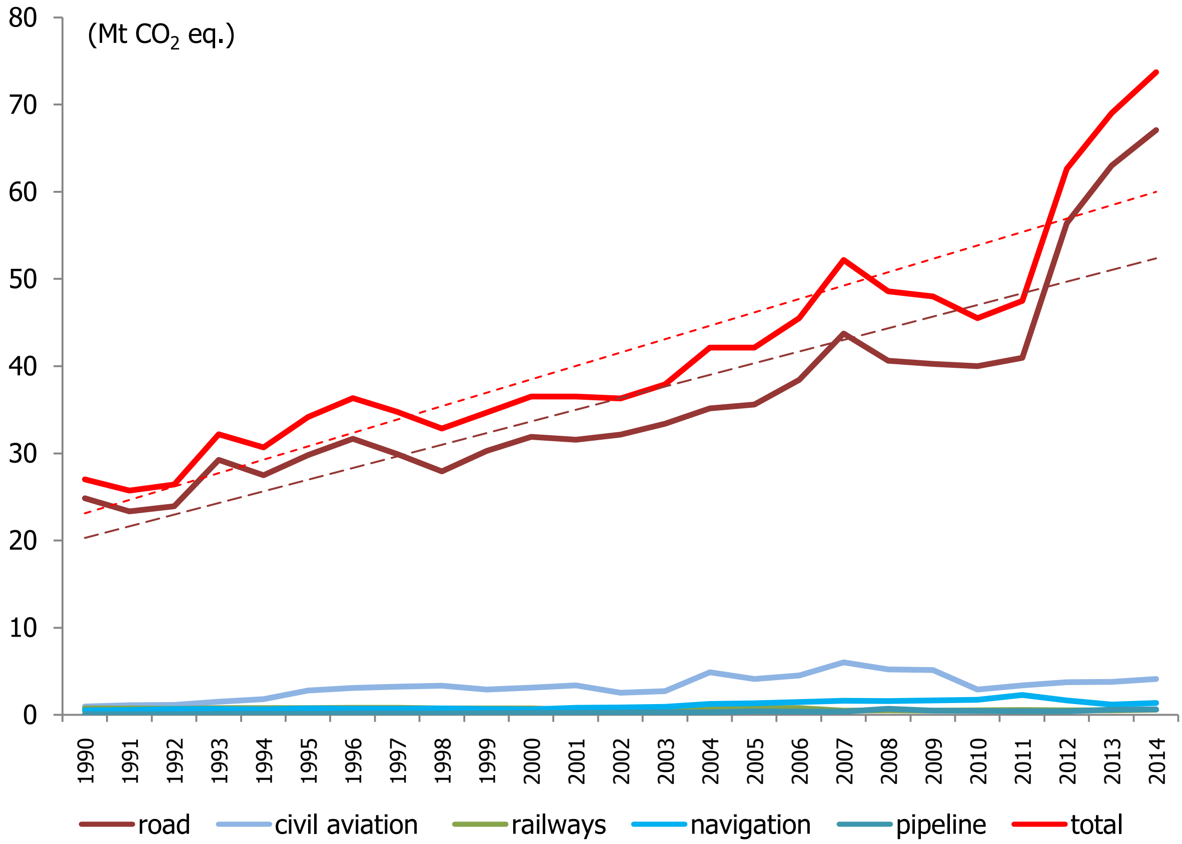
Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	26 284	4.0	2.1	27 004	364 617
1991	25 014	3.9	2.0	25 706	347 164
1992	25 670	4.2	2.1	26 398	356 995
1993	31 306	5.1	2.5	32 182	435 401
1994	29 823	5.0	2.4	30 676	415 493
1995	33 216	5.5	2.7	34 152	463 044
1996	35 316	5.9	2.9	36 313	492 752
1997	33 735	7.1	2.7	34 726	474 602
1998	31 843	7.6	2.6	32 813	450 289
1999	33 667	7.9	2.7	34 655	475 419
2000	35 527	9.1	2.5	36 508	503 352
2001	35 573	8.6	2.4	36 501	503 006
2002	35 356	8.0	2.4	36 282	498 404
2003	36 938	8.3	2.5	37 879	520 124
2004	41 110	8.6	2.6	42 105	578 405
2005	41 095	8.9	2.6	42 106	578 712
2006	44 433	9.5	2.8	45 492	625 285
2007	51 055	10.7	2.9	52 177	718 824
2008	47 495	11.1	2.7	48 569	674 397
2009	46 932	11.3	2.6	47 984	664 439
2010	44 444	11.8	2.4	45 468	630 304
2011	46 428	11.8	2.5	47 461	657 982
2012	61 341	12.9	3.2	62 632	862 220
2013	67 586	13.5	3.6	68 997	948 734
2014	72 999	14.1	3.8	73 700	1 013 762

Table 3.28 GHG emissions by transport mode, 1990-2014

(kt CO_2 eq.)

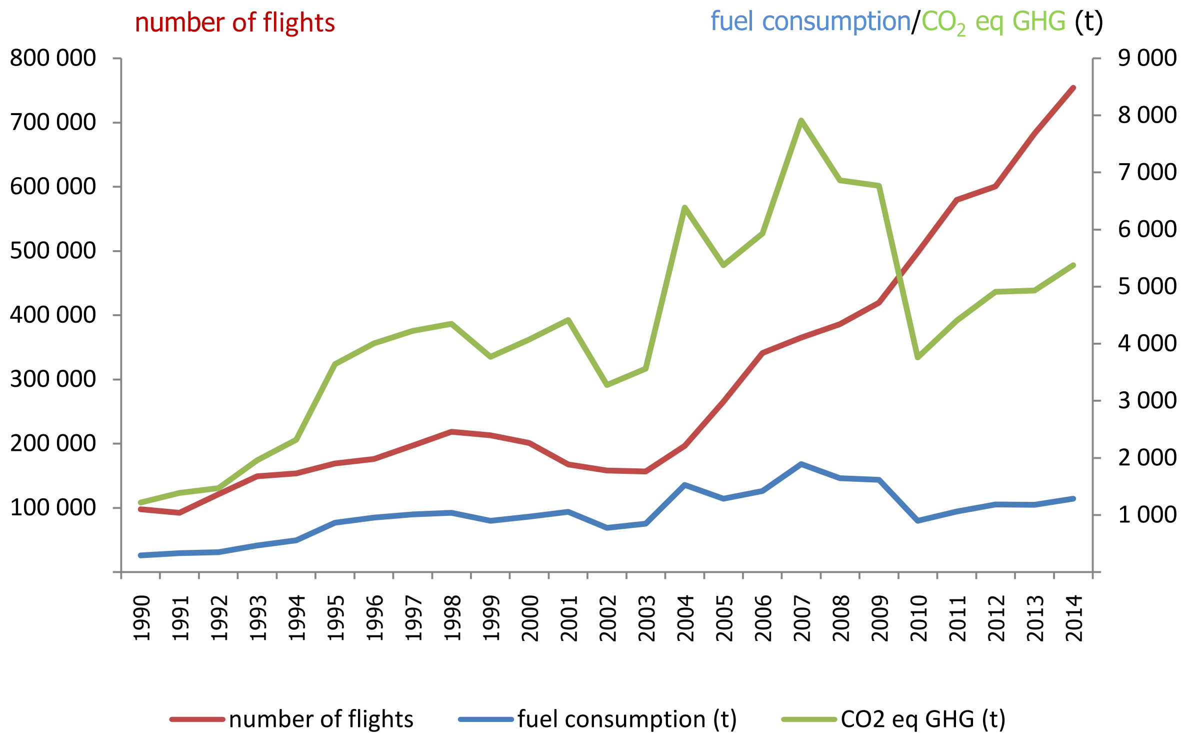
Year	Total	Domestic aviation	Road transportation	Railways	Domestic navigation	Other transportation
1990	27 004	923	24 808	722	509	42
1991	25 706	1 053	23 317	742	543	52
1992	26 398	1 118	23 899	686	639	57
1993	32 182	1 489	29 213	753	664	63
1994	30 676	1 764	27 450	770	623	69
1995	34 152	2 775	29 793	770	727	88
1996	36 313	3 048	31 663	800	700	103
1997	34 726	3 215	29 886	801	699	126
1998	32 813	3 311	27 903	742	726	131
1999	34 655	2 868	30 246	723	659	158
2000	36 508	3 099	31 882	714	624	190
2001	36 501	3 358	31 545	588	801	209
2002	36 282	2 503	32 120	613	823	223
2003	37 879	2 713	33 386	630	892	258
2004	42 105	4 859	35 132	630	1 230	255
2005	42 106	4 089	35 575	759	1 301	383
2006	45 492	4 512	38 418	762	1 466	334
2007	52 177	6 019	43 731	471	1 600	356
2008	48 569	5 218	40 611	500	1 545	695
2009	47 984	5 149	40 255	485	1 635	459
2010	45 468	2 862	39 993	517	1 685	411
2011	47 461	3 344	40 952	533	2 246	387
2012	62 632	3 727	56 393	493	1 617	401
2013	68 997	3 754	62 985	506	1 156	596
2014	73 700	4 090	67 070	563	1 350	628

Figure 3.18 GHG emission trend by transport mode, 1990-2014



When analyzed in detail (Figure 3.19), there are different factors influencing GHG emissions resulted from civil aviation. Fuel consumption raised steadily in civil aviation sector up to year 1999. As a consequence of economic reasons, fuel consumption values declined from 1999 to 2002. However, the rearrangement policy of MTMAC was given a sudden improvement in civil aviation sector. Then again, number of flights and fuel consumption started to increase. Especially, number of flights has increased inalterably. On the other hand, in the same period, fuel consumption and GHG emissions showed ups and downs harmoniously. Especially, from 2007 to 2010 fuel consumption and GHG emissions declined by approximately 50% while number of flights increased by roughly 35%. This decoupling could partially be explained with renewal of the Turkish air fleet and global economic crisis. But main reason of decoupling could be determined with improving data quality in civil aviation sector.

Figure 3.19 Comparison of number of flights, fuel consumption and GHG emissions of civil aviation, 1990-2014



The other transportation mode needed to be analyzed is road transportation (Figure 3.20). In road transportation until the year 1997, only diesel oil and gasoline were used. Utilization of LPG started in 1997 and consumption increased steadily. Then, diesel oil consumption and LPG consumption increased while gasoline consumption declined. From 2007 to 2010 diesel oil consumption decreased probably because of global economic crisis. After that there is remarkable rise in diesel fuel oil consumption. When analyzed in detail, it is determined that data of diesel fuel used in agriculture sector have not been separated from those used in road transportation since 2011. That is why there happened a big jump in GHG emissions resulting from diesel fuel.

Figure 3.20 Emission distributions by fuel types in road transportation, 1990-2014

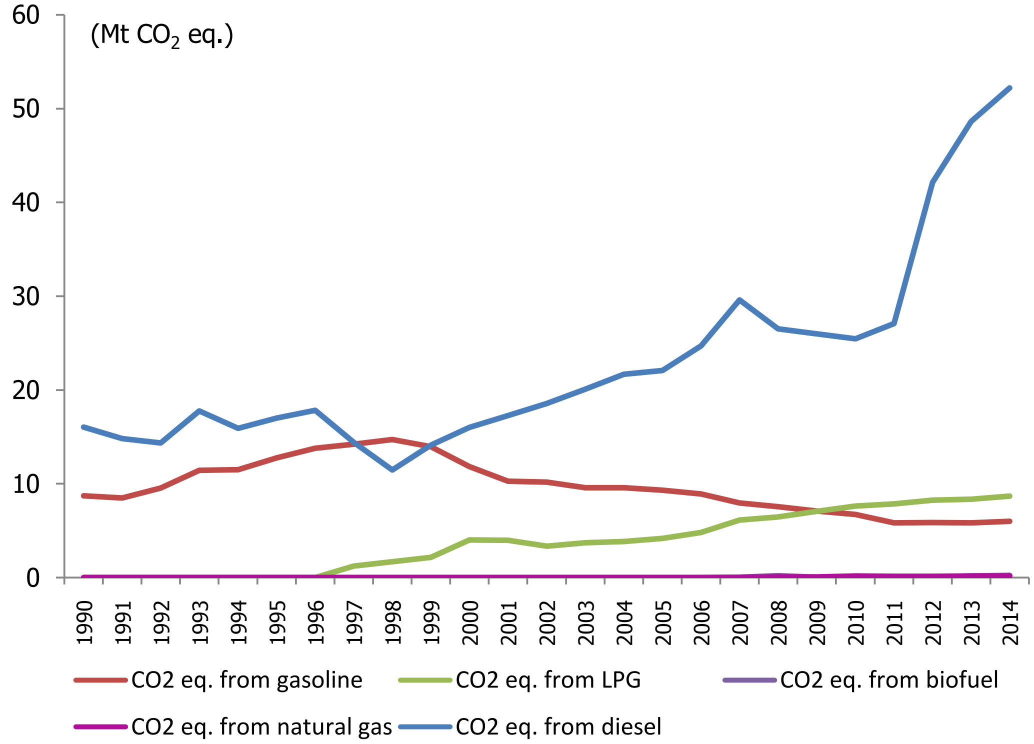
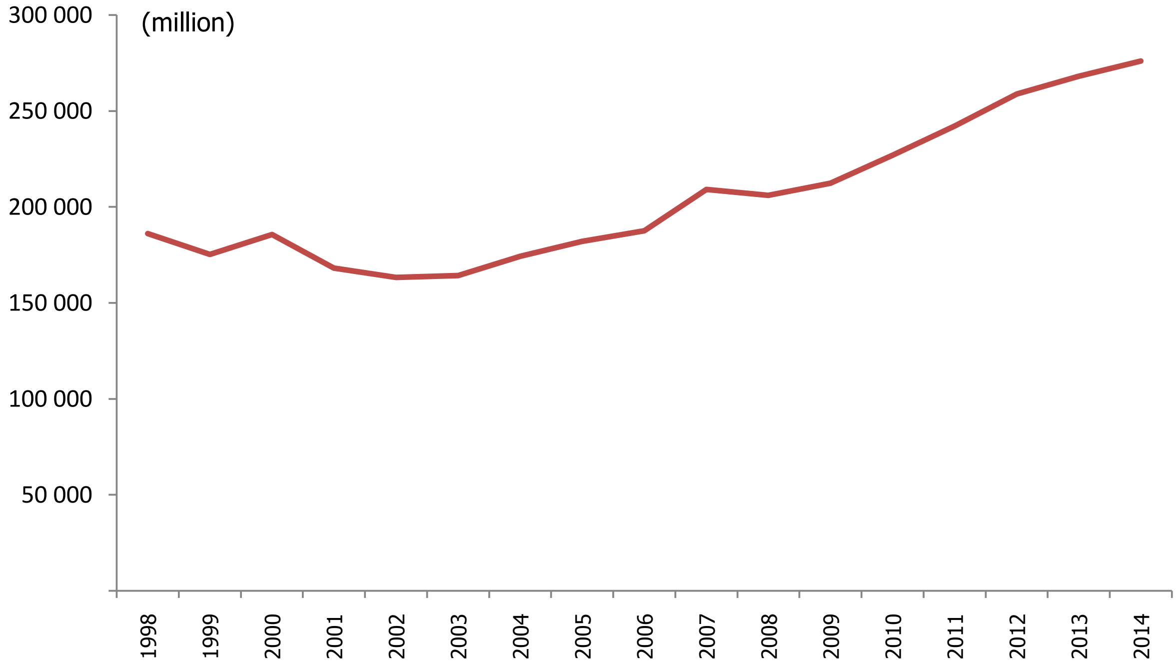
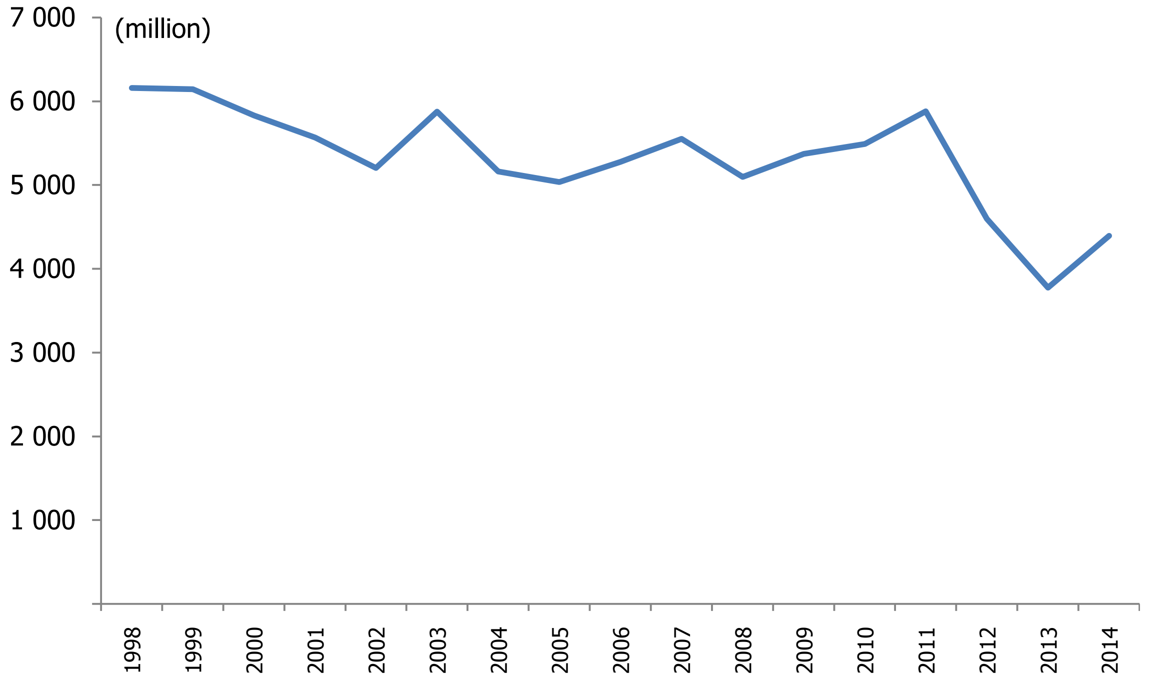


Figure 3.21 Passenger-km by road, 1998-2014



As seen from the graph, million passenger kilometers has been on an increasing trend over the years. Especially, from 2008 onward the increase has been significant year by year. The reasoning behind this is the number of cars has increased which leads to increase in the number of people traveling by road.

Figure 3.22 Passenger-km by railway, 1998-2014



Above graph represents million passenger kilometers by rail. In recent years, Turkey has put a lot of emphasis on redeveloping and modernizing the rail infrastructure which has had an effect on the number of passenger kilometers over the years. The modernization of the rail infrastructure requires a temporary stoppage of railway transport and once the modernization is complete restarting the operation. This can clearly be seen from the significant drop from 2011 until 2014, where a comprehensive modernization was undergoing. Hence, after 2014 the passenger kilometers have started to rise once again.

Source Category Description:

The source category comprises GHG emissions resulted from transport sector as follows; aviation, railways, road transportation and navigation. In addition to these, international aviation and international navigation were also included in this category. Among these categories;

- Civil Aviation in terms of CO_2 emissions from jet fuel,
- Road transportation in terms of CO_2 emissions from diesel fuel, LPG and gasoline,
- Water-borne Navigation in terms of CO_2 emissions from diesel fuel and fuel oil,

were the key categories.

Emissions from civil aviation were covered as international aviation and domestic aviation under (1.A.3.a.i) and (1.A.3.a.ii) categories.

Road transportation is the largest contributor to transport emissions and estimations were made under a wide variety of vehicle types using not only gasoline but also diesel fuel and LPG. It is covered under category (1.A.3.b).

Emissions from railways were reported under category (1.A.3.c).

Emission estimates from the navigation section cover international water-borne navigation (1.A.3.d.i) and domestic navigation-coastal shipping (1.A.3.d.ii).

Pipeline transportation emission estimate is covered under category other transportation (1.A.3.e.i).

Methodological Issues:

Methodology used for the estimation of GHG emissions of mobile sources for time series 1990-2014 is the multiplication of fuel data with corresponding EFs. All EFs were taken from IPCC Guidelines for National GHG Inventories (IPCC, 2006).

The IPCC methods used in transport sector calculations are listed in Table 3.29.

Table 3.29 Method used in the calculation of GHG emissions by transport modes

Modes of transport	CO_2	CH_4	CO	N_2O	NOx	NMVOC	SO_2	Tier I	Tier II
Domestic aviation	√	√		√				X	X
Road transportation	√	√		√				X	X
Railways	√	√		√				X	X
Domestic navigation	√	√		√				X	X
Pipeline transportation	√	√		√				X	X

For the Transport source category (1.A.3), the following data sources were used to estimate and calculate emissions:

- Fuel consumption values for source categories (1.A.3.a.i), (1.A.3.a.ii), (1.A.3.b), (1.A.3.c), (1.A.3.d.i), (1.A.3.d.ii) and (1.A.3.e.i) were provided by MENR in the form of the national energy balance tables.
- Air traffic data is provided by Directorate of General (DG) of State Airports Authority for National Aviation (1.A.3.a.ii). Emissions were estimated by using IPCC T2 methodology explained in IPCC Guidelines for National GHG Inventories (IPCC, 2006). The calculation

methodology is based on the national energy consumption data and air traffic data for each airport in terms of aircraft type. For the activities, default EFs were used. Air traffic data which consists of landing and take-off (LTO) cycles and cruise is processed for all 52 airports in Turkey. All activities below 914 m were included in LTO cycle; movements over 914 m altitude were covered in the cruise phase. Domestic flights for all aircraft types have been accounted considering estimated individual fuel consumption values. The necessary EFs for LTO and cruise for each type of aircraft have been chosen from IPCC reference manual.

- The emissions from road transportation were calculated by using IPCC Tier 1&2 methodology. Other values for database improvement were provided from DG of Highways, DG of Turkish State Railways and DG of Civil Aviation.

Source-Specific QA/QC and Verification:

The IPCC Good Practice Guidance is used for the QA/QC procedures of National GHG Emission Inventory. For the quality control purposes, GHG emissions, estimated by using T2 approach, were compared with emissions estimated by using T1 approach. If the difference between the emission values obtained by both methods is less than 5%, calculations were considered to be appropriate.

Recalculation:

All emissions from CRF category 1A3 have been recalculated for 1990-2014 by using 2006 IPCC guidelines.

3.2.6.1. Civil aviation (Category 1.A.3.a)

3.2.6.1.1. Domestic aviation (Category 1.A.3.a.ii)

The domestic aviation source category was a key category, in terms of CO_2 emissions from the jet fuel in 2014. In domestic aviation only jet fuel is consumed. Air traffic data is provided by DG of State Airports Authority for all civil airports in Turkey. The number of LTO values for all aircraft types were provided for each airport. In the year 2014 total number of LTO's in domestic travel for all aircraft types is 754 259. The increase in passenger and freight traffic from 2005 to 2014 is also given in Figure 3.23 and Figure 3.24 respectively. Figure 3.25 shows number of domestic LTOs for Turkish airports from 1990 to 2014.

Figure 3.23 Passenger traffic, 2005-2014

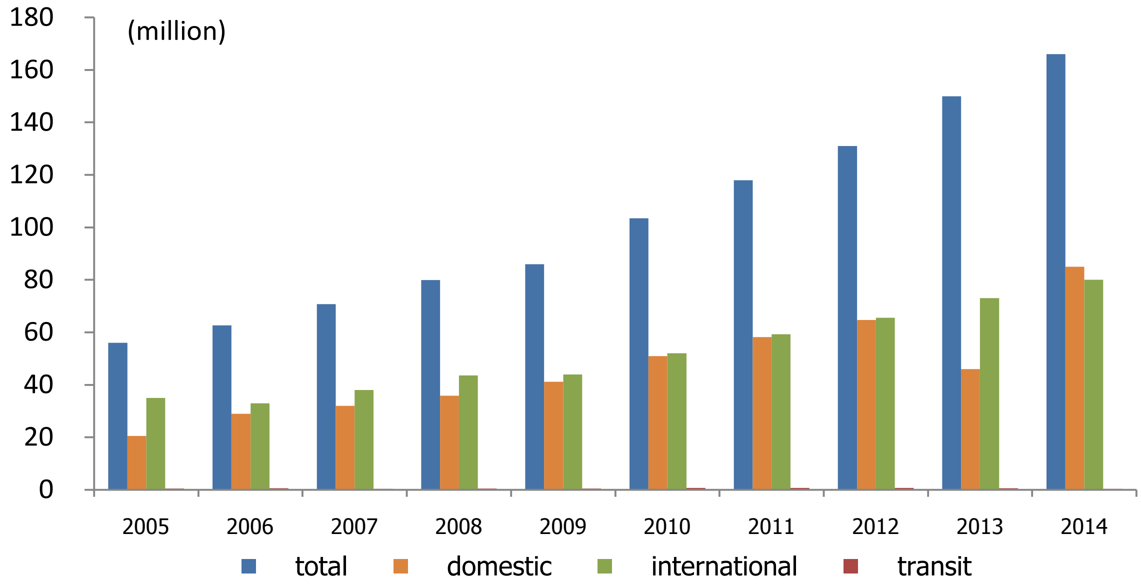
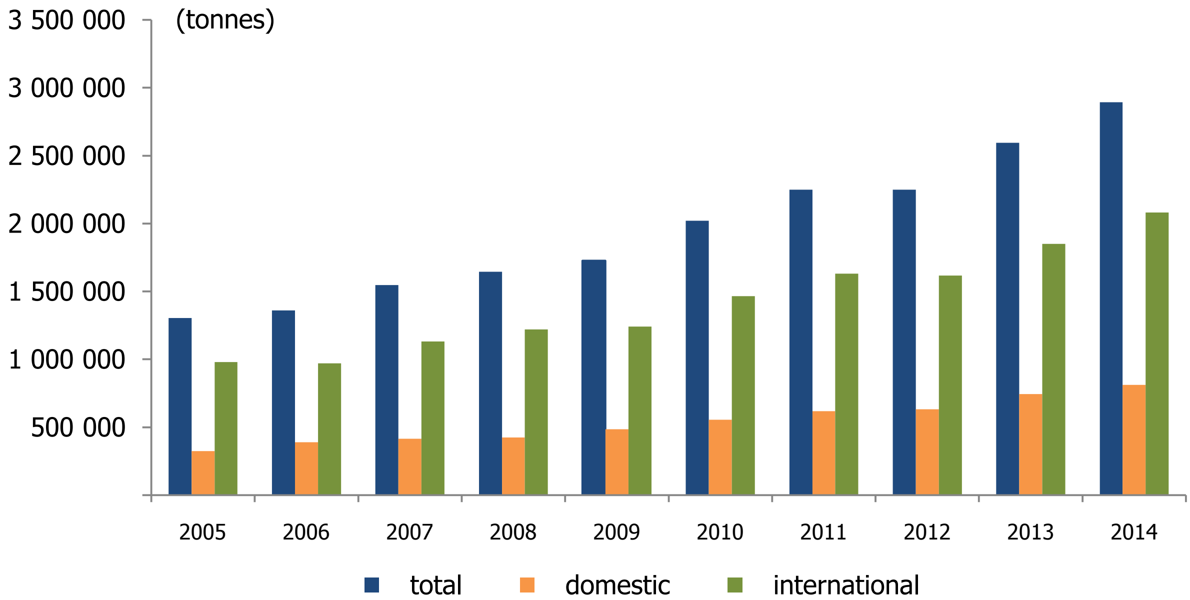


Figure 3.24 Freight traffic, 2005-2014



EFs for all aircraft types were obtained from IPCC Guidelines for National GHG Inventories (IPCC 2006). Default values were applied for aircrafts where specific data is not available.

In the light of these explanations, the total fuel consumption for domestic aviation is 1.284 Mt. The calculated total LTO fuel consumption is 0.643 Mt and cruise fuel consumption is 0.641 Mt, resulting CO_2 emission values of 2.028 Mt and 2.019 Mt for LTO and cruise respectively. CO_2, CH_4 and N_2O emission values and average EFs are given in Table 3.30 for domestic aviation.

Figure 3.25 Number of domestic LTO, 1990-2014

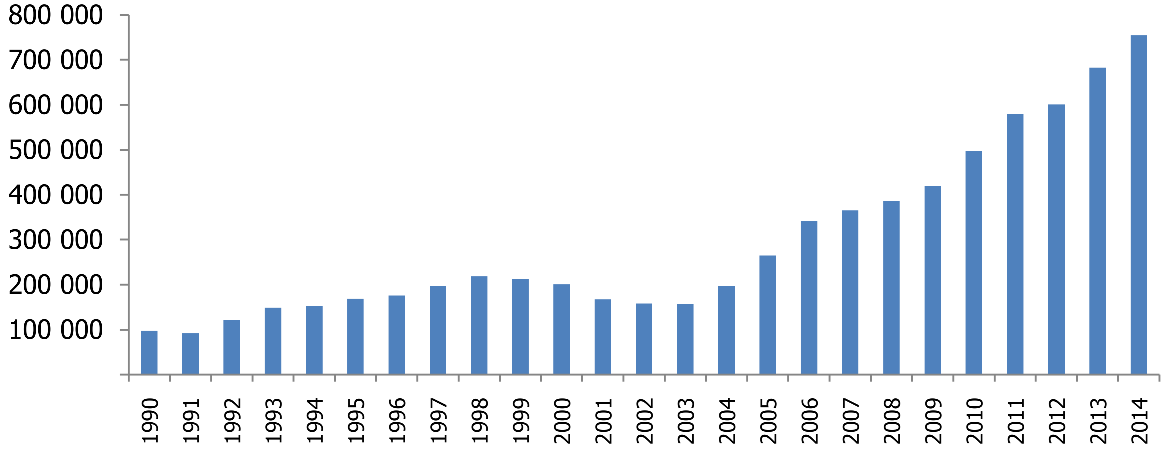


Table 3.30 GHG emissions from domestic aviation, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	914	0.01	0.03	923	13 030
1991	1 043	0.01	0.03	1 053	14 755
1992	1 107	0.02	0.04	1 118	15 648
1993	1 474	0.02	0.05	1 489	20 875
1994	1 747	0.02	0.06	1 764	24 653
1995	2 748	0.04	0.09	2 775	38 670
1996	3 018	0.04	0.10	3 048	42 642
1997	3 183	0.04	0.10	3 215	45 028
1998	3 278	0.04	0.11	3 311	46 302
1999	2 840	0.04	0.09	2 868	40 106
2000	3 068	0.04	0.10	3 099	43 296
2001	3 325	0.03	0.11	3 358	47 044
2002	2 478	0.03	0.08	2 503	35 266
2003	2 686	0.03	0.09	2 713	37 923
2004	4 811	0.04	0.16	4 859	68 082
2005	4 048	0.05	0.13	4 089	57 276
2006	4 467	0.05	0.15	4 512	63 194
2007	5 960	0.05	0.19	6 019	84 334
2008	5 166	0.06	0.17	5 218	73 201
2009	5 096	0.07	0.17	5 149	72 049
2010	2 833	0.04	0.09	2 862	40 043
2011	3 308	0.04	0.12	3 344	47 199
2012	3 688	0.05	0.13	3 727	52 686
2013	3 715	0.05	0.13	3 754	52 467
2014	4 047	0.05	0.14	4 090	57 243
Changes from 1990 (%)	342.8	400	366.7	343.1	339.3

Table 3.31 GHG emissions for LTO and cruise in domestic aviation, 2014

(kt)

	CO_2	CH_4	N_2O	Jet kerosene
Total	4 047	0.052	0.14	1 284
LTO	2 028	0.052	0.076	643
Cruise	2 019	-	0.064	641

Table 3.32 IEFs of domestic aviation 1990-2014

		IEFs		
	Activity	CO_2	CH_4	N_2O
Year	TJ	t/TJ	kg/TJ	kg/TJ
1990	13 030	70.13	0.96	2.29
1991	14 755	70.67	0.96	2.28
1992	15 648	70.72	0.98	2.42
1993	20 875	70.60	0.99	2.41
1994	24 653	70.84	0.98	2.29
1995	38 670	71.06	0.95	2.29
1996	42 642	70.77	0.99	2.28
1997	45 028	70.69	0.98	2.30
1998	46 302	70.79	0.84	2.31
1999	40 106	70.80	0.94	2.31
2000	43 296	70.86	0.86	2.31
2001	47 044	70.69	0.70	2.30
2002	35 266	70.28	0.96	2.26
2003	37 923	70.82	0.88	2.30
2004	68 082	70.67	0.57	2.28
2005	57 276	70.68	0.80	2.31
2006	63 194	70.68	0.84	2.32
2007	84 334	70.68	0.57	2.30
2008	73 201	70.57	0.76	2.31
2009	72 049	70.74	0.97	2.38
2010	40 043	70.75	0.95	2.36
2011	47 199	70.09	0.92	2.46
2012	52 686	69.99	0.88	2.45
2013	52 467	70.81	0.92	2.45
2014	57 243	70.70	0.90	2.44

Figure 3.26 and Figure 3.27 illustrate the total emissions and the emissions of N_2O and CH_4 increasing trends as CO_2 eq. emissions as CO_2 eq. have increased approximately 343% since 1990 and reached to 4.09 Mt CO_2 in 2014. The calculated amounts of N_2O and CH_4 emissions were 41.67 kt CO_2 eq. and 1.29 kt CO_2 eq. respectively in 2014.

Figure 3.26 GHG emissions for domestic aviation, 1990-2014

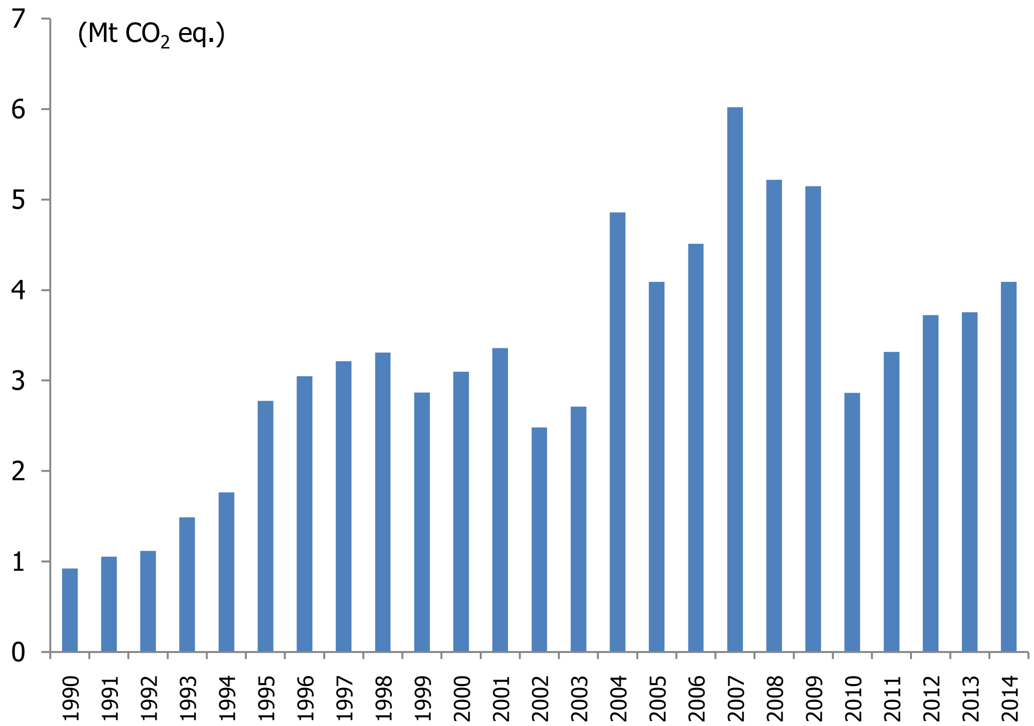
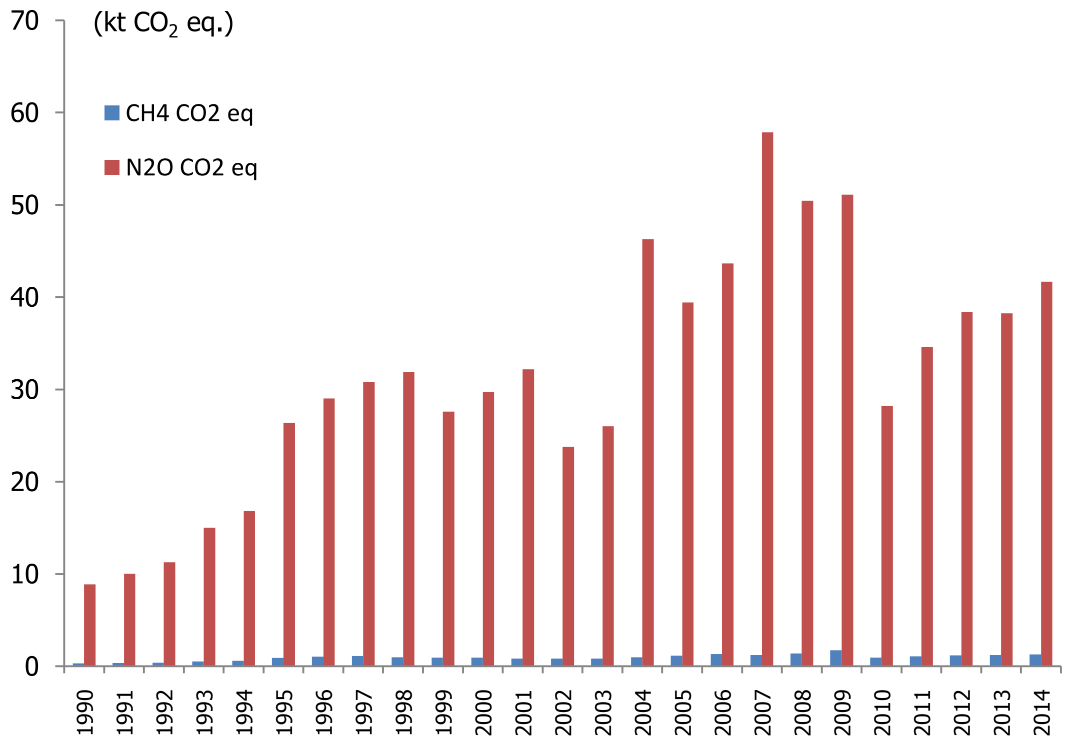


Figure 3.27 GHG emissions from domestic aviation, 1990-2014



Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 5.48% liquid fuels.

EF uncertainty for CO_2 was considered as 5% as indicated in 2006 IPCC guidelines Vol. 2 page 3.69. For CH_4 and N_2O mid value of default uncertainty given in 2006 IPCC guidelines as 80% and 85% were considered respectively.

Planned Improvement:

Work on data quality regarding fuel consumption and air traffic will be continued in cooperation with experts from related institutions.

3.2.6.2. Road transportation (Category 1.A.3.b)

Road Transportation source category was a key category, in terms of emission level of CO_2 from diesel oil, LPG and gasoline in 2014. This category was also a key category in terms of emission trend of CO_2 from gasoline and diesel oil. The results according to IPCC Tier 1&2 were in Table 3.33.

Table 3.33 GHG emissions from road transportation, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	24 174	3.9	1.8	24 808	335 589
1991	22 714	3.7	1.7	23 317	315 543
1992	23 260	4.0	1.8	23 899	323 808
1993	28 437	4.9	2.2	29 213	395 708
1994	26 703	4.8	2.1	27 450	372 206
1995	28 975	5.3	2.3	29 793	404 093
1996	30 788	5.7	2.5	31 663	429 564
1997	29 020	6.9	2.3	29 886	408 624
1998	27 055	7.3	2.2	27 903	383 300
1999	29 374	7.6	2.3	30 246	415 241
2000	31 019	8.8	2.2	31 882	439 986
2001	30 727	8.3	2.0	31 545	434 724
2002	31 300	7.7	2.1	32 120	441 038
2003	32 556	7.9	2.1	33 386	458 427
2004	34 271	8.2	2.2	35 132	482 069
2005	34 711	8.4	2.2	35 575	488 494
2006	37 511	9.0	2.3	38 418	527 725
2007	42 747	10.2	2.4	43 731	601 495
2008	39 682	10.3	2.3	40 611	562 707
2009	39 340	10.7	2.2	40 255	556 696
2010	39 085	11.2	2.1	39 993	554 362
2011	40 048	11.2	2.1	40 952	567 688
2012	55 225	12.4	2.9	56 393	775 067
2013	61 704	12.8	3.2	62 985	864 602
2014	65 711	13.4	3.4	67 070	921 018
Changes from 1990 (%)	172	243.6	88.9	170	174

In road transportation, gasoline, diesel, LPG, natural gas and biodiesel were used as fuel. Road transportation being the major source within transportation sector contributed 67.1 Mt of CO_2 eq. in 2014 with 91.9% of the transport emissions (Table 3.33). The emissions of N_2O reached 1.02 Mt CO_2 eq. and CH_4 reached 0.34 Mt CO_2 eq. in 2014 (Figure 3.29). Emissions from the consumption of biofuels were taken into consideration for CH_4 and N_2O emissions.

Figure 3.28 GHG emissions for road transportation, 1990-2014

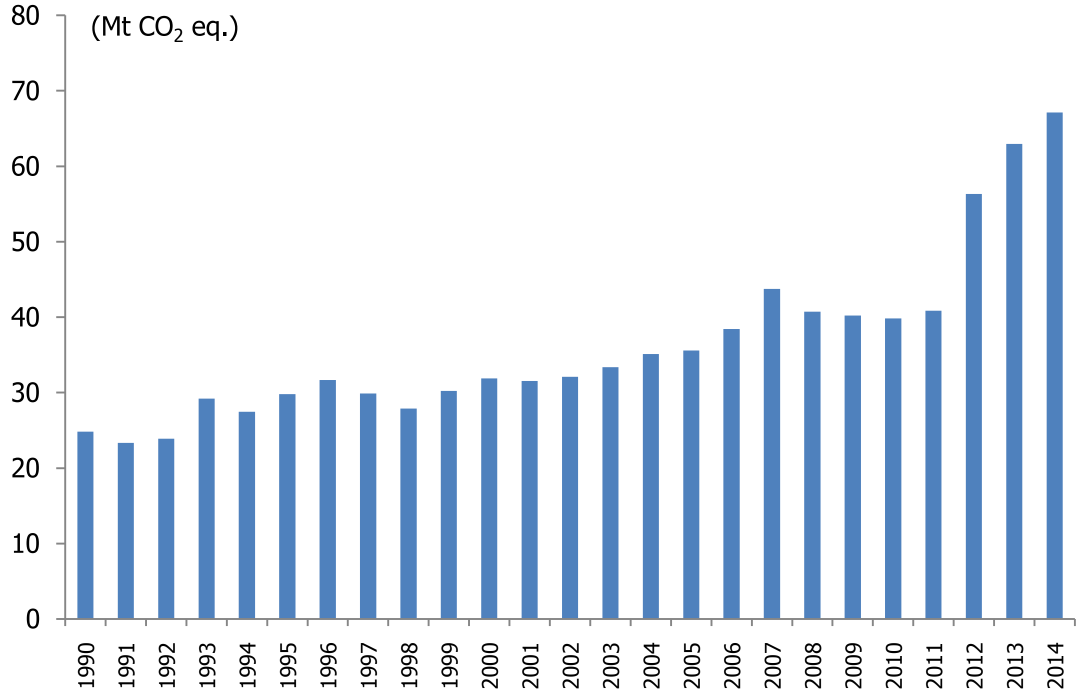
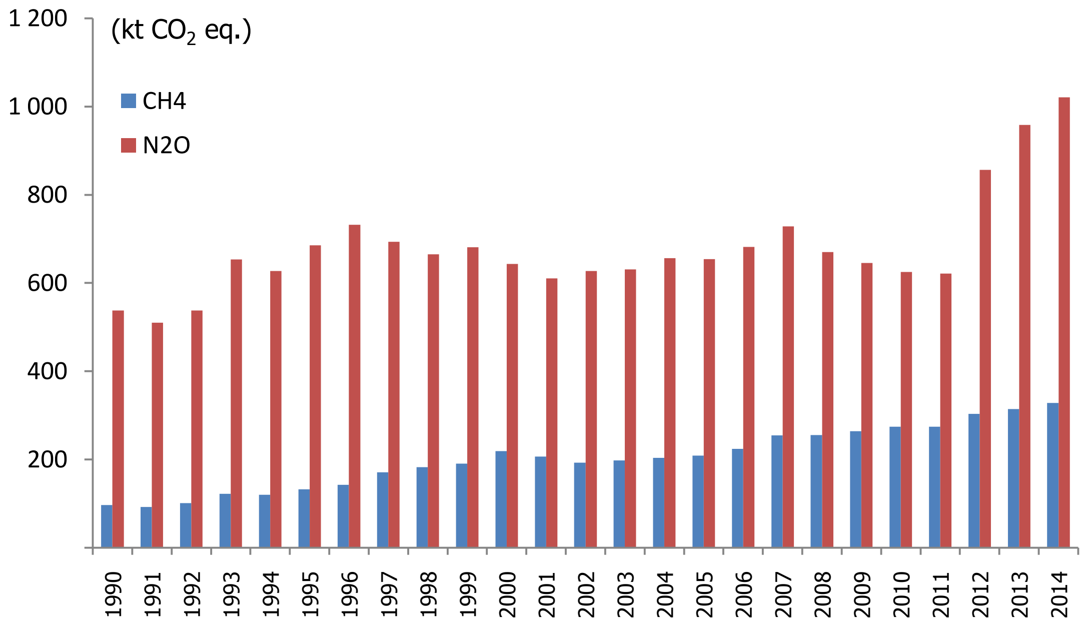
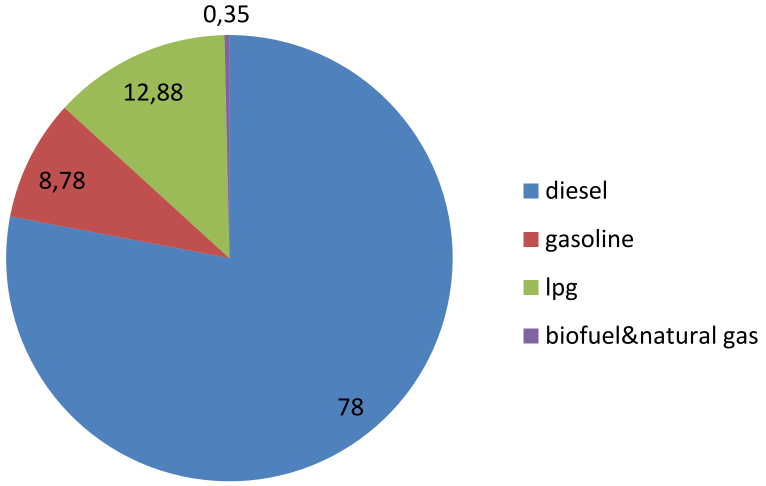


Figure 3.29 CH_4 and N_2O emissions for road transportation, 1990-2014



CO_2 emissions according to fuel types are illustrated in Figure 3.30. Most important portion of CO_2 emission is occurred from diesel fuel consumption, which is about 78% of total emissions of road transportation.

Figure 3.30 CO_2 emission distributions by fuel types (%), 2014



Source-Specific QA/QC and Verification:

Fuel consumption amounts in road transportation provided by the MENR were compared with those of DG of Petroleum Affairs, reported to IEA.

For the purpose of verifying data documentation; the assumptions and selection criteria on data, EFs and other calculation parameters as well as the completeness of inventory dossiers were checked with the IPCC Guidelines.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 10.05% for liquid fuels.

EF uncertainty for CO_2 was considered as 5% (max. value of given range) as indicated in 2006 IPCC guidelines Vol. 2 page 3.29. For CH_4 and N_2O mid value of default uncertainty given in 2006 IPCC guidelines as 250 were considered.

Planned Improvement:

Since the category is key category, Tiers used in emission estimation needs to be increased. The data availability required for T2 have been searched. Vehicle-km travelled is registered by the vehicle inspection stations during the periodical inspection of vehicles. However, dealing with such a big data scattered across the country is huge work. It is planned to gather vehicle km travelled data in collaboration with inspection stations.

3.2.6.3. Railways (Category 1.A.3.c)

The railways source category was not a key category in 2014. The data availability for railways is limited. Therefore IPCC Tier 1&2 approach has been used for this subsector. Diesel oil used in railways is taken into consideration. In addition coal was used for railways from 1990 to 2000. In this context emissions resulted from coal have been calculated.

Figure 3.31 and Figure 3.32 show the total emissions and the emissions of N_2O and CH_4 increase trends as CO_2 equivalents. CO_2 equivalent emissions have declined 14.7% since 1990. The amount of emissions calculated for railways is 0.56 Mt CO_2 in 2014.

Table 3.34 GHG emissions from railway, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	652	0.03	0.23	722	8 670
1991	669	0.04	0.24	742	8 923
1992	617	0.03	0.23	686	8 287
1993	676	0.04	0.25	753	9 110
1994	690	0.04	0.26	770	9 338
1995	690	0.04	0.27	770	9 348
1996	718	0.04	0.27	800	9 697
1997	718	0.04	0.27	801	9 717
1998	665	0.04	0.25	742	8 900
1999	649	0.04	0.25	723	8 780
2000	639	0.04	0.25	714	8 686
2001	526	0.03	0.20	588	7 150
2002	548	0.03	0.21	613	7 453
2003	564	0.03	0.22	630	7 670
2004	564	0.03	0.22	630	7 670
2005	679	0.04	0.26	759	9 230
2006	682	0.04	0.27	762	9 273
2007	421	0.02	0.16	471	5 724
2008	447	0.03	0.17	500	6 080
2009	434	0.02	0.17	485	5 900
2010	463	0.03	0.18	517	6 296
2011	477	0.03	0.19	533	6 485
2012	442	0.02	0.17	493	6 001
2013	453	0.03	0.18	506	6 154
2014	503	0.03	0.20	563	6 843
Changes from 1990 (%)	-22.9	0	-13.0	-22.0	-21.1

Figure 3.31 GHG emissions for railways, 1990-2014

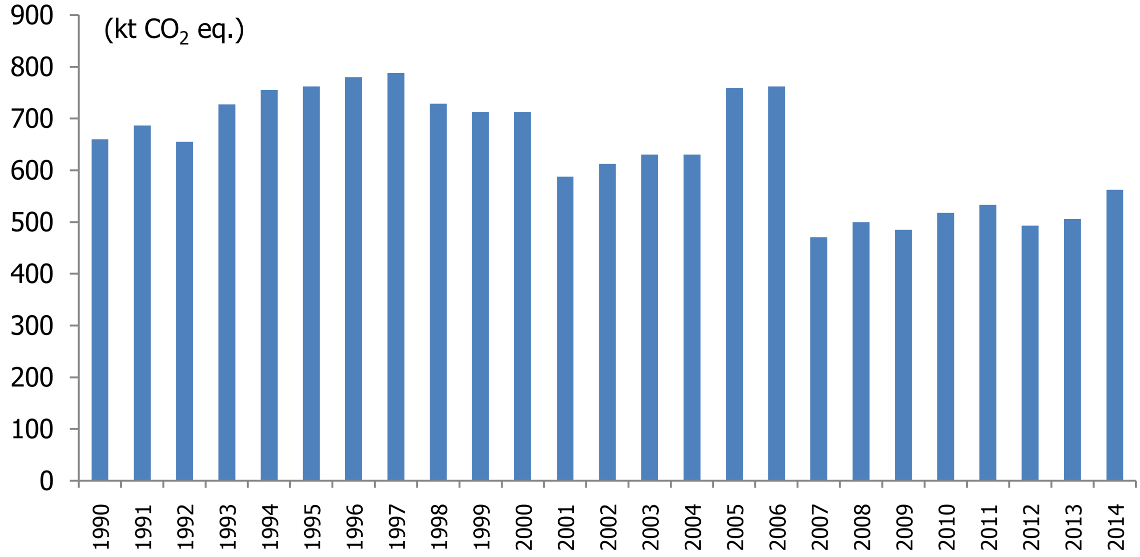
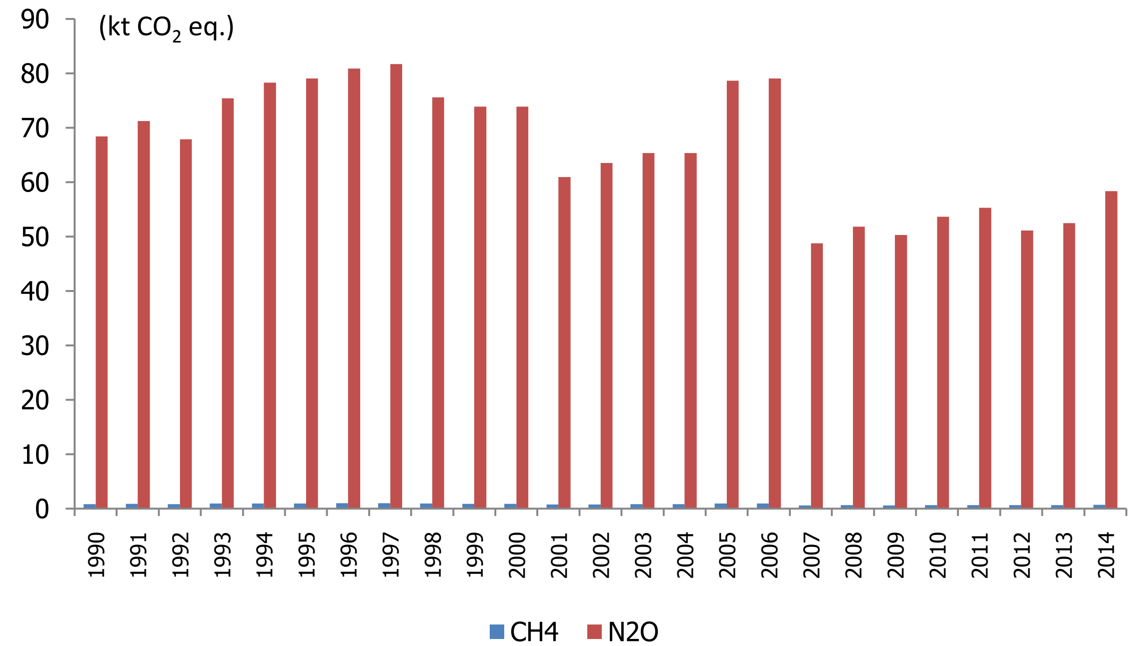


Figure 3.32 GHG emissions from railways, 1990-2014



Source-Specific QA/QC and Verification:

In terms of calculations made by alternative methods; verification on this sector was made by using different AD (passenger/km) and different EFs provided in the document "Structure of Costs and Charges Review – Environmental Costs of Rail Transport Final Report to the Office of Rail Regulation (August 2005)". As a result of the verification, it was observed that the results obtained were very same in each calculation methodology. In addition, fuel consumption values obtained from Energy Balance Table were compared with those reported to IEA.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 5% for liquid and solid fuels.

EF uncertainty for CO_2 was derived from 2006 IPCC guidelines Vol. 2 table 3.4.1 as 1.5% for liquid fuels and 14% for solid fuels. For CH_4, EF uncertainties were derived as 105% for liquid fuels and 135% for solid fuels. For N_2O EFs uncertainties were derived as 142% for liquid fuels and 150% for solid fuels.

Planned Improvement:

It is planned to have improvement of data on passenger, cargo, fuel consumption and distance travelled of diesel motor locomotives in railways sector.

3.2.6.4. Water-borne navigation (Category 1.A.3.d)

3.2.6.4.1. Domestic water-borne navigation (Category 1.A.3.d.ii)

The domestic water borne navigation source category was not a key category in 2014. The data availability is limited in this sub-sector. In domestic water-borne navigation only, diesel and residual fuel oil were consumed as energy source. In emission calculation, IPCC Tier 1&2 approach is used.

Domestic water-borne navigation contributed 1.336 Mt of CO_2 in 2014. The emissions of N_2O increased to 10.78 kt CO_2 eq. and CH_4 increased to 3.16 kt CO_2 eq. in 2014 compared to 2013 (Figure 3.34).

Table 3.35 GHG emissions from domestic navigation, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	504	0.05	0.01	509	6 624
1991	538	0.05	0.01	543	7 068
1992	632	0.06	0.02	639	8 290
1993	658	0.06	0.02	664	8 632
1994	617	0.06	0.02	623	8 129
1995	720	0.07	0.02	727	9 444
1996	693	0.06	0.02	700	9 104
1997	692	0.06	0.02	699	9 090
1998	719	0.07	0.02	726	9 466
1999	652	0.06	0.02	659	8 610
2000	618	0.06	0.02	624	8 167
2001	793	0.07	0.02	801	10 535
2002	814	0.08	0.02	823	10 821
2003	883	0.08	0.02	892	11 732
2004	1 217	0.11	0.03	1 230	16 266
2005	1 288	0.12	0.03	1 301	17 225
2006	1 451	0.14	0.04	1 466	19 436
2007	1 584	0.15	0.04	1 600	21 241
2008	1 529	0.14	0.04	1 545	20 561
2009	1 619	0.15	0.04	1 635	21 991
2010	1 667	0.16	0.05	1 685	22 658
2011	2 222	0.21	0.06	2 246	30 058
2012	1 601	0.15	0.04	1 617	21 670
2013	1 144	0.11	0.03	1 156	15 486
2014	1 336	0.13	0.04	1 350	18 083
Changes from 1990 (%)	165	160	300	165	173

Figure 3.33 GHG emissions from domestic water-borne navigation, 1990-2014

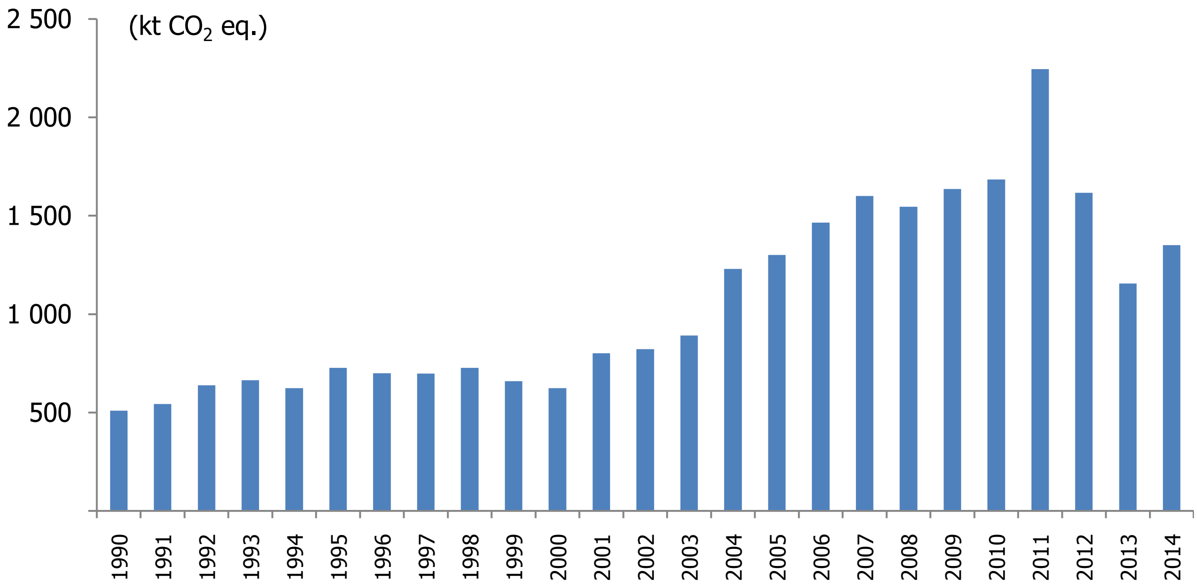
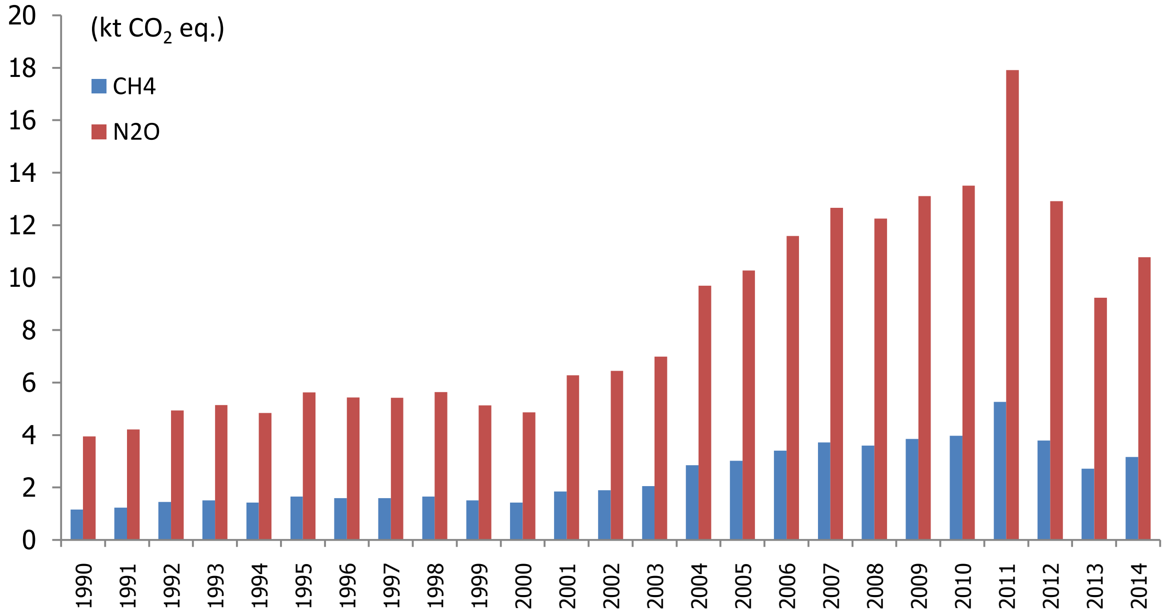


Figure 3.34 GHG emissions from domestic water-borne navigation, 1990-2014



Source-Specific QA/QC and Verification:

On the energy balance table provided by the MENR, diesel and fuel oil consumption values were compared with the values provided by MTMAC's DG of Merchant, as well as the Annual Activity Report results of Energy Market Regulatory Authority and also with the "Domestic Navigation" fuel consumption amount values which DG of Petroleum Affairs regularly reports to the IEA.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 15% for liquid fuels.

EF uncertainty for CO_2 was considered as 1.5% for liquid fuels as indicated in 2006 IPCC guidelines Vol. 2 page 3.54. It was considered as 50% for CH_4 and 140% for N_2O.

Planned Improvement:

In order to tackle the negative effects of this growing maritime traffic on environment and public health, Turkey has been taking steps forward to reduce this kind of emissions and implement relevant international and EU legislation.

In this context, MTMAC's DG of Maritime and Inland Waters Regulation launched a Twinning Project titled "Control of Ship-Sourced Emissions in Turkey" in collaboration with the EU, which was finalized in 2014; the project will provide extensively detailed calculations on domestic water-borne navigation. Thus, the project will extensively contribute to the overall efforts of the Turkish administration to diminish this sort of emissions on the long term.

The objectives of this twinning project are broadly the following:

- Help to improve the current knowledge on the level and distribution of ship sourced emissions in Turkey, developing instant and reliable monitoring systems.
- Propose specific measures at different levels of action to decrease ship emissions.
- Contribute to enhance legislation on this particular field, according to international and European Law, as well as taking into account best legislative practices in other countries.
- Boost the performance of port inspection services, throughout specific training on the field of ship sourced emissions.

There are a few different sources of emissions to air on ships. For most pollutants, the exhaust gases from the engines are by far the most important source of emissions. Other sources that should be considered are related to boilers and leakage of refrigerant gases from refrigerated storage rooms, refrigerated containers or air conditioning.

The general way of estimating emissions is by multiplying activity, e.g. fuel consumption or power output, by an EF. Different EFs are used depending on different properties of the emission source. When it comes to emissions caused by the engines, examples of such properties would be fuel type, engine age, engine stroke-type or engine RPM. Corresponding AD for ships would be engine power output or fuel consumption. As an example, the emission of CO_2 from main engines of a ship could be estimated by:

$$E_{NOx}^{ME} = P^{ME} * EF_{NOx}^{ME} \qquad (3.1)$$

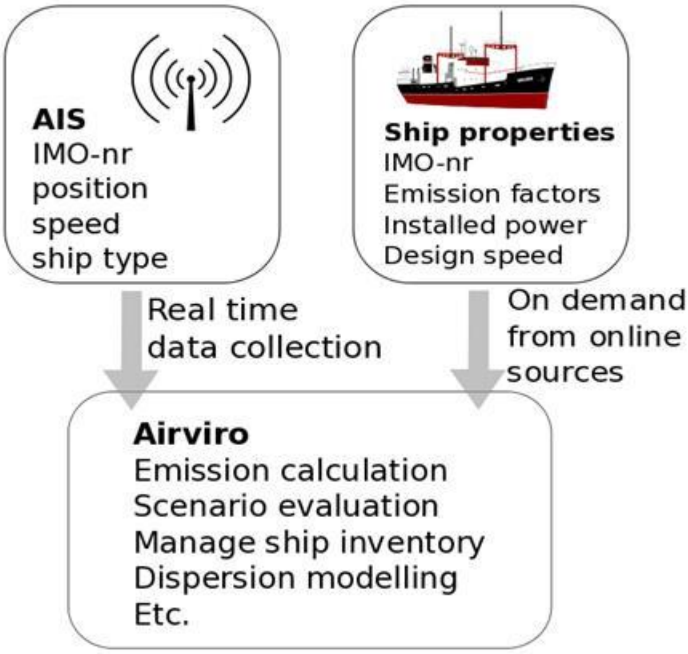
Where E_{NOx}^{ME} is the emission [g/h], P^{ME} represents output of the main engine in kW (denoted by ME) and EF_{NOx}^{ME} is the EF in [g/kWh]. For estimation of emissions of substances that are directly related to the content of the fuel, the EF should be expressed as emission per mass of fuel, e.g. [g/g]. In case the available AD is expressed as power output, it has to be converted to amount of fuel using the Specific Fuel Oil Consumption of the engine (SFOC). SFOC can be regarded as a measure of the engine efficiency, and is usually expressed in [g/kWh]. The emission would then be estimated by:

$$E_{CO2}^{ME} = P^{ME} * SFOC^{ME} * EF_{CO2} \qquad (3.2)$$

Where E_{CO2}^{ME} refers to emission of CO_2 from main engine [g/h], P^{ME} represents the power output from main engine [kW], $SFOC^{ME}$ represents SFOC of main engine [g/kWh] and EF_{CO2} is the EF for CO_2 expressed without units (mass CO_2 /mass fuel).

The Ship Emission Model (SEM) is dependent on access to positioning data from automatic idendification system (AIS), as well as technical properties for the ships. AIS-data can be collected directly from receivers, or from other sources, such as databases or networks of AIS-receivers. Ship properties can for example be transferred from databases maintained by national authorities or commercial companies. In Figure 3.35, the different components necessary to perform calculations of emissions from shipping are shown. It can be seen in the figure that ship properties are acquired from external sources. The framework is not restricted to any special source of information and can also make combined use of multiple source of information. An important part of the logic connected to estimation of shipping emissions is connected to the estimation EFs and assumptions related to how the ships are operated.

Figure 3.35 The different components necessary to calculate emissions from shipping.



The logic of the SEM is mainly implemented in five different parts:

- Automatic creation of ship sources
- AIS-data post-processing
- Fetch of ship data from IHS fair play or other data sources
- Assignment of ship template values and model assumptions
- Pre-defined time-series parameters
- Definitions of emission activities

For each emission source, any number of emission activities can be specified. An emission activity is defined by an algebraic/logical expression. When evaluated, the expression returns the emission of a specific substance in g/s.

Different types of parameters can be used when defining the expressions:

- Time-series
- Constants
- Variables

Common for all the parameters is that their values are stored separately for each ship and emission activity.

They are based on AIS, and therefore have the same temporal resolution (5 minutes). Constants are typically used for ship properties, such as installed power on main engine, or model assumptions such as degree of usage of auxiliary engines during cruise. These values do not change over time. Variables are parameters with a prescribed monthly, daily or hourly variation.

Table 3.36 The Time-series parameters available in SEM

Time series parameter	Long name	Unit	Comment
_V_	Ship speed	Knots	Ship speed over ground
status	Status		Refers to operational mode defined as an integer code. 0=undefined (not yet set) 1=cruise 2=maneuvering 3=anchored 4=on-shore power supply 5=at berth
_P_ME_	Power output Main Engines	kW	Current power output from main engines
_P_AE_	Power output Auxiliary Engines	kW	Current power output from auxiliary engines
_EL_ME_	Engine Load Main Engines	-	Fraction of installed power used for engines – assumed equal for all main engines
_EL_AE_	Engine Load Auxiliary Engines	-	Fraction of installed power used for engines – assumed equal for all auxiliary engines
_SFOC_ME_	Specific Fuel Oil Consumption Main Engines	g/kWh	Current SFOC of main engines, considering engine load
_SFOC_AE_	Specific Fuel Oil Consumption Auxiliary Engines	g/kWh	Current SFOC of auxiliary engines, considering engine load

Besides the predefined time-series parameters, a large number of constants are used in the expressions defining the emission activities. A few different types of constants can be distinguished:

- Constants describing properties of the ship or engines. These are typically acquired from IHS Fair play or other ship databases. Default values are estimated from statistics for each ship category.
- Constants representing model assumptions. An example is the degree of usage of main engines, auxiliary engines and boilers during different operational modes.
- Emission activities are defined separately for main engines, auxiliary engines, boilers and for leakage of refrigerant gases.

In addition, there are activities defined that allows calculation of fuel consumption, run-time and travel distance. These activities are typically used for validation purposes.

The emissions of CO_2 are direct proportional to the carbon content in the fuel and set to 3 130 and 3 190 kg/tonnes fuel for residual fuel oil and marine diesel oil respectively (IPCC, 2006). The EFs for CH_4 and N_2O are taken from IPCC 2006/CORINAIR and set to 0.3 and 0.08 kg per tonnes fuel respectively.

Fuel consumption is calculated as a total, independent of fuel type. Runtime refers to time in motion, i.e. time during hoteling is not included. Travel-distance is simply the distance travelled, based on speed calculated from AIS and run-time.

Due to inherent uncertainties in EFs, validation of the overall model performance is preferably made by comparisons between calculated and measured fuel consumption. Since it is common that ships are only active during short time periods of a year, while fuel reports are commonly available on an annual or monthly basis, the run-time and travel-distance can be used for checking that the obtained results are reasonable.

Results of the projects named "Control of Ship-Sourced Emissions in Turkey" will be available in the next years. So direct emission measurement from domestic navigation sectors will be used in the inventory.

3.2.6.4.2. Pipeline transport (Category 1.A.3.e.i)

In emission calculation, IPCC Tier 1&2 approach is used. Pipeline Transport contributed 0.6 Mt of CO_2 in 2014. Table 3.37 shows the trend in GHG emissions from pipeline transport.

Table 3.37 The trend in GHG emissions from pipeline transport

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	40	0.04	0.002	42	705
1991	50	0.04	0.003	52	875
1992	55	0.05	0.003	57	962
1993	61	0.05	0.003	63	1 075
1994	66	0.06	0.004	69	1 167
1995	85	0.07	0.004	88	1 489
1996	99	0.09	0.005	103	1 745
1997	122	0.11	0.006	126	2 143
1998	126	0.11	0.007	131	2 221
1999	152	0.13	0.008	158	2 682
2000	183	0.16	0.010	190	3 217
2001	202	0.18	0.011	209	3 553
2002	215	0.19	0.011	223	3 826
2003	249	0.22	0.013	258	4 372
2004	245	0.22	0.013	255	4 317
2005	369	0.32	0.019	383	6 487
2006	322	0.28	0.017	334	5 658
2007	343	0.30	0.018	356	6 030
2008	670	0.59	0.036	695	11 848
2009	443	0.39	0.023	459	7 803
2010	396	0.35	0.021	411	6 945
2011	372	0.33	0.020	387	6 552
2012	387	0.34	0.020	401	6 796
2013	571	0.51	0.040	596	10 025
2014	602	0.54	0.042	628	10 575

3.2.6.4.3. Off road transportation (Category 1.A.3.e.ii)

No information is reported under this category.

3.2.7. Other sectors (Category 1.A.4)

Source Category Description:

The emissions that are included in this category mainly arise from fuel consumption in heating of the sectors of commercial/institutional, residential and agriculture/forestry/fisheries. The source category (1.A.4.a) and (1.A.4.b) are considered together since they are not presented separately in the national energy balance tables. The source category includes the emission from the agricultural activities but does not include forestry and fisheries.

Autoproducers within the commercial and institutional sector were also included in this category.

The share of GHG emissions as CO_2 eq. from manufacturing industry in total fuel combustion was 16.5% in 2014 while it was 25.6% in 1990.

Table 3.38 Fuel combustion emissions from other sectors, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ	Share in fuel combustion sector (%)	Fuel combustion total (kt)
1990	29 297	133	1.5	33 072	655 452	25.6	129 154
1991	30 161	134	1.5	33 960	674 081	25.5	133 430
1992	32 176	137	1.5	36 053	693 276	25.8	139 555
1993	33 041	133	1.5	36 813	707 789	25.0	147 445
1994	29 499	122	1.4	32 980	672 020	22.9	144 219
1995	33 155	126	1.5	36 747	717 614	23.4	157 353
1996	34 204	124	1.5	37 745	740 642	21.9	172 594
1997	36 812	128	1.5	40 464	774 556	21.9	185 187
1998	33 457	119	1.4	36 852	741 759	20.0	184 513
1999	31 901	111	1.3	35 073	718 605	19.2	183 139
2000	34 408	109	1.3	37 516	747 303	17.9	209 658
2001	28 216	97	1.2	31 004	659 658	16.0	194 007
2002	29 757	98	1.2	32 573	665 714	16.1	201 964
2003	32 811	100	1.2	35 665	695 600	16.6	215 196
2004	36 494	102	1.2	39 389	735 089	17.5	225 314
2005	39 529	100	1.2	42 380	778 675	17.1	248 370
2006	41 267	98	1.1	44 059	799 294	16.3	270 699
2007	44 121	99	1.1	46 927	833 911	15.7	299 841
2008	61 457	146	1.4	65 521	1 010 959	22.7	288 617
2009	66 626	162	1.4	71 107	1 049 762	25.9	274 455
2010	63 991	160	1.4	68 411	998 601	24.5	279 355
2011	69 751	134	1.2	73 456	1 086 309	25.3	290 758
2012	59 787	133	1.0	63 414	884 704	20.2	313 505
2013	54 706	131	1.2	58 326	949 579	19.2	303 048
2014	51 433	106	0.9	54 351	872 050	16.5	330 385

Methodological Issues:

GHG emissions from 1A4 sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

MENR compiles fuel data from all electricity producers via survey. Plant specific fuel consumption and NCVs of the autoproducers were taken from MENR.

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from all subcategories of 1A2 and 1A4 were recalculated for the 1990-2013 period.

2006 IPCC default oxidation rate was used. CO_2 emissions from biomass were estimated by using 2006 IPCC default emissions factors. CH_4 and N_2O emissions were also estimated by using 2006 IPCC default EFs.

Recalculation:

CO_2 emissions for hard coal, lignite and natural gas fuels were calculated by using country specific carbon contents for all inventory years. Moreover, country specific oxidation rate of hard coal and lignite was used for all inventory years.

3.2.7.1. Commercial/Institutional (Category 1.A.4.a)

The fuel consumption of commercial/institutional is not separated in the energy balance tables, and given combined with residential sector. Therefore emissions are given under category (1.A.4.b).

3.2.7.2. Residential (Category 1.A.4.b)

Source Category Description:

The source category residential was a key category in terms of emission level of CO_2 from solid, liquid and gaseous fuels and in terms of emission trend of CO_2 from liquid and solid fuels in 2014. The source category was also a key category in terms of emission level of CH_4 from solid fuels and in terms of emission trend of CH_4 from biomass. Although, residential and commercial/institutional fuel consumptions are not separable in the national energy balance tables, high percentage of fuel is consumed in households. Autoproducers within the commercial and institutional sector were also included in this category.

The share of GHG emissions as CO_2 eq. from residential sector in other sectors of fuel combustion emissions was 94.2% in 2014 while it was 82.1% in 1990. It was 15.5% of total fuel combustion emissions in 2014.

Table 3.39 Fuel combustion emissions from residential sector, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ	Share in sector 1A4 (%)	Fuel combustion total (kt)
1990	23 424	132.3	1.45	27 165	575 626	82.1	33 072
1991	24 263	133.2	1.46	28 028	593 914	82.5	33 960
1992	26 262	136.2	1.47	30 105	612 892	83.5	36 053
1993	25 757	131.9	1.45	29 486	608 779	80.1	36 813
1994	22 177	121.0	1.38	25 616	572 505	77.7	32 980
1995	25 684	125.2	1.41	29 232	616 066	79.5	36 747
1996	26 328	123.2	1.39	29 823	633 596	79.0	37 745
1997	28 649	127.4	1.41	32 253	663 606	79.7	40 464
1998	25 370	117.8	1.35	28 719	631 850	77.9	36 852
1999	23 592	109.7	1.28	26 715	605 663	76.2	35 073
2000	25 754	107.5	1.25	28 812	629 680	76.8	37 516
2001	19 935	95.8	1.16	22 675	547 106	73.1	31 004
2002	21 349	97.1	1.14	24 116	551 428	74.0	32 573
2003	24 273	98.8	1.13	27 078	579 561	75.9	35 665
2004	27 319	100.4	1.11	30 160	610 383	76.6	39 389
2005	30 271	99.0	1.08	33 068	652 843	78.0	42 380
2006	31 324	96.8	1.05	34 057	664 146	77.3	44 059
2007	33 289	97.3	1.04	36 032	686 687	76.8	46 927
2008	47 735	144.4	1.25	51 718	824 448	78.9	65 521
2009	53 172	160.5	1.31	57 575	866 911	81.0	71 107
2010	50 807	158.4	1.28	55 150	819 395	80.6	68 411
2011	54 367	132.0	1.06	57 983	877 033	78.9	73 456
2012	56 482	132.3	0.94	60 070	840 354	94.7	63 414
2013	52 232	130.5	1.14	55 832	915 733	95.7	58 326
2014	48 281	105.3	0.89	51 178	828 386	94.2	54 351

The decrease since 2014 is 4 653 kt CO_2 eq. (8.3% of decrease) decrease in total emissions from *Residential* subcategory. The main reason for decreasing emissions in this sector is due to reduction of consumption of liquid (especially Lignite) and solid fuels in commercial/institutional and residential sector.

Methodological Issues:

GHG emissions from 1A4 sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

MENR compiles fuel data from all electricity producers via survey. Plant specific fuel consumption and NCVs of the autoproducers were taken from MENR.

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from all subcategories of 1A2 and 1A4 were recalculated for 1990-2013 period.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 7.07% for liquid fuels, 14.14% for solid fuels, 5% for gaseous fuels and 300% for biomass.

EFs uncertainty was taken from 2006 IPCC guideline Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A4b category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined.

Recalculation:

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from all subcategories of 1A2 and 1A4 were recalculated for 1990-2013 period.

Planned Improvement:

There is no planned improvement for this category.

3.2.7.3. Agriculture/Forestry/Fisheries (Category 1.A.4.c)

Source Category Description:

The source category is only including the emission from the consumption of fuel in agricultural activities. This source category was a key category in terms of emission level and trend of CO_2 from liquid fuels in 2014. The share of GHG emissions as CO_2 eq. from residential sector in other sectors fuel combustion emissions was 5.8% in 2014 while it was 17.9% in 1990.

The AD of this sub-category generally keeps consistency during the period 1990-2011, increasing gradually. However, there was a drop in 2012. Before 2012, Diesel fuel was distributed in accordance with the definitions given below:

- Diesel oil (sulfur content up to 10 mg/kg)
- Rural diesel (maximum sulfur content of 1000 mg/kg).

First one is used mainly in road transportation and the second one is used in agriculture and off-road vehicles. Based on this definition, diesel oil consumption in road transportation and agriculture can be separated. But "Technical Regulation Notification on Types of Diesel" entered into force by being published on Official Gazette No. 27312 dated 08.07.2009 and restricted diesel oil sulfur content up to 10 mg/kg. The deadline for implementation is extended to April 2011. After April 2011, it is not possible to separate the different use of diesel fuel. So in 2012 energy balance, diesel oil is included in road transportation. Due to this fact, a sharp increase in diesel consumption in road transportation and a sharp decrease in fuel consumption of Agriculture/Forestry/Fisheries sector were observed.

Table 3.40 Fuel combustion emissions from agriculture sector, 1990-2014

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ	Share in sector 1A4 (%)	Fuel combustion total (kt)
1990	5 873	0.80	0.048	5 907	79 826	17.9	33 072
1991	5 898	0.80	0.048	5 933	80 167	17.5	33 960
1992	5 914	0.80	0.048	5 949	80 383	16.5	36 053
1993	7 285	0.99	0.059	7 327	99 010	19.9	36 813
1994	7 322	1.00	0.060	7 364	99 515	22.3	32 980
1995	7 471	1.02	0.061	7 515	101 548	20.5	36 747
1996	7 876	1.07	0.064	7 922	107 045	21.0	37 745
1997	8 163	1.11	0.067	8 211	110 950	20.3	40 464
1998	8 086	1.10	0.066	8 134	109 909	22.1	36 852
1999	8 310	1.13	0.068	8 358	112 943	23.8	35 073
2000	8 654	1.18	0.071	8 704	117 623	23.2	37 516
2001	8 281	1.13	0.068	8 329	112 553	26.9	31 004
2002	8 408	1.14	0.069	8 457	114 286	26.0	32 573
2003	8 537	1.16	0.070	8 587	116 039	24.1	35 665
2004	9 175	1.25	0.075	9 229	124 705	23.4	39 389
2005	9 258	1.26	0.075	9 312	125 832	22.0	42 380
2006	9 943	1.35	0.081	10 001	135 149	22.7	44 059
2007	10 832	1.47	0.088	10 895	147 224	23.2	46 927
2008	13 722	1.87	0.112	13 802	186 511	21.1	65 521
2009	13 454	1.84	0.110	13 532	182 852	19.0	71 107
2010	13 184	1.80	0.108	13 261	179 206	19.4	68 411
2011	15 383	2.09	0.125	15 473	209 276	21.1	73 456
2012	3 305	1.19	0.029	3 344	44 349	5.3	63 414
2013	2 474	0.58	0.020	2 494	33 847	4.3	58 326
2014	3 152	0.57	0.024	3 173	43 664	5.8	54 351

Methodological Issues:

GHG emissions from 1A4 sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from all subcategories of 1A2 and 1A4 were recalculated for 1990-2013 period.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 14.14% for liquid fuels and 7% for gaseous fuels.

EFs uncertainty was taken from 2006 IPCC guideline Vol.2 page 2.38. Uncertainty values were considered as 7% for CO_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A4c category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined.

Recalculation:

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from all subcategories of 1A2 and 1A4 were recalculated for 1990-2013 period.

Planned Improvement:

There is no planned improvement for this category.

3.2.8. Other (Category 1.A.5)

No other sectors were covered under energy sector. Emissions from fuel delivered to the military is included under category 1A4b (for stationary) and 1A3 (for mobile).

3.3. Fugitive Emission from Fuels (Category 1.B)

Source Category Description:

Fugitive emissions from extraction, processing, storage and transport of fossil fuels were covered under this category. CH_4 emission from coal mining, CH_4, CO_2, N_2O and NMVOC emissions from exploration, production/processing, transport/transmission, refining and storage of oil and natural gas were covered. Abandoned underground coal mines could not be covered due to insufficient data.

Table 3.41 Fugitive emissions from fuels, 1990-2014

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	220	124	0.003	3 324
1991	263	118	0.004	3 211
1992	254	113	0.004	3 069
1993	231	112	0.003	3 044
1994	219	103	0.003	2 785
1995	209	100	0.003	2 701
1996	208	97	0.003	2 637
1997	206	108	0.003	2 919
1998	194	120	0.003	3 183
1999	178	163	0.002	4 254
2000	168	182	0.002	4 707
2001	155	166	0.002	4 296
2002	148	154	0.002	3 998
2003	145	151	0.002	3 933
2004	140	149	0.002	3 863
2005	142	166	0.002	4 282
2006	135	176	0.002	4 529
2007	133	246	0.002	6 274
2008	135	262	0.002	6 694
2009	138	252	0.002	6 434
2010	156	261	0.002	6 694
2011	151	290	0.002	7 405
2012	144	307	0.002	7 810
2013	146	274	0.002	6 989
2014	145	343	0.002	8 719

CO_2 and CH_4 were the main fugitive emissions in this category. CH_4 was emitted mainly from coal mining while CO_2 was emitted from venting and flaring. Fugitive emissions as CO_2 eq. constitute 2.6% of total energy emissions in 2014. 67% of fugitive emissions as CO_2 eq. were from solid fuels and 33% were from oil and gas systems in the same year.

Table 3.42 Fugitive emissions from fuels by subcategory, 1990-2014

(kt CO_2 eq.)

Year	Total	Solid fuels	Oil and natural gas
1990	3 324	2 432	891
1991	3 211	2 151	1 060
1992	3 069	2 022	1 046
1993	3 044	2 047	997
1994	2 785	1 808	977
1995	2 701	1 688	1 013
1996	2 637	1 570	1 067
1997	2 919	1 767	1 152
1998	3 183	2 028	1 155
1999	4 254	3 038	1 215
2000	4 707	3 421	1 286
2001	4 296	3 005	1 291
2002	3 998	2 665	1 333
2003	3 933	2 433	1 500
2004	3 863	2 323	1 540
2005	4 282	2 497	1 784
2006	4 529	2 591	1 938
2007	6 274	4 078	2 196
2008	6 694	4 429	2 265
2009	6 434	4 385	2 049
2010	6 694	4 640	2 054
2011	7 405	5 024	2 381
2012	7 810	5 304	2 507
2013	6 989	4 813	2 176
2014	8 719	5 843	2 876

Methodological Issues:

GHG emissions from 1B sector were calculated by using 2006 IPCC T1 approaches by TurkStat. Domestic production data for coal, oil and natural gas were taken from the national energy balance tables in kt. MENR provided domestic coal production in underground and surface mining details. Pipeline transmission amount of oil and natural gas and natural gas storage were provided by, Petroleum Pipeline Company (BOTAŞ) (which is state own enterprise and authority for crude oil and natural gas transportation and pipeline operation). Petroleum refining data were taken from Turkish Petroleum Refineries Co. (TÜPRAŞ). For LPG and gasoline distribution, consumption values presented in the national energy balance tables were used as AD.

Fugitive GHG emissions were estimated by using 2006 IPCC default EFs.

Recalculation:

There was a recalculation for 1990-2013 in oil and gas system. Details are given under the recalculation part of section 3.3.2.

3.3.1. Solid fuels (Category 1.B.1)

Source Category Description:

This source category covers CH_4 emissions which occur during the surface and underground extraction of solid fuels and post-mining activities. The emissions due to combustions of those fuels to support production activities is not included in this section. Under this category only CH_4emissions from coal mining and handling were calculated. Abandoned underground mines were not covered due to lack of data.

The share of fugitive CH_4 emissions from coal mining was 68.2% in total fugitive CH_4 emissions and 50% in total energy sector CH_4 emissions in 2014. This source category was a key category in terms of emission level of CH_4. The category was also a key category in terms of emission trend of CH_4 emissions.

Table 3.43 Fugitive emissions from solid fuels
(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	NE	97	NE,NO	2 432
1991	NE	86	NE,NO	2 151
1992	NE	81	NE,NO	2 022
1993	NE	82	NE,NO	2 047
1994	NE	72	NE,NO	1 808
1995	NE	68	NE,NO	1 688
1996	NE	63	NE,NO	1 570
1997	NE	71	NE,NO	1 767
1998	NE	81	NE,NO	2 028
1999	NE	122	NE,NO	3 038
2000	NE	137	NE,NO	3 421
2001	NE	120	NE,NO	3 005
2002	NE	107	NE,NO	2 665
2003	NE	97	NE,NO	2 433
2004	NE	93	NE,NO	2 323
2005	NE	100	NE,NO	2 497
2006	NE	104	NE,NO	2 591
2007	NE	163	NE,NO	4 078
2008	NE	177	NE,NO	4 429
2009	NE	175	NE,NO	4 385
2010	NE	186	NE,NO	4 640
2011	NE	201	NE,NO	5 024
2012	NE	212	NE,NO	5 304
2013	NE	193	NE,NO	4 813
2014	NE	234	NE,NO	5 843

The share of underground coal production is 26% in 2014 but the share of CH_4 emissions from underground mines is more than 99%.

Figure 3.36 Domestic coal production, 1990–2014

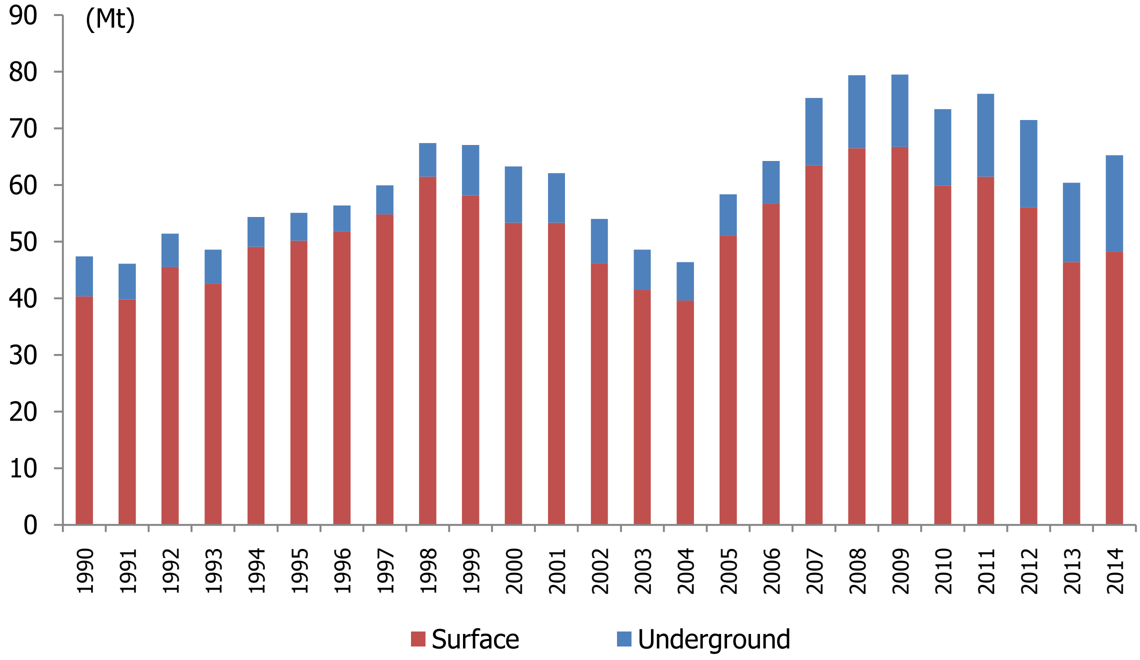
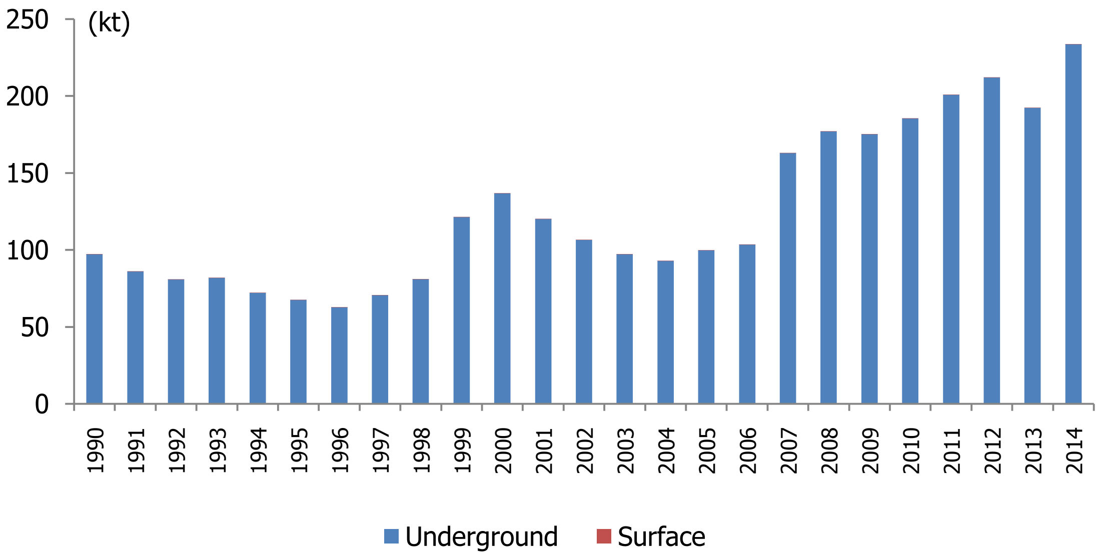


Figure 3.37 CH_4 emissions from coal mining, 1990-2014



Methodological Issues:

GHG emissions from 1B1 sector were calculated by using 2006 IPCC T1 approaches by TurkStat. Domestic coal production data were taken from the national energy balance tables. MENR provided domestic coal production in underground and surface mining details.

Fugitive GHG emissions from coal mines were estimated by using 2006 IPCC default EFs. Both mining and post mining fugitive emissions from underground and surface mines were estimated.

Since the category is a key category, the Tiers in CH_4 estimation needs to be increased. Detailed investigation has been performed to find out the availability of country specific or basin specific EFs within both general directorates for lignite and hardcoal structured under the MENR, namely, DG Turkish Lignite Enterprises and DG Turkish Hard Coal Enterprises. However, information for the generation of country-specific EFs are not available centrally in those coal authorities. Therefore it is necessary to communicate and cooperate with mining enterprises directly to search the availability of required information for T2 estimation of CH_4. It is planned to continue with investigations in mining establishments either via meetings with the bigger ones or via official letters to find out the availability or possibility of availability of appropriate data necessary for higher Tiers.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 16.6% for coal production and 7% for oil and gas systems.

Default EFs uncertainty for coal mining was taken from 2006 IPCC guideline Vol.2 Table 4.1.2 and Table 4.1.4. CH_4 EFs uncertainty value was determined as 557%.

Default EFs uncertainty for oil and gas systems was taken from 2006 IPCC guideline Vol.2 Table 4.2.4. Oil and gas systems EFs uncertainty values were determined as 334% for CO_2, 356% for CH_4, and 224% for N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1B1 category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined.

Planned Improvement:

In order to increase the Tiers for CH_4 emission estimation, availability of detailed information have been searched. It is planned to communicate and collaborate coal mining establishments either via meetings with the bigger ones or via official letter to find out the availability or possibility of availability of appropriate data for higher Tiers.

3.3.2. Oil and natural gas (Category 1.B.2)

Source Category Description:

This source category covers fugitive CO_2, N_2O, CH_4 emissions from exploration, production (processing), transport (transmission), refining and storage of oil and natural gas. Three sub-source categories, oil (1.B.2.a), natural gas (1.B.2.b) and venting and flaring (1.B.2.c) were covered under this category.

This source category was a key category in terms of emission level of CH_4. CO_2 emissions are mainly coming from oil production. About 95% of CO_2 emissions from oil and gas systems are venting and flaring emissions during oil extraction and production. CH_4 emissions are mainly coming from oil production and pipeline transmission and distribution of natural gas. In parallel to the increase in natural gas transmission and distribution, the share of natural gas transmission and distribution in total CH_4 emissions from oil and gas systems increased from 22.6% to 86.9% while the share of oil production decreased from 70.1% in 1990 to 10.9% in 2014.

Table 3.44 Fugitive emissions from oil and natural gas systems

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	220	27	0.003	891
1991	263	32	0.004	1 060
1992	254	32	0.004	1 046
1993	231	31	0.003	997
1994	219	30	0.003	977
1995	209	32	0.003	1 013
1996	208	34	0.003	1 067
1997	206	38	0.003	1 152
1998	194	38	0.003	1 155
1999	178	41	0.002	1 215
2000	168	45	0.002	1 286
2001	155	45	0.002	1 291
2002	148	47	0.002	1 333
2003	145	54	0.002	1 500
2004	140	56	0.002	1 540
2005	142	66	0.002	1 784
2006	135	72	0.002	1 938
2007	133	83	0.002	2 196
2008	135	85	0.002	2 265
2009	138	76	0.002	2 049
2010	156	76	0.002	2 054
2011	151	89	0.002	2 381
2012	144	94	0.002	2 507
2013	146	81	0.002	2 176
2014	145	109	0.002	2 876

Figure 3.38 Oil production, 1990–2014

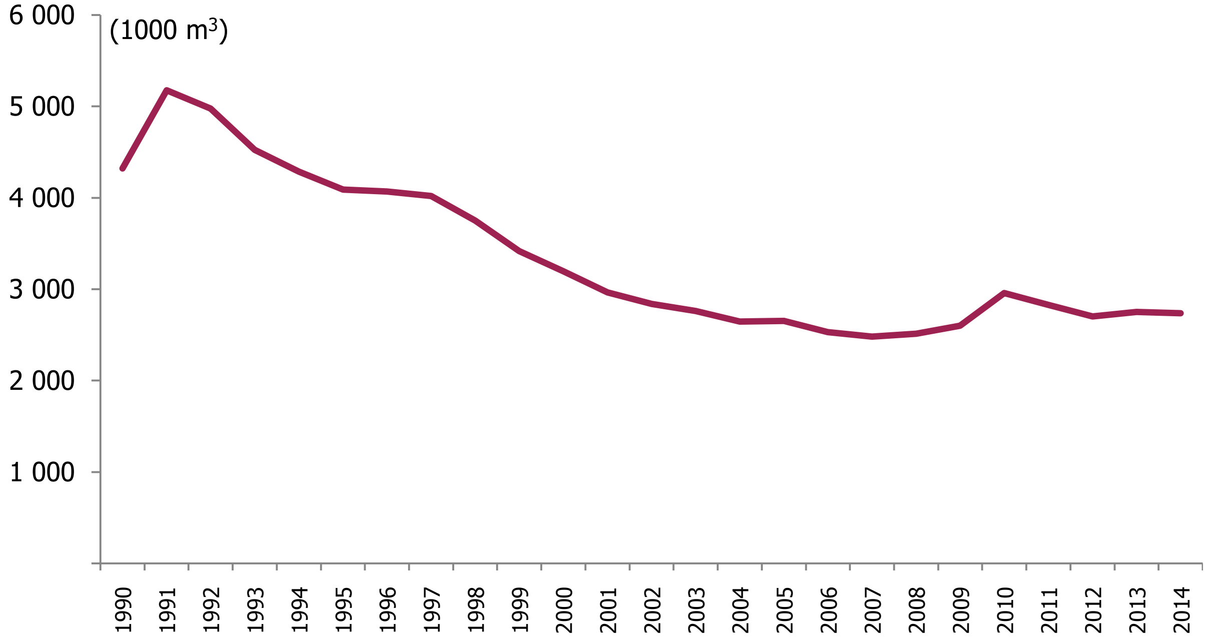


Figure 3.39 Natural gas production, 1990-2014

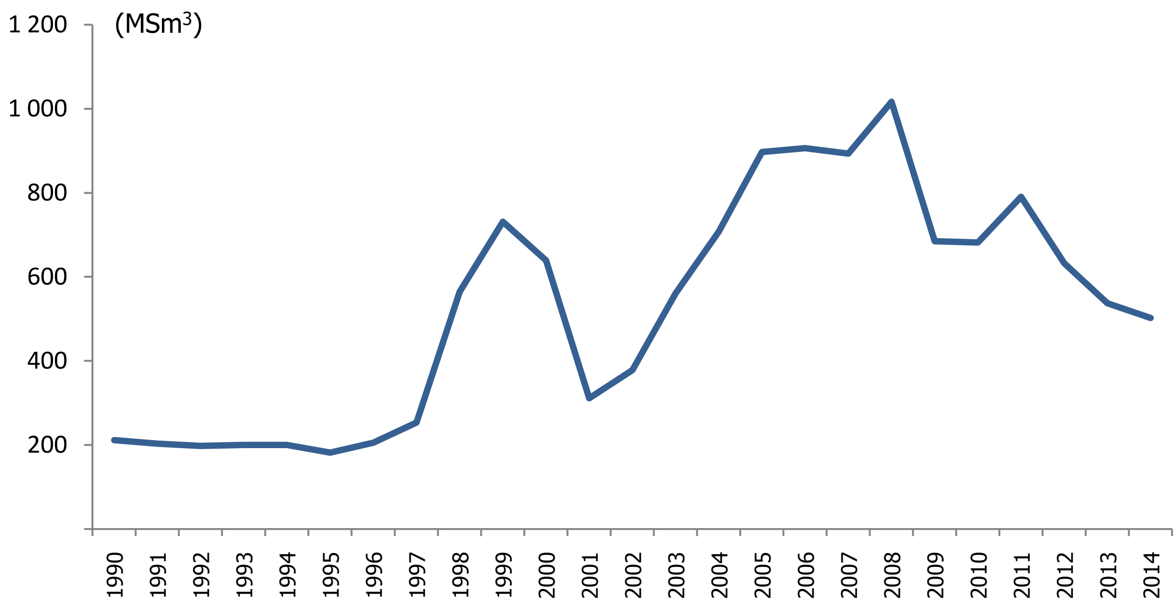


Figure 3.40 Natural gas transmission by pipeline, 1990-2014

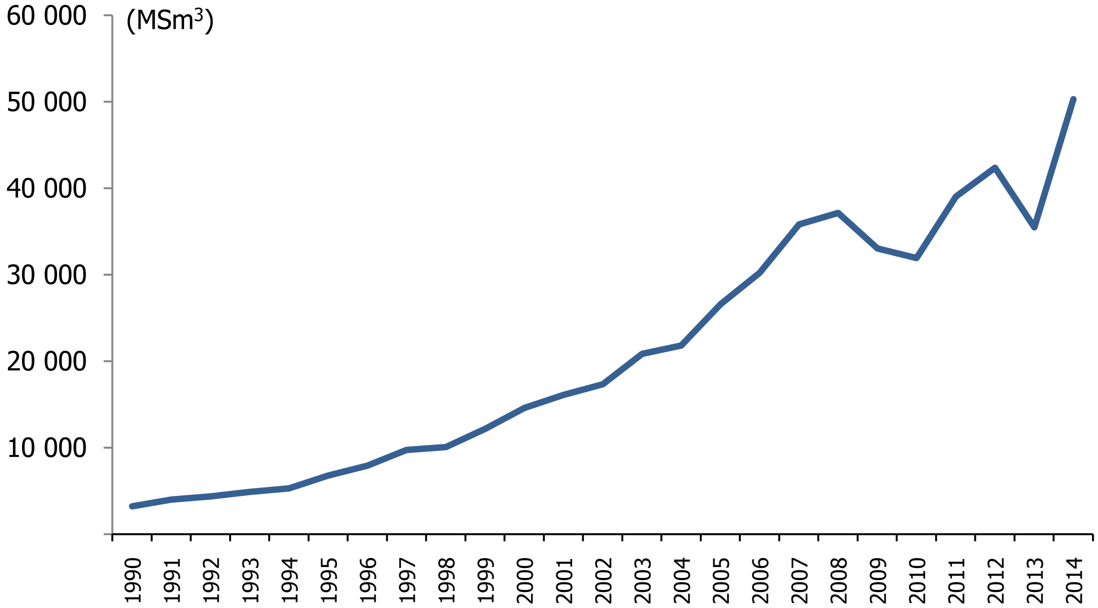
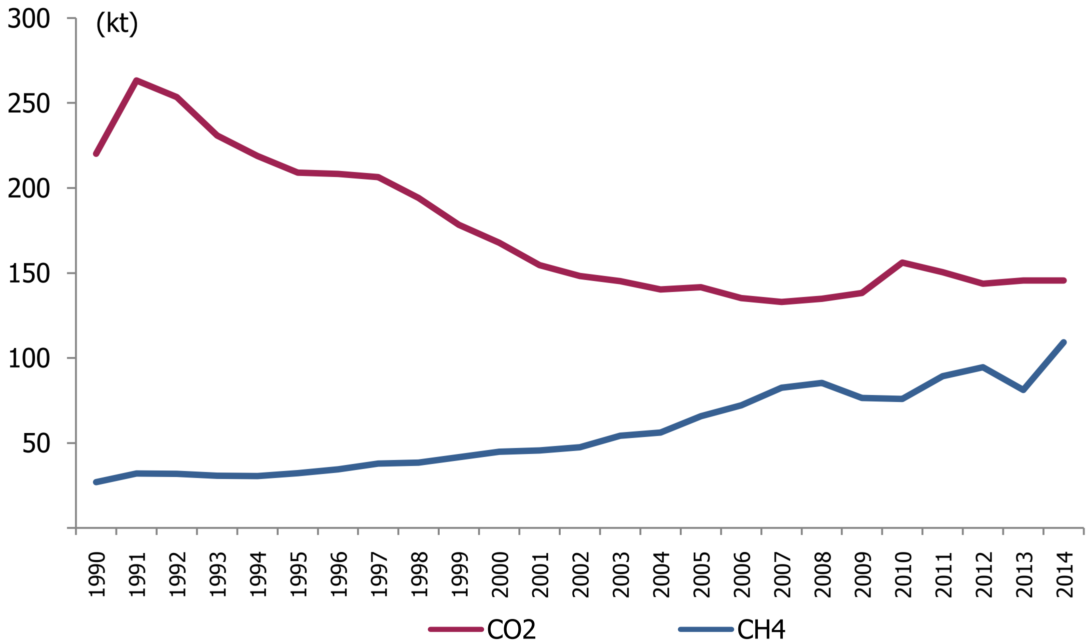


Figure 3.41 Fugitive eimisions from oil and gas system, 1990-2014



Methodological Issues:

GHG emissions from 1B2 sector were calculated by using 2006 IPCC T1 approaches by TurkStat.

Domestic production data for oil and natural gas were taken from the national energy balance tables in kt. Pipeline transmission amount of oil and natural gas and data related to storage of natural gas were provided by BOTAŞ, Petroleum Pipeline Company (which is a state own enterprise and authority for crude oil and natural gas transportation and pipeline operations). Petroleum refining data were taken from Turkish Petroleum Refineries Co. (TÜPRAŞ). For LPG and gasoline distribution, consumption values for those fuels were used from the national energy balance tables.

Fugitive GHG emissions from oil and natural gas systems were estimated by using 2006 IPCC default EFs.

In 2013 inventory it was realized that there was a problem in allocation of emissions into oil, gas and venting and flaring categories mainly due to unfamiliariness to CRF Reporter. All the emissions were reallocated into appropriate categories.

Uncertainties and Time-Series Consistency:

The AD were taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR. AD uncertainties were determined as 7% for oil and gas systems.

Default EFs uncertainty for oil and gas systems was taken from 2006 IPCC guideline Vol.2 Table 4.2.4. Oil and gas systems EFs uncertainty values were determined as 334% for CO_2, 356% for CH_4, and 224% for N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1B2 category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined.

Recalculation:

There was a recalculation for 1990-2013 in oil and gas system. AD used for the estimation of fugitive emissions were chosen based on the guidance provided in the 2006 IPCC Guideline Vol.2 Chapter 4. Table 4.2.7. In that table, for natural gas transmission and storage, the use of marketable gas amount is recommended as AD. The national gas transmission data were available for 1990-2013 and same amount were used for the emission estimation from natural gas storage. However, in the framework of the improvement activities to find more appropriate and qualified data, it was found out that there was no natural gas storage facilities until 2007 in Turkey and quite small capacity storage (3-5%) of natural gas transmission amount has been available since 2007. BOTAŞ provided real natural gas storage values for 2007-2014 and emissions were recalculated for 1990-2013 period.

Planned Improvement:

In order to increase the Tiers in CH_4 emission estimation availability of detailed information have been searched. It is planned to communicate and collaborate with coal oil and gas companies either via meetings with the bigger ones or via official letters to find out the availability or possibility of availability of the appropriate data for higher Tiers.

3.4. CO_2 Transport and Storage (Category 1.C)

Source Category Description:

This source category covers only fugitive CO_2 from pipeline transportation of CO_2. This source category is not a key category. CO_2 emissions were calculated on the basis of pipeline length as 0.126 kt for whole 1990-2014 period.

Methodological Issues:

CO_2 emissions from 1C sector were calculated by using 2006 IPCC T1 approaches by TurkStat. Pipeline length was obtained from Turkish Petroleum Incorporation. Pipeline length was the same for 1990-2014 periods. Fugitive CO_2 emissions from CRF category 1C were estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD were taken from Turkish Petroleum Incorporation. AD uncertainty was considered 2% as indicated in Table 2.15 of 2006 IPCC Guideline Vol.2. Since AD have been taken directly from the company uncertainty level for survey data were considered and to be conservative the maximum uncertainty value was used.

EFs uncertainty was taken from 2006 IPCC Guideline Vol.2 Table 5.2. Uncertainty values were considered as 200% for CO_2.

Planned Improvement:

There is no planned improvement for this category.

4. INDUSTRIAL PROCESSES AND PRODUCT USE (CRF Sector 2)

4.1. Sector Overview

The GHG emissions from industrial processes and product use are released as a result of manufacturing processes. It means this category includes only emissions from processes and not from fuel combustion used to supply energy for carrying out the processes. For that reason, emissions from industrial processes are referred to as non-combustion.

Industrial processes whose contribution to CO_2 emissions were identified as key category are production of cement, lime, and iron and steel, as well as other process uses of carbonates in different industrial activities. PFC emissions from aluminium production and HFCs from product uses as ODS substitutes are also considered key categories.

The general methodology applied to estimate emissions associated with each industrial process, as recommended by the 2006 IPCC Guidelines for National GHG Inventories, involves the product of amount of material produced or consumed, and an associated EF per unit of production/consumption.

GHG emissions from industrial processes and product use contributed 13.4% to the total anthropogenic GHG emissions in Turkey in 2014 (Table 4.1), totaling 62 809 kt CO_2 eq.

Table 4.1 Industrial processes and product use sector CO_2 eq. emissions, 2014 (kt CO_2 eq.)

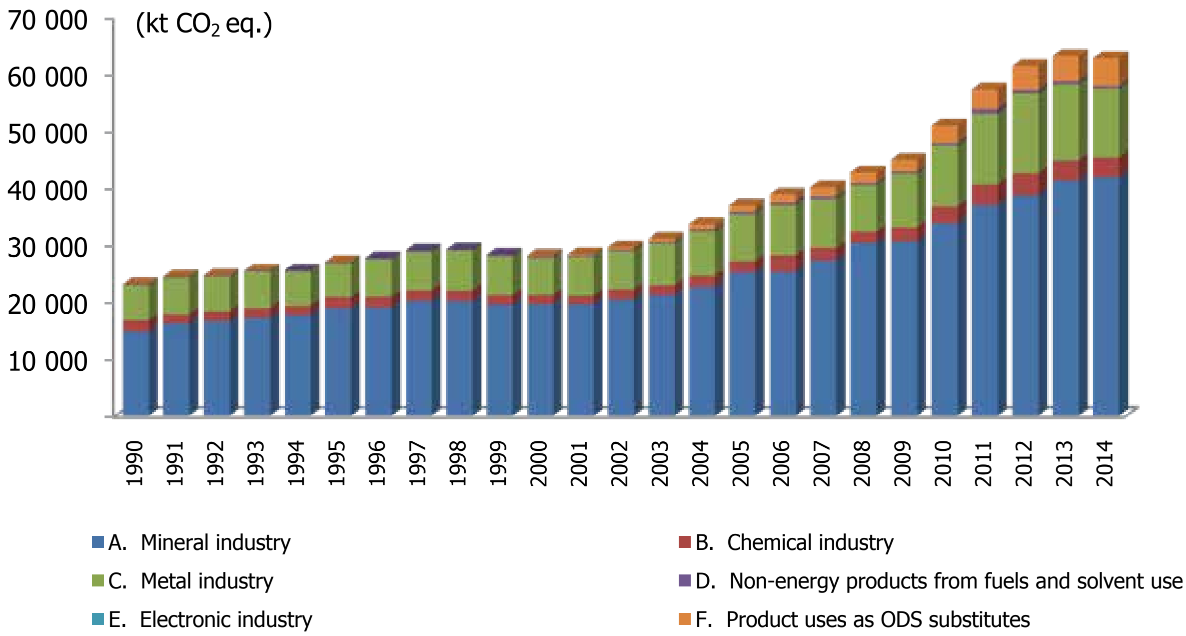
GHG sources and sink categories	CO_2	CH_4	N_2O	HFCs /PFCs/SF_6	Total
2. Industrial processes and product use	55 955	130	1 808	4 917	62 810
A. Mineral industry	41 884	NA	NA	NA	41 884
B. Chemical industry	1 636	25	1 808	NA	3 469
C. Metal industry	12 046	105	NA	NA	12 151
D. Non-energy products from fuels and solvent use	388	NA,NE	NA,NE	NA	388
E. Electronic Industry					
F. Product uses as ODS substitutes	NA	NA	NA	4 917	4 917
G. Other product manufacture and use			NE,NO		
H. Other	NA	NA,NE	NA		

The most important GHG emission sources of industrial processes in the Turkish inventory in 2014 were CO_2 emissions from cement production and, iron and steel production with 7.3% and 2.5% shares of the total national GHG emissions, respectively.

The mineral industry contributed 66.7% of the sector's emissions, the metal industry contributed 19.3%, product uses as ODS substitutes contributed 7.8%, while the chemical industry contributed 5.5%.

The main gas emitted by the IPPU sector in 2014 was CO_2, contributing 89.1% (55 955 kt) of the sector emissions in 2014. HFCs, PFCs and SF_6 contributed 7.8% (4 917kt CO_2 eq.) while the share of N_2O emissions was 2.9% (1 808 kt CO_2 eq.) and CH_4 emissions was 0.2% (130 kt CO_2 eq.).

Figure 4.1 Emissions from industrial processes and product use by subsector, 1990–2014



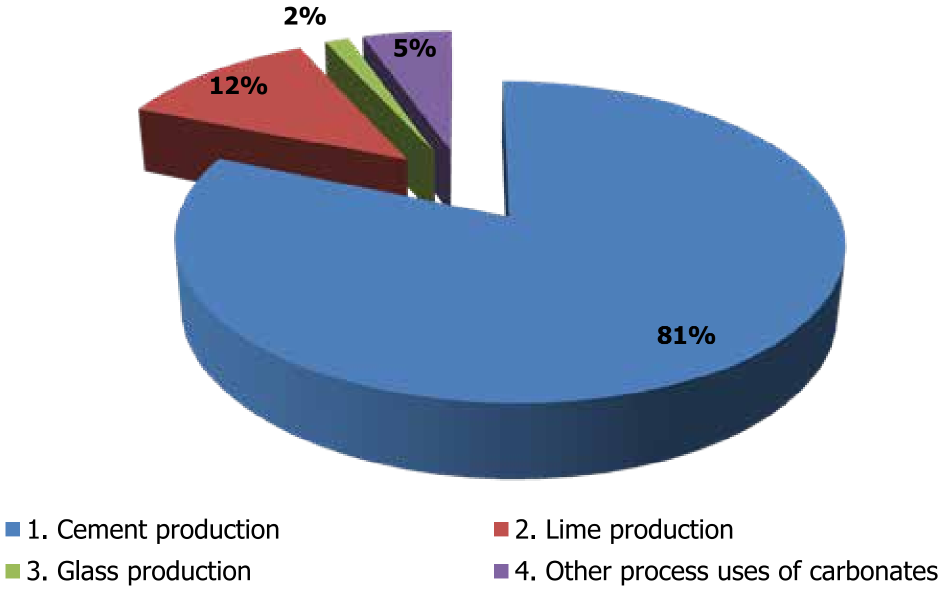
Total emissions from industrial process and product use increased 171.6% between 1990 (23 124 kt CO_2 eq) and 2014, but decreased by 0.6% between 2013 (63 213 kt CO_2 eq.) in 2014. The increases in sectoral emissions observed over the longer term are principally due to growth in emissions associated with the mineral industry, predominantly cement production, and metal industry, primarily iron and steel production. The increases in emissions in these sectors correspond with economic development and the increased demand for construction materials. Each source category's contribution to total emissions and to sectoral trends within the IPPU sector between 1990 and 2014 is shown in Figure 4.1.

4.2. Mineral Industry (Category 2.A)

Non-fuel CO_2 emissions from cement and lime production and from limestone and dolomite use, glass production as well as emissions from ceramics production, soda ash use and non-metallurgical magnesia production are reported in this category.

Figure 4.2 depicts the share of CO_2 emissions in this category. The major share (81%) results from 2A1 cement production, 12% from 2A3 lime production and 5% from 2A4 other process uses of carbonates. Glass production is responsible for 2% of emissions in the mineral industry.

Figure 4.2 Share of CO_2 emissions from mineral production, 2014



4.2.1. Cement production (Category 2.A.1)

Source Category Description:

In cement production, a mixture of raw materials containing calcium carbonate ($CaCO_3$), silica, alumina and iron oxides forms a by-product called clinker. During the production of clinker, limestone is heated (calcined) to produce lime (CaO) and CO_2, then reacts with silica, aluminum and iron oxides in the raw materials. The clinker is then removed from the kiln, cooled and ground. After addition of certain minerals to this ground clinker, cement is produced as the final product.

Clinker production increased by 214% between 1990 and 2014 but the growth slowed down in recent years. The Turkish construction industry slowed down in recent years and realized 2.2% growth between 2013 and 2014. Cement production decreased by 2.4% with respect to 2013 due to a decrease in demand for cement export in 2014. In the year 2014 cement production was 72.6 million tons and it resulted 34 070 kt of CO_2 release to atmosphere.

The cement industry occupies a significant position in the national economy with 4 billion dollars turnover, 740 million dollars export revenue and direct employment volume for 15 000 people. 14.5% of cement produced in 2014 was exported. Capacity utilization rate for clinker production was calculated at 92% on average in 2014.

Methodological Issues:

Estimation of CO_2 emissions is accomplished by applying a country specific EF, in tonnes of CO_2 released per tonnes of clinker produced, to the annual national clinker output, corrected with the fraction of clinker that is lost from the kiln in the form of cement kiln dust (CKD). This is the T2 methodology in the 2006 IPCC Guidelines.

In Turkey, clinker production data is gathered from plants by TCMA for both members and non-members ona a yearly basis. Data for CaO content in clinker and CKD were gathered from representative 10-14 plants for the years 1990-2013. The size of sample is different for years. It was determined that the average weight fraction of CaO varies between 60.6% - 67.2% throughout the years and was 66.9% in 2013. The same value of 66.9% is also used in 2014. Turkey applies the IPCC default CKD correction factor of 1.02.

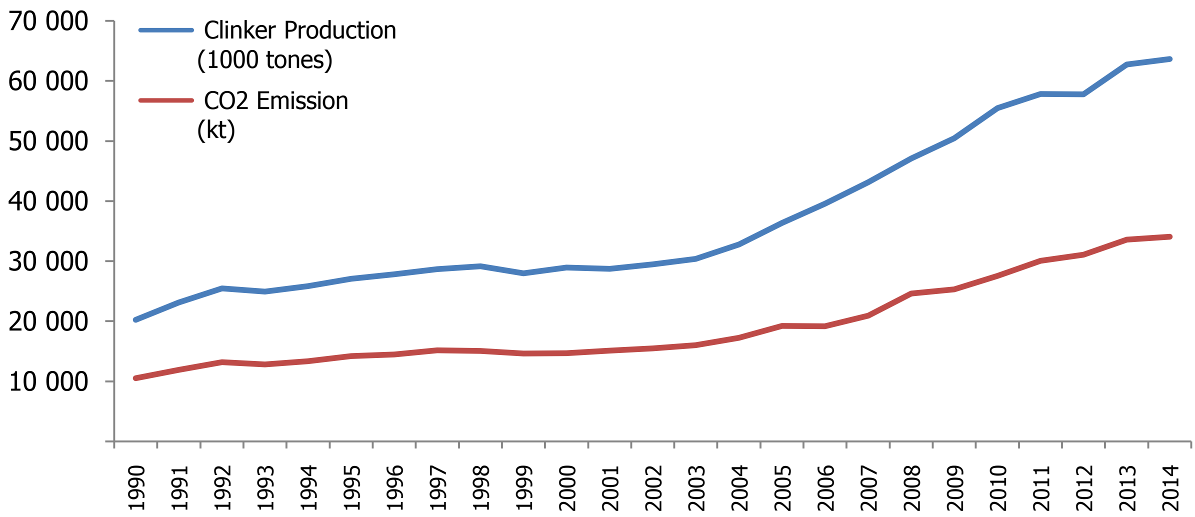
There are 48 integrated cement plants in Turkey, which produce clinker and final product cement. There are also 19 cement plants in Turkey producing only cement from imported/purchased clinker and final product cement. The clinker production was around 63.6 Mt and cement production was around 72.6 mtin 2014 (data consist of TCMA Members & estimations for non-members). In Turkey, about 98% of the cement kilns (not the plants) are based on dry systems (with or without pre-calciner). The remaining 2% covers semi-wet (Lepol) or wet systems.

Table 4.2 CO_2 emissions from cement production, 1990-2014

Year	Clinker production (kt)	Cement production (kt)	CaO content (%)	CO_2 EF	CO_2 Emission (kt)
1990	20 252	24 416	64.9	0.509	10 521
1991	23 153	26 261	64.3	0.505	11 915
1992	25 489	28 607	64.6	0.507	13 182
1993	24 941	31 366	64.2	0.504	12 817
1994	25 880	29 515	64.5	0.506	13 355
1995	27 094	33 140	65.4	0.513	14 179
1996	27 852	35 233	65.0	0.510	14 498
1997	28 706	36 007	65.9	0.517	15 146
1998	29 148	37 488	64.5	0.506	15 047
1999	27 966	34 817	65.3	0.513	14 626
2000	28 950	35 953	63.4	0.497	14 690
2001	28 746	29 959	65.7	0.516	15 115
2002	29 499	32 758	65.7	0.515	15 511
2003	30 419	35 095	65.9	0.517	16 037
2004	32 779	38 796	65.6	0.515	17 225
2005	36 382	42 787	66.1	0.518	19 237
2006	39 569	49 100	60.6	0.475	19 185
2007	43 174	51 226	60.6	0.475	20 925
2008	47 095	54 362	65.3	0.512	24 609
2009	50 436	59 273	62.7	0.492	25 301
2010	55 485	66 027	62.1	0.487	27 563
2011	57 823	67 805	64.9	0.510	30 057
2012	57 758	67 519	67.2	0.527	31 068
2013	62 736	74 437	66.9	0.525	33 585
2014	63 642	72 639	66.9	0.525	34 070

Below Figure 4.3 shows that data trends for clinker production show a general increase in the late years due to increase demand in construction sector.

Figure 4.3 CO_2 emissions from cement productions, 1990-2014



Uncertainties and Time-Series Consistency:

The uncertainty value of the EF was determined to be 10% for all years which results from the consideration of uncertainty error in the assumption that all CaO is from $CaCO_3$, CaO content of clinker and CKD parameter. In 2006 IPCC Guideline Volume 3, Table 2.3, 10% uncertainty level is given for aggregated plant production data.

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were conducted according to the Turkish QA/QC plan, which is consistent with 2006 IPCC Guidelines (Volume 1, Chapter 6. QA/QC and Verification). In this scope, these activities mainly focused on completeness and consistency of data from different sources.

Plant specific clinker production data, as reported by TCMA and used in the national GHG inventory, is compared with TurkStat Industrial Production Statistics Survey (PRODCOM) result. Comparison shows that there is difference between TCMA's data and PRODCOM data which is caused by a coverage deficiency of TurkStat data. Cement production data is also compared with the Turkish construction sector report - 2015. Although there is a slight difference with the production data trend is confirmed.

4.2.2. Lime production (Category 2.A.2)

Source Category Description:

The production of lime involves a series of steps which include quarrying the raw material, crushing and sizing, calcination and hydration. CO_2 is generated during the calcination stage, when limestone ($CaCO_3$) or dolomite ($CaCO_3$*$MgCO_3$) are burned at high temperature (900-1200°C) in a kiln to produce quicklime (CaO) or dolomitic lime (CaO*MgO) and CO_2 which is released in the atmosphere.

Methodological Issues:

CO_2 emissions from lime production are estimated by multiplying by a default IPCC emission factor by national lime production data. The EF is taken as default as suggested in Table 2.4 in 2006 IPCC Guidelines. According to the Turkish Lime Association (TLA); All lime produced in Turkey is high-calcium lime and there is no production for hydraulic lime. A small amount of dolomitic lime is produced in the iron and steel industry but there is no available data the amount is assumed to be negligible. Lime (CaO) production data are collected from the TLA and the Anatolian Lime Producers Association (ALPA). There are two lime associations in Turkey and the plants are member one of these plants. For the national total lime production, data are gatgered from both associations.

The statistics from TLA and ALPA reflect only marketed lime production. Lime may also be produced as an intermediate product in several industries. As noted above, sufficient data are not available in Turkey to estimate lime production in the iron and steel industry, although it is known to occur. Turkey has not obtained information regarding the amount, if any, of non-marketed lime prodution In other industries. It is possible that lime is produced in production of synthetic soda ash, calcium carbide and magnesia as well as in copper smelters and sugar mills.

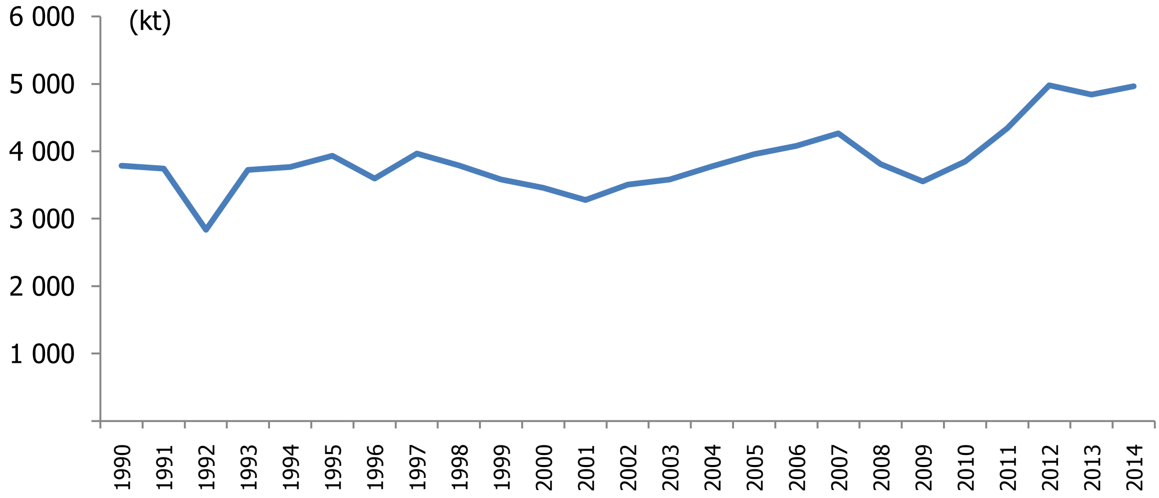
The default IPCC EF for high calcium lime as suggested in table 2.4 of the 2006 IPCC (750 kg CO_2/tonne lime produced), is applied for the full time series.

Table 4.3 Lime production and CO_2 emissions, 1990-2014

Year	High-calcium lime production (kt)	EF (kg CO_2/tones produced CaO)	CO_2 Emissions (kt)
1990	5 050	750	3 788
1991	4 995	750	3 746
1992	3 783	750	2 837
1993	4 970	750	3 728
1994	5 025	750	3 769
1995	5 250	750	3 938
1996	4 795	750	3 596
1997	5 294	750	3 971
1998	5 059	750	3 794
1999	4 777	750	3 583
2000	4 612	750	3 459
2001	4 372	750	3 279
2002	4 675	750	3 506
2003	4 781	750	3 586
2004	5 040	750	3 780
2005	5 279	750	3 959
2006	5 445	750	4 084
2007	5 692	750	4 269
2008	5 085	750	3 814
2009	4 737	750	3 553
2010	5 135	750	3 851
2011	5 789	750	4 342
2012	6 641	750	4 981
2013	6 460	750	4 845
2014	6 622	750	4 967

Lime production increased by 31% between 1990 and 2014. Figure 4.4 shows the trend in the CO_2 emissions from lime production from 1990 to 2014.

Figure 4.4 CO_2 emissions from lime production, 1990-2014



Uncertainties and Time-Series Consistency:

The greatest contributor to the uncertatiny of the AD is the possible omission of non-marketed lime production. In some situations lime is not produced for marketing but for internal consumption in the industrial plant and may be not properly reported in surveys. Turkey estimates the uncertainty due to omission of non-marketed lime production to be 25.1%, based on 2006 IPCC Guideline. In addition, there is uncertainty associated with assuming no dolomitic and hydraulic lime production, and that no hydrated lime is produced.

The uncertainty value of the EF is 2% as recommended in Table 2.5of the2006 IPCC Guidelines Volume 3 is applied. Because the EF is based on the stoichiometric ratio, it is assumed to be known with relatively high certainty.

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were conducted according to the Turkish QA/QC plan, which is consistent with the 2006 IPCC Guidelines (Volume 1, Chapter 6. QA/QC Control and Verification). In this scope, these activities mainly focused on completeness and consistency of data from different sources.

Plant specific lime production data from ALPA and TLA is compared with the Turkish Construction Sector Report - 2015 and found consistent. Moreover, plant specific lime production data is also compared with TurkStat PRODCOM result. Comparison shows that there is difference between TLA and ALPA data and PRODCOM data which is caused by coverage deficiency of TurkStat data.

Planned Improvement:

The national level data on the types of lime produced are already available. It is planned to determine the country specific EF for the high-calcium lime and make T2 calculation in the next years. The lack of reporting of non marketed lime production tried to be solved at least iron and steel facilities and sugar plants.

4.2.3. Glass production (Category 2.A.3)

Source Category Description:

Limestone (CaCO3), dolomite Ca,Mg $(CO_3)_2$ and soda ash (Na_2CO_3) are the major raw materials are involved in the melting process during glass manufacturing and emit CO_2. The Turkish glass industry ranks 17th in total world production of glass and 6th in EU production. The Turkish glass industry has roots back to the establishment of Pasabahce in 1935 with a production capacity of only 3 kt. According to TurkStat figures, Turkey glass industry production reached to 4.15 Mt in 2014, Since the Turkish glass industry does not have an advantage in terms of raw material and energy costs compared to its European peers, capacity utilization rates of the industry are the key indicator of the competitive edge and profitability. The industry depicted a tremendous growth trend either through capacity additions or through new product initiations between 1990 (1 589 kt glass produced) and 2014 (4 154 kt glass produced), increasing 161.4 percent.

Methodological Issues:

Estimation is based on the T2 method described in the 2006 IPCC Guidelines. Specifically, the calculation relies on applying default EFs and cullet ratios on the various types of glass produced in Turkey. Turkey produces float glass, container glass (including household glassware) and fiberglass for insulation. Activity data by glass type and raw material consumption per tones of glass were gathered from The Union of Chambers and Commodity Exchanges of Turkey (TOBB) for the years 2010-2014. Total production data from 2002 to 2009 was taken from Glass Industry Sectoral Report published by TOBB in 2010. Total production data from 1990 to 2001 is estimated. For this estimation (2010-2012) TurkStat records on glass production is compared with the TOBB records and a ratio is found and then TurkStat records for 1990 to 2001 is multiplied with this ratio.

For the years 1990-2009; the total production data is distributed to the glass types according to their average ratios within the years 2010-2012.

CO_2 emission estimation is calculated using 2006 IPCC default EFs and cullet ratio which is given below;

Table 4.4 EF and cullet ratios for glass production

Glass type	EF (tonnes CO_2/tonnes glass)	Cullet ratio (%)
Float Glass	0.21	20
Container	0.21	40
Fiberglass (Insulation)	0.25	10

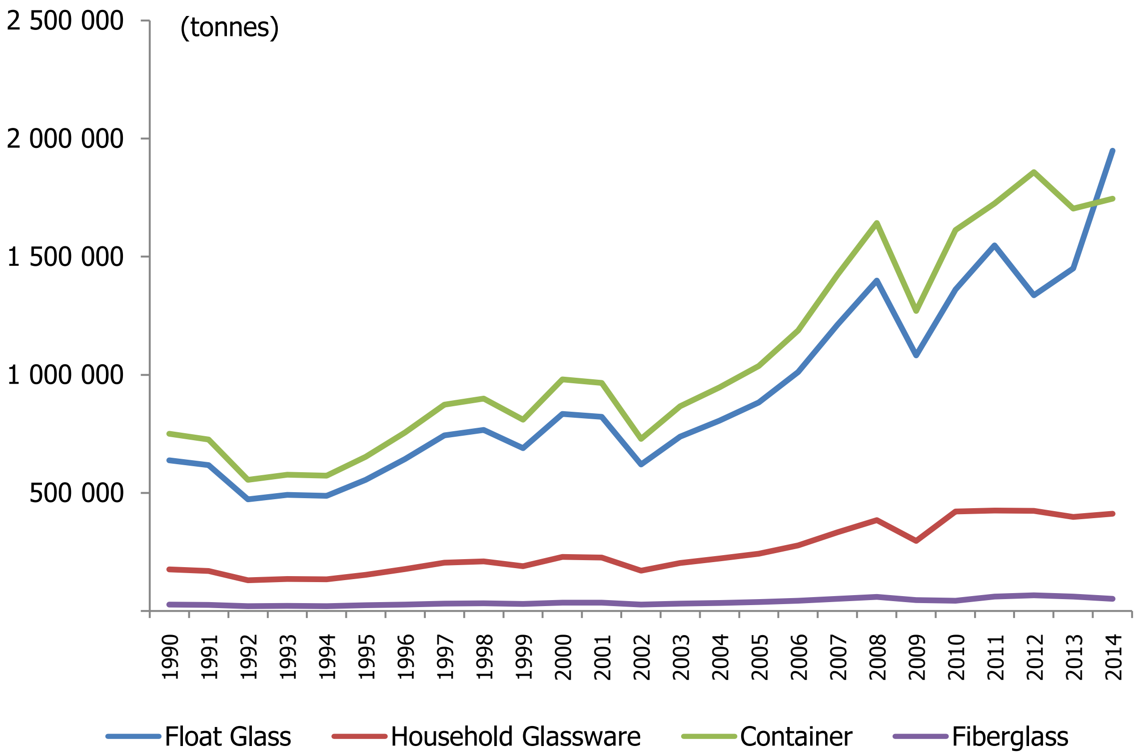
Total glass production and CO_2 emissions by type of glass are given in Table 4.5.

Table 4.5 Total glass production and CO_2 emissions by type of glass, 1990-2014

Year	Float glass (tonnes)	Household glassware (Container) (tonnes)	Container (tonnes)	Fiberglass (tonnes)	CO_2 emission from float (kt)	CO_2 emission from container (kt)	CO_2 emission from fiber (kt)	Total CO_2 (kt)
1990	637 961	175 109	749 274	26 838	107	116	6	230
1991	617 229	169 419	724 924	25 966	104	113	6	222
1992	472 264	129 628	554 666	19 868	79	86	4	170
1993	491 050	134 785	576 730	20 658	82	90	5	177
1994	486 679	133 585	571 596	20 474	82	89	5	175
1995	555 079	152 360	651 930	23 352	93	101	5	200
1996	643 002	176 493	755 194	27 050	108	117	6	232
1997	743 428	204 058	873 144	31 275	125	136	7	268
1998	765 613	210 148	899 199	32 209	129	140	7	276
1999	688 646	189 021	808 802	28 971	116	126	7	248
2000	833 936	228 901	979 443	35 083	140	152	8	300
2001	821 865	225 588	965 266	34 575	138	150	8	296
2002	619 823	170 131	727 971	26 075	104	113	6	223
2003	737 445	202 416	866 116	31 024	124	135	7	266
2004	805 689	221 148	946 268	33 895	135	147	8	290
2005	883 167	242 414	1 037 265	37 154	148	161	8	318
2006	1 010 825	277 454	1 187 197	42 524	170	185	10	364
2007	1 211 545	332 548	1 422 939	50 968	204	221	11	436
2008	1 398 214	383 786	1 642 179	58 821	235	255	13	503
2009	1 081 077	296 737	1 269 706	45 480	182	197	10	389
2010	1 361 000	421 000	1 612 000	43 000	229	256	10	494
2011	1 548 000	425 000	1 724 000	60 000	260	271	14	544
2012	1 336 000	424 000	1 857 000	66 000	224	287	15	527
2013	1 450 000	398 000	1 703 000	61 000	244	265	14	522
2014	1 948 527	410 999	1 744 130	50 830	327	272	11	610

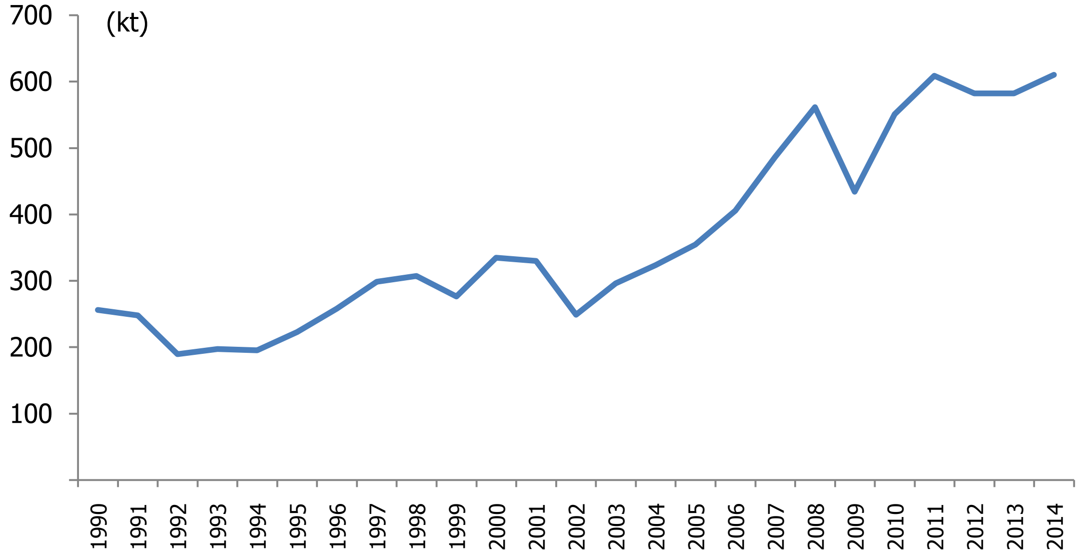
According to the figures in table 4.5; glass production shows a steady increase for the years 2002-2008 (1 544 kt in 2002 and 3 483 kt in 2008). The production decreased in the year 2009 due to the economic crisis. Then it showed a rapid growth till 2011 and it remained steady until 2014. In 2014 float glass production increased dramatically (15%) due to a %1 growth of the European construction sector and increasing float glass export of Turkey, hence in 2014 total glass production reached to its maximum level and as did CO_2 emissions (610 kt).

Figure 4.5 Total glass production by type, 1990-2014



The trend in CO_2 emissions from glass production is given in Figure 4.6, the time series shows a minimum value in 1992 with the value of 170 kt CO_2 and a maximum in 2014 of 610 kt. For the economic crisis years in 2001 and 2008, emissions show considerable decrease.

Figure 4.6 CO_2 emissions from glass production, 1990-2014



Uncertainties and Time-Series Consistency:

Due to glass production data are typically measured fairly accurately and 90% percent of total production belongs one company, uncertainty for AD is considered as 5% 2006 IPCC Guideline Volume 3 (page 2.31). As it is recommended 2006 IPCC Guidelines, uncertainty of EF is considered as 10 percent.

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were conducted according to the Turkish QA/QC plan, which is consistent with 2006 IPCC Guidelines (Volume 1, Chapter 6. QA/QC and Verification). In this scope, these activities mainly focused on completeness and consistency of data from different sources.

The glass production data used for the emissions calculation was gathered from TOBB and it was compared with the Turkish Construction Sector Report - 2015.

4.2.4. Other process uses of carbonates (Category 2.A.4)

The category, other process uses of carbonates, is a key category in Turkey. In this category, Turkey reports emissions from ceramics production, other uses of soda ash and non-metallurgical magnesa production. Between 1990 (258 kt CO_2 eq.) and 2014 (2 237 kt CO_2 eq.) emissions have increased by over 768%, driven largely by the increase in CO_2 emissions from ceramics production (1 284 kt CO_2 increase between 1990 and 2014).

4.2.4.1. Ceramics (Category 2.A.4.a)

Source Category Description:

Ceramics production is a source of CO_2 emission since raw materials like limestone and magnesite are calcined during manufacturing. The Turkish ceramics industry, which started production in industrial sense, has become one of the largest ceramics manufacturers in the world in the last 50 years which may be deemed quite short. It's becoming the third largest manufacturer in Europe in tiles with a production of 5 100 kilotons of tiles and again, the third largest in ceramic sanitary ware with production over 280 kilotons. Turkey is the world's sixth and Europe's third largest ceramic tile manufacturer.

Ceramics include the production of vitrified clay pipes, refractory products, expanded clay products, wall and floor tiles, table and ornamental ware, sanitary ware. Process related emissions from ceramics result from the calcination of carbonates in the clay.

Methodological Issues:

The T2 method is used to estimate emissions from the ceramics industry. The method requires consumption data for each of the CO_2 emission source raw materials consumed and multiplying by the respective emission factor for the carbonate to estimate CO_2 emissions.

Calcite, limestone, dolomite, magnesite and hydro-magnesite are consumed as raw materials in the ceramics industry. Production of ceramic tile and sanitary ware (see Table 4.6) are gathered from the Turkish Ceramics Federation for all years in the time series 1990-2014 The Turkish Ceramics Federation does not provide information on the type and quantity of carbonates consumed in the production of ceramics so Turkey must determine the fractions consumed.

Default EF provided in table 2.1 of the 2006 IPCC Guidelines are applied to the total raw material consumption for the entire time series to estimate emissions.

Table 4.6 Raw material consumption and production, 1990-2014

	Raw material (tonnes)				Product (tonnes)		
Year	Calcite	Limestone	Dolomite	Magnesite-hydro magnesite	Ceramic tile	Sanitary ware	Total product (kt)
1990	7 449	277 982	7 449	239 639	884 000	46 600	931
1991	8 589	282 347	8 589	243 403	1 020 000	55 600	1 076
1992	10 087	392 077	10 087	337 997	1 207 000	56 100	1 263
1993	11 890	443 559	11 890	382 378	1 428 000	58 900	1 487
1994	13 174	425 610	13 174	366 905	1 575 900	71 400	1 647
1995	15 176	543 867	15 176	468 851	1 819 000	78 000	1 897
1996	17 045	601 744	17 045	518 745	2 053 600	86 900	2 141
1997	20 926	701 423	20 926	604 675	2 514 300	101 500	2 616
1998	21 746	846 131	21 746	729 423	2 618 000	102 200	2 720
1999	21 246	831 984	21 246	717 228	2 550 000	106 400	2 656
2000	24 703	967 522	24 703	834 070	2 975 000	114 175	3 089
2001	22 288	835 560	22 288	720 310	2 558 500	109 280	2 668
2002	23 096	904 056	23 096	779 359	2 762 500	123 980	2 886
2003	26 755	1 047 661	26 755	903 156	3 204 500	140 530	3 345
2004	30 792	1 205 595	30 792	1 039 306	3 672 000	176 870	3 849
2005	37 393	1 463 772	37 393	1 261 872	4 437 000	236 600	4 674
2006	38 070	1 490 625	38 070	1 285 022	4 505 000	253 750	4 759
2007	37 440	1 465 776	37 440	1 263 600	4 420 000	260 000	4 680
2008	32 440	1 270 026	32 440	1 094 850	3 825 000	230 000	4 055
2009	29 440	1 152 576	29 440	993 600	3 485 000	195 000	3 680
2010	35 080	1 373 382	35 080	1 183 950	4 165 000	220 000	4 385
2011	37 320	1 457 765	37 320	1 256 694	4 420 000	245 000	4 665
2012	40 160	1 572 264	40 160	1 355 400	4 760 000	260 000	5 020
2013	47 040	1 841 616	47 040	1 587 600	5 610 000	270 000	5 880
2014	43 040	1 685 016	43 040	1 452 600	5 100 000	280 000	5 380

CO_2 emissions from raw material are given in Table 4.7 and Figure 4.7.

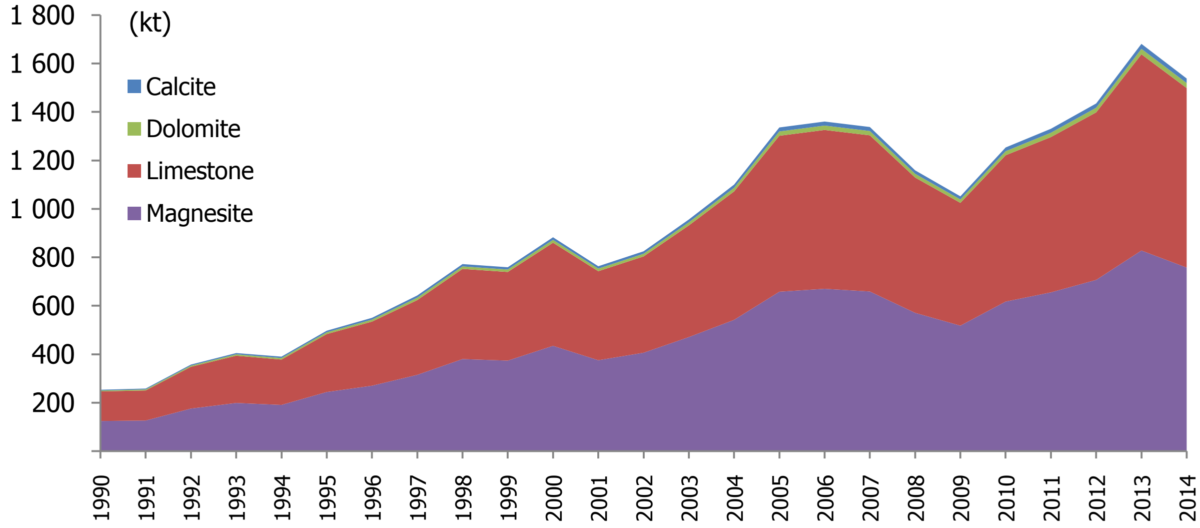
Table 4.7 CO_2 emissions from raw material consumption, 1990-2014

(kt)

Year	Calcite	Limestone	Dolomite	Magnesite	Total
1990	3.3	122.23	3.56	125.08	254.1
1991	3.8	124.15	4.10	127.05	259.1
1992	4.4	172.40	4.81	176.42	358.1
1993	5.2	195.04	5.68	199.59	405.5
1994	5.8	187.14	6.29	191.51	390.7
1995	6.7	239.14	7.24	244.73	497.8
1996	7.5	264.59	8.14	270.77	551.0
1997	9.2	308.42	9.99	315.62	643.2
1998	9.6	372.05	10.38	380.74	772.7
1999	9.3	365.83	10.14	374.37	759.7
2000	10.9	425.43	11.79	435.36	883.4
2001	9.8	367.40	10.64	375.98	763.8
2002	10.2	397.52	11.02	406.80	825.5
2003	11.8	460.67	12.77	471.42	956.6
2004	13.5	530.11	14.70	542.49	1 100.8
2005	16.4	643.63	17.85	658.66	1 336.6
2006	16.7	655.44	18.17	670.74	1 361.1
2007	16.5	644.52	17.87	659.56	1 338.4
2008	14.3	558.44	15.48	571.48	1 159.7
2009	12.9	506.80	14.05	518.63	1 052.4
2010	15.4	603.89	16.74	617.99	1 254.0
2011	16.4	640.99	17.81	655.96	1 331.2
2012	17.7	691.34	19.17	707.48	1 435.6
2013	20.7	809.78	22.45	828.68	1 681.6
2014	18.9	740.92	20.54	758.21	1 538.6

CO_2 emissions from ceramic production show an increasing trend for the years 1990-2014 overall. In 2014, ceramic production and the resulting CO_2 emissions decreased (8.5%) due to the slow down of the construction sector in Turkey.

Figure 4.7 Production data for lime type, 1990-2014



Uncertainties and Time-Series Consistency:

As the EF is the stoichiometric ratio reflecting the amount of CO_2 released upon calcination of the carbonate, the EF uncertainty in this category is relatively low. There is some uncertainty associated with assuming a fractional purity of limestone and dolomite in cases where only carbonate rock data are available (1-5%)

AD uncertainties are greater than the uncertainties associated with EFs. Assuming that carbonate consumption is allocated to the appropriate consuming sectors/industries, the uncertainty associated with weighing or proportioning the carbonates for any given industry is 1-3 percent. For this category AD uncertainty is considered as 10% while the EF uncertainty is considered 2% which is in line with 2006 IPCC Guideline Volume 3 (page 2.39)

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were conducted according to the Turkish QA/QC plan, which is consistent with 2006 IPCC Guidelines (Volume 1, Chapter 6. QA/QC and Verification). In this scope, these activities mainly focused on completeness and consistency of data from different sources.

Ceramics production data for both the ceramic tiles and sanitary-ware are compared to the Turkish construction sector report 2015. Both data are confirmed.

4.2.4.2. Other use of soda ash (Category 2.A.4.b)

Source Category Description:

In this category, emissions from soda ash consumption are considered. CO_2 emissions from soda ash used in glass manufacturing industry are included in Glass Production.

Methodological Issues:

Turkey does not collect annual statistics on soda ash consumption, by industry, therefore it estimates CO_2 emissions from soda ash use by determining total apparent consumption of soda ash, and subtracting soda ash consumed in glass production. This is similar to the IPCC tier 2 method

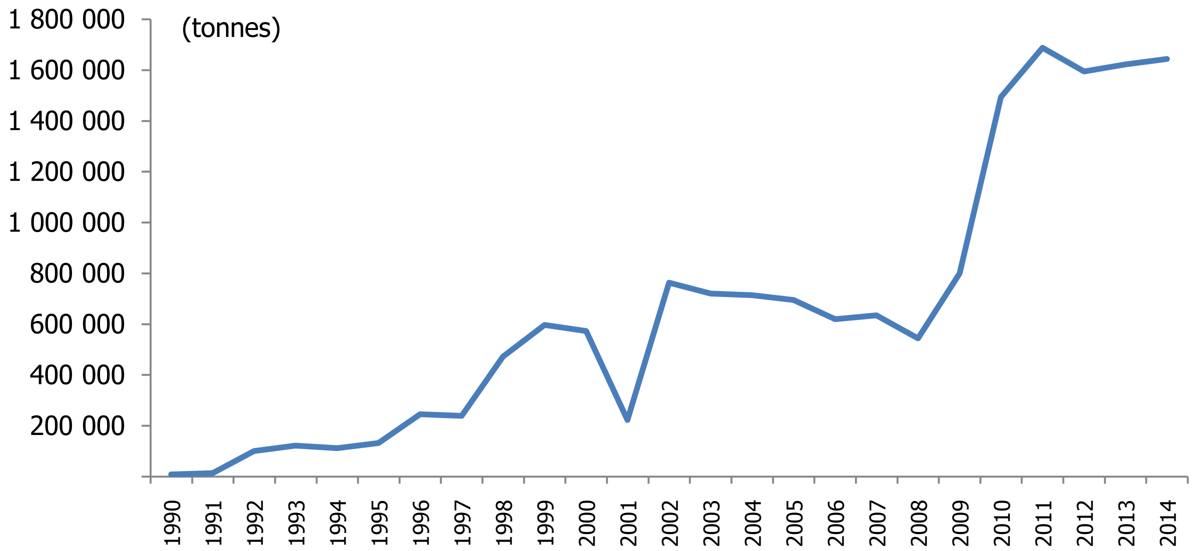
Apparent consumption is calculated (as production+imports-exports-use in glass industry). Total production values are gathered from two soda ash producer plants while foreign trade statistics are provided by TurkStat. Default EF (0.415 tonnes CO_2 /tonnes product) taken from Table 2.1. of the 2006 IPCC Guidelines, Volume 3, Chapter 2 is applied for the full time series. Total production values are gathered from soda ash producer plants while foreign trade statistics are provided TurkStat. Production, import, export and CO_2 emissions from soda ash consumption are given in Table 4.8.

Table 4.8 Soda ash use and CO_2 emissions, 1990-2014

Year	Production (tonnes)	Import (tonnes)	Export (tonnes)	Use in glass industry (tonnes)	Apparent consumption (tonnes)	CO_2 (kt)
1990	357 245	60 948	80 318	329 493	8 382	3
1991	430 018	272	97 919	318 785	13 586	6
1992	448 781	1 932	106 813	243 914	99 985	41
1993	467 603	4 794	96 912	253 617	121 868	51
1994	471 479	5 732	113 745	251 359	112 107	47
1995	530 473	3 489	115 859	286 686	131 417	55
1996	568 506	8 584	33	332 097	244 961	102
1997	550 187	72 400	54	383 965	238 568	99
1998	667 455	199 847	4	395 423	471 876	196
1999	726 319	226 136	150	355 671	596 634	248
2000	757 939	245 630	310	430 710	572 549	238
2001	774 660	250 209	378 026	424 475	222 368	92
2002	791 900	292 595	1 040	320 125	763 330	317
2003	809 300	292 337	1 095	380 874	719 668	299
2004	824 082	307 073	1 397	416 121	713 637	296
2005	840 307	311 133	849	456 137	694 454	288
2006	868 573	273 391	316	522 070	619 578	257
2007	926 350	333 557	178	625 737	633 992	263
2008	946 155	320 545	291	722 148	544 261	226
2009	1 079 715	278 000	120	558 353	799 242	332
2010	1 936 161	274 350	237	716 447	1 493 827	620
2011	2 162 555	306 032	203	780 712	1 687 672	700
2012	2 045 613	309 154	121	760 656	1 593 989	661
2013	2 173 213	198 791	652	748 894	1 622 458	673
2014	2 302 046	211 469	395	869 261	1 643 859	682

Since soda ash is an important intermediate product for the industry soda ash apperant consumption increased dramatically from 1990 to 2014 as the Turkish industry grew. In the 2001 and in 2008 economic crisis soda ash consumption decreased remarkably. Since 2009 consumption has increased dramatically, with economic growth. In 2014 the GHG release due to the apparent consumption of soda ash is 682 kilotons of CO_2.

Figure 4.8 Soda ash apparent consumption, 1990-2014



Uncertainties and Time-Series Consistency:

AD uncertainty for this source is considered 10% based on expert judgement due to using national statistics and using a general apparent consumption calculation formula. Because a default EF based on stoichiometry is used for the emission calculation, uncertainty for the EF is defined as 2%.

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were conducted according to the Turkish QA/QC plan, which is consistent with 2006 IPCC Guidelines (Volume 1, Chapter 6. QA/QC and Verification). In this scope, these activities mainly focused on completeness and consistency of data from different sources.

4.2.4.3. Non metallurgical magnesia production (Category 2.A.4.c)

Source Category Description:

This source category should include emissions from magnesia (MgO) production that are not included elsewhere.

Magnesite ($MgCO_3$) is one of the key inputs into the production of magnesia, and ultimately fused magnesia. There are three major categories of magnesia products: calcined magnesia, deadburned magnesia (periclase) and fused magnesia. Calcined magnesia is used in many agricultural and industrial applications (e.g., feed supplement to cattle, fertilizers, electrical insulations and flue gas desulphurisation). Deadburned magnesia is used predominantly for refractory applications, while fused magnesia is used in refractory and electrical insulating markets.

Methodological Issues:

CO_2 emission is calculated by using magnesite production as an AD and multiplied by default EF (0.52197 tonnes CO_2 /tonnes carbonate).

Table 4.9 Magnesite production and CO_2 emissions, 2005-2014

Year	Magnesite production (tonnes)	CO_2 (kt)
2005	35 266	18.4
2006	31 754	16.6
2007	4 449	2.3
2008	1 204	0.6
2009	471	0.2
2010	23 616	12.3
2011	43 154	22.5
2012	19 504	10.2
2013	30 886	16.1
2014	31 912	16.7

AD are provided only between 2005-2014 due to lack of data of data and so the emission estimation could not be conducted for the period 1990-2004. Therefore, Turkey assumes that non-metallurgical magnesia production is not occurring between 1990 and 2004. The default IPCC EF (0.52197 tonnes CO_2 /tonnes carbonate) taken from Table 2.1 of the 2006 IPCC Guidelines, volume 3, Chapter 2, is applied for the years 2005-2014.

Uncertainties and Time-Series Consistency:

AD uncertainty for this source is considered 10% due to using national statistics and using general apparent calculation formula. Because default EF is used for emission calculation, uncertainty for EF is defined as 2%.

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were conducted according to the Turkish QA/QC plan, which is consistent with 2006 IPCC Guidelines (Volume 1, Chapter 6. QA/QC and Verification). In this scope, these activities mainly focused on completeness and consistency of data from different sources.

Planned improvement:

Researches are going through collecting AD for the years 1990-2004. Although some data are collected within the series the data is not verified in terms of QC/QA and it is not a complete series yet. It is planned to search for any mining sector reports or academic reports regarding to history of magnesite production.

4.3. Chemical Industry (Category 2.B)

In 2014, the chemical industry was responsible for 5.5 % of the total carbon dioxide equivalent emissions from the industrial processes and product use sector. Between 1990 (1 956 kt CO_2 eq) and 2014 (3 469 kt CO_2 eq), total carbon equivalent emissions increased by 77.3%. The increase in emissions is driven exclusively by the increase in CO_2 emissions from ammonia production and N_2O emissions from nitric acid production; emissions from all other sub-categories declined over the reporting period 1990-2014.

Over half of the CO_2 eq. emissions are from nitric acid production (52.1%), followed by petrochemical industry and ammonia production (with 22.3 and 21.2 % repectively). Soda ash production and carbide production are much smaller contributors to emissions (3.9% and 0.4%, respectively). There is no production of adipic acid, caprolactam, glyoxal, glyoxylic acid, or titanium dioxide produced in Turkey, therefore emissions are reported as "NO" for these sub-categories.

4.3.1. Ammonia production (Category 2.B.1)

Source Category Description:

Ammonia is a major industrial chemical and the most important nitrogenous material produced. Ammonia gas is used directly as a fertilizer, in heat treating, paper pulping, nitric acid and nitrates manufacture, nitric acid ester and nitro compound manufacture, explosives of various types, and as a refrigerant. Amines, amides, and miscellaneous other organic compounds, such as urea, are made from ammonia. IGSAŞ is one of two ammonia plants in Turkey and started production in 1977. In 1993 a second other ammonia plant, GEMLIK GUBRE started operation.

Methodological Issues:

In Turkey there are two ammonia production plants and both use natural gas as a feedstock. A T2 method is used in accordance with the 2006 IPCC Guidelines. As an initial step, the total fuel requirement is estimated by determining the total quantity of ammonia produced and the fuel requirement (i.e. natural gas) per unit of output.

In order to calculate CO_2 emissions; the total fuel requirement is multiplied by a country-specific carbon content and carbon oxidation factor. CO_2 emissions recovered for downstream use are then deducted from total CO_2 emissions.

Ammonia production and fuel requirement data are obtained from producers on an annual basis. Calculation for CO_2 emissions; total fuel requirement is multiplied by country specific carbon content and carbon oxidation factor. CO_2 emissions recovered for downstream use deducted from total CO_2 emissions assuming 0.733 tonnes of CO_2 are required per tonnes of urea produced. This value is taken from 2006 IPCC Guideline.

To avoid double counting the total quantities of natural gas used in ammonia production is subtracted from the quantity reported under energy use in the energy sector. In Turkey; there was no ammonia production in 2007 and 2009 as shown in Table 4.10. During these two years, ammonia was imported to meet domestic demand.

Due to the fact that there are only two ammonia producers in Turkey, activity data are confidential. Therefore production data are given as 1990=100 and all years are reported relative to ammonia production in 1990.

Turkey applies the carbon content of natural gas and an oxidation factor to the total fuel requirement to estimate emissions.

Table 4.10 Ammonia production and CO_2 emissions, 1990-2014

Year	Ammonia production (1990=100)	CO_2 Emission (kt)
1990	100.0	353.0
1991	95.0	335.5
1992	90.7	320.3
1993	82.4	287.6
1994	72.7	222.8
1995	82.1	288.6
1996	75.9	271.1
1997	80.6	275.2
1998	66.0	246.1
1999	22.5	86.5
2000	14.6	75.7
2001	18.3	68.7
2002	82.0	289.7
2003	78.9	300.3
2004	89.9	392.5
2005	103.7	492.1
2006	25.0	99.6
2007	NO	NO
2008	27.3	129.3
2009	NO	NO
2010	20.7	103.7
2011	128.1	734.0
2012	142.9	928.4
2013	97.4	572.6
2014	107.4	736.2

There are large inter-annual changes in CO2 emissions from ammonia production, particularly in the last 10 years. Rapid increases in emissions can be seen shortly after periods of economic downturns (e.g., emissions incrased 329.4 % between 2001 and 2002 and increased again by 610.8% between 2010 and 2011).

Uncertainties and Time-Series Consistency:

Because country specific EF is used for the calculation of emissions from ammonia production, uncertainty is taken as 5% based on information from ammonia producers.

Consistent with the 2006 IPCC Guidelines, due to the use of plant specific activity data, uncertainty value for AD is considered as 2%.

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were conducted according to the Turkish QA/QC plan, which is consistent with 2006 IPCC Guidelines (Volume 1, Chapter 6. QA/QC and Verification). In this scope, these activities mainly focused on completeness and consistency of data from different sources.

Ammonia production data obtained from producers is compared with data from PRODCOM.

Recalculation:

Ammonia is produced using natural gas. In the previous submission the carbon content of the natural gas was assumed to be constant for the full time series 1990 to 2013, and it was 15.38 kg C/Gj. The AD for the carbon content of the natural gas for the time series were gathered from the producers and the CO_2 emission recalculated accordingly. The impact of the recalculation on CO_2 emissions was an increase in emissions from ammonia production of 8.2 kt CO_2 eq. for 2013 (1.5%), and an increase of 6.2 kt CO_2 eq. in 1990 (1.8%).

4.3.2. Nitric acid production (Category 2.B.2)

Source Category Description:

Nitric acid is used as a raw material mainly in the manufacture of nitrogeneous-based fertilizer. Nitric acid may also be used in the production of adipic acid and explosives, for metal etching and in the processing of ferrous metals. Production of nitric acid results in N_2O emissions.

In Turkey; these are three nitric acid plants. These are operating in medium pressure combustion plant. One of these plants indicates its use of a selective catalytic reduction system.

Methodological Issues:

N_2O emissions from nitric acid production are not a key category in Turkey. N_2O emissions are calculated using the T1 method in the 2006 IPCC Guidelines. Total nitric acid production is multiplied by an emission factor as shown below.

$$E_{N2O} = EF * nitric\ acid\ production$$

Where:

E_{N2O} = N_2O emissions, kg

EF = N_2O emission factor (default), kg N_2O/tonne nitric acid produced

Due to the confidentiality reason; total nitric acid production is given as 1990=100 as shown in Table 4.11.

Nitric acid production data were obtained from plants. For two of the plants, the assumption is made that there is no abatement, consistent with the assumptions for use of T1 in the 2006 IPCC Guidelines.

Table 4.11 Nitric acid production and N_2O emissions, 1990-2014

Year	Nitric acid production (1990=100)	Total N_2O emission (kt)
1990	100	2.33
1991	79	1.84
1992	90	2.09
1993	82	1.91
1994	58	1.35
1995	97	2.26
1996	99	2.31
1997	105	2.45
1998	99	2.32
1999	97	2.27
2000	88	2.04
2001	70	1.65
2002	82	1.92
2003	77	1.80
2004	81	1.90
2005	105	2.45
2006	236	5.51
2007	155	3.62
2008	156	2.76
2009	231	4.50
2010	275	5.55
2011	289	5.82
2012	291	5.96
2013	296	5.99
2014	297	6.07

N_2O emissions were relatively stable between 1990 (2.33 kt N_2O) and 2005 (2.45 kt N_2O), increasing by 5.2 per cent. Emissions increased by 125 per cent between 2005 and 2006 owing to [insert rationale], before declining between 2006 and 2008 (-50%), and increasing again between 2008 and 2009 (63%). In recent years, emissions have stabilized again.

Uncertainties and Time-Series Consistency:

The 2006 IPCC Guidelines recommended default uncertainty value of ±20% is used for the EF, consistent with the value in Table 3.3 for medium pressure combustion plants.

Turkey applies the default IPCC uncertainty value for e AD uncertainty of ±2%, which is in line with the 2006 IPCC Guidelines Volume 3 (page 3.25).

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were conducted according to the Turkish QA/QC plan, which is consistent with 2006 IPCC Guidelines (Volume 1, Chapter 6. QA/QC and Verification). In this scope, these activities mainly focused on completeness and consistency of data from different sources.

Plant specific nitric acid production data is compared with TurkStat PRODCOM result. Comparisons show that there is significant difference between plant’s data and PRODCOM data which is caused by coverage deficiency of TurkStat data.

Recalculation:

The previous NIR included data for two producers of nitric acid. A third producer started operation in 2006, but data were not available for the previous submissions. Data from the third nitric acid plant was gathered and so the emission estimation between 2006 to 2013 is recalculated to account for emissions from all three producers. Due to the recalculation, emissions from nitric acid production increased by 2.6 kt N_2O in 2013. There was no change to 1990 values.

4.3.3. Adipic acid production (Category 2.B.3)

There is no adipic acid production in Turkey.

4.3.4. Caprolactam, glyoxal and glyoxylic acid production (Category 2.B.4)

There is no caprolactam, glyoxal and glyoxylic acid production in Turkey.

4.3.5. Carbide production (Category 2.B.5)

Source Category Description:

The production of carbide can result in emissions of CO_2, CH_4, CO and SO_2. Silicon carbide is a significant artificial abrasive. It is produced from silica sand or quartz and petroleum coke. Calcium carbide is used in the production of acetylene in the manufacture of cynamide and as a reductant in EAF. It is made from two carbon containing raw materials: calcium carbonate (limestone) and petroleum coke. In Turkey there is no silicon carbide production. Calcium carbide has been produced in Turkey for the entire time series.

Methodological Issues:

Carbide production is not a key category in Turkey. Only calcium carbide is produced and by a single plant. The calculation of emissions is based on plant specific data and applying the following T1 equation:

$$E_{CO2} = AD * EF$$

Where:

E_{CO2} = emissions of CO_2, tonnes

AD = activity data on coke,

EF = CO_2 emission factor.

AD on the amount of raw material metallurgical coke is directly obtained from the producer on an annual basis. The plant does not report information on thet use of CaC_2 in acetylene production for welding application; therefore these emissions are not included in the plant-level calculation. Turkey does not have any additional data available to report on CaC2 used for acetylene production for welding applications in other parts of the country.

Confidential production data is given as 1990=100 in Table 4.12 with CO_2 emission from calcium carbide production. As raw material metallurgical coke is used and it is considered as AD. EF is calculated by multiplying metallurgical coke carbon content and carbon oxidation factor and result multiplied with 44/12 to convert C to CO_2.

Table 4.12 Carbide production and CO_2 emissions, 1990-2014

Year	Calcium carpide production (1990=100)	CO_2 Emissions (kt)
1990	100.0	58.12
1991	51.2	30.69
1992	65.3	36.83
1993	37.5	20.81
1994	46.3	26.74
1995	24.2	14.24
1996	40.6	24.22
1997	37.7	22.48
1998	56.3	32.75
1999	40.7	23.38
2000	43.3	24.96
2001	33.8	19.88
2002	25.7	15.13
2003	34.3	21.26
2004	40.6	27.95
2005	27.1	18.90
2006	29.4	18.29
2007	50.5	30.67
2008	11.9	8.32
2009	29.4	17.86
2010	19.8	12.33
2011	28.0	16.78
2012	28.8	16.90
2013	27.4	15.84
2014	25.9	15.49

CO_2 emissions from calcium carbide production have declined by 73.3 per cent between 1990 (58.12 kt CO_2) and 2014 (15.49 kt CO_2).

Uncertainties and Time-Series Consistency:

As 2006 IPCC guideline recommended default uncertainty values is used as 10% for EF while AD uncertainty is considered as 5% due to plant specific data are used. (2006 IPCC Guideline Volume 3 page 3.45).

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were conducted according to the Turkish QA/QC plan, which is consistent with 2006 IPCC Guidelines

(Volume 1, Chapter 6. QA/QC and Verification). In this scope, these activities mainly focused on completeness and consistency of data from different sources.

Plant specific production data is compared with national statistics data. There is no difference for the available years.

4.3.6. Titanium dioxide production (Category 2.B.6)

There is no titanium dioxide production in Turkey.

4.3.7. Soda ash production (Category 2.B.7)

Source Category Description:

Soda ash (sodium carbonate, Na_2CO_3) is a white crystalline solid that is used as a raw material in a large number of industries including glass manufacture, soap and detergents, pulp and paper production and water treatment. CO_2 is emitted from the use of soda ash and these emissions are accounted for as a source under the relevant using industry as discussed in Volume 3, Chapter 2 in the 2006 IPCC Guidelines. CO_2 is also emitted during production of soda ash with the quantity emitted dependent on the industrial process used to manufacture soda ash.

Emissions of CO_2 from the production of soda ash vary substantially with the manufacturing process. Four different processes may be used commercially to produce soda ash. Three of these processes, monohydrate, sodium sesquicarbonate (trona) and direct carbonation, are referred to as natural processes. The fourth, the Solvay process, is classified as a synthetic process. Calcium carbonate (limestone) is used as a source of CO_2 in the Solvay process.

Methodological Issues:

There are two soda ash plants in Turkey. One of these plants produces soda ash by utilizing trona while other produces synthetic soda ash (solvay process).

In the Solvay process, sodium chloride brine, limestone, metallurgical coke and ammonia are the raw materials used in a series of reactions leading to the production of soda ash. Ammonia, however, is recycled and only a small amount is lost. From the series of reactions CO_2 is generated in two pyrolysis processes. The CO_2 generated is captured, compressed and directed to Solvay precipitating towers for consumption in a mixture of brine (aqueous NaCl) and ammonia. Although CO_2 is generated as a by-product, the CO_2 is recovered and recycled for use in the carbonation stage and in theory the process is neutral, i.e., CO_2 generation equals uptake.

However the natural production process of soda ash results in CO_2 emissions. The amount of trona utilized is the AD and it was directly taken from the plant. EF is confidential.

The production trend can be seen from the Table 4.13. Soda ash production by utilizing trona started in 2009 and emissions from soda ash production in solvay process is not estimated due to the carbon neutral characteristic of the process. Therefore; for the years 1990-2008, emissive soda ash production was not occurred.

Table 4.13 Soda ash production and CO_2 emissions, 2009-2014

Year	Soda ash production (2009=100)	CO_2 Emissions (kt)
2009	100	24
2010	451	110
2011	538	132
2012	535	131
2013	511	125
2014	554	135

Uncertainties and Time-Series Consistency:

As 2006 IPCC guideline recommended default uncertainty values is used as 5% for EF and AD. (2006 IPCC Guideline Volume 3 page 3.55).

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables according to QA/QC plan. Plant specific production data is compared with national statistics data. There is no difference for the available years.

Recalculation:

The 2009-2013 emissions are multiplied with 100 because of a formulation mistake in the previous NIR.

4.3.8. Petrochemical and carbon black production (Category 2.B.8)

Source Category Description:

The petrochemical industry uses fossil fuels (e.g., natural gas) or petroleum refinery products (e.g., naphtha) as feedstocks. Within the petrochemical industry and carbon black industry, primary fossil fuels (natural gas, petroleum, coal) are used for non-fuel purposes in the production of petrochemicals and carbon black. The use of these primary fossil fuels may involve combustion of part of the hydrocarbon content for heat raising and the production of secondary fuels (e.g., off gases).

Turkey reports CO_2 and CH_4 emissions from ethylene, vinyl chloride monomer, acrylonitril and carbon black production. Overall, between 1990 (821 kt CO_2) and 2014 (749 kt CO_2) CO_2 emissions declined by 8.8% for the petrochemicals category. The largest source of emissions in the petrochemicals category is from ethylene production. Atlhough emissions in 2014 (79 kt CO_2) were not very different than in 1990 (80 kt CO_2) there were some significant inter-annual variations in intervening years, most recently a 29.1% decline in emissions between 2013 and 2014. CO_2 emissions from the production of vinyl chloride monomer (VCM) and acrylonitrile remained fairly stable over the time series, decreasing by 11.9 per cent for VCM between 1990 and 2014, and increasing by 11.2% for acrylonitrile. There was a significant reduction in CO_2 emissions from carbon black production between 2006 and 2010, before starting to increase again in recent years.

Methodological Issues:

Calculation method for emissions from petrochemical process is T1. It is applied by multiplying the AD for production of each petrochemical and the process specific EF for each petrochemical.

AD were directly obtained from producers and due to confidentiality reasons AD and EF was not given. Production trend is given table below;

Table 4.14 Petrochemicals and carbon black production, 1990-2014

(kt)

Year	Ethylene	Vinyl chloride monomer	Acrylonitrile	Carbon black
1990	373	97	68	31
1991	340	79	52	32
1992	339	102	64	35
1993	356	99	75	35
1994	381	92	89	28
1995	412	115	86	40
1996	392	121	83	39
1997	380	110	70	39
1998	403	113	79	40
1999	411	108	78	26
2000	395	105	77	35
2001	400	117	88	34
2002	419	117	91	37
2003	396	127	84	39
2004	376	140	88	26
2005	314	120	71	27
2006	490	128	91	52
2007	486	144	92	40
2008	496	118	90	20
2009	501	132	94	1
2010	513	142	94	NO
2011	454	129	98	20
2012	469	140	95	21
2013	463	118	88	28
2014	328	91	75	30

The resulting CO_2 emissions from petrochemicals are given in Table 4.15. CH_4 is also released from the production of these petrochemicals. Although CH_4 data are entered in the CRF they are not tabulated here because they are negligibly small.

Table 4.15 CO_2 emissions from petrochemicals, 1990-2014

(kt)

Year	Ethylene	Vinyl chloride monomer	Acrylonitrile	Carbon black
1990	645	29	68	80
1991	588	23	52	84
1992	586	30	64	91
1993	615	29	75	91
1994	659	27	89	73
1995	712	34	86	105
1996	679	35	83	103
1997	658	32	70	102
1998	697	33	79	105
1999	710	32	78	69
2000	683	31	77	92
2001	691	34	88	89
2002	724	34	91	98
2003	686	37	84	103
2004	651	41	88	68
2005	544	35	71	70
2006	848	38	91	136
2007	841	42	92	106
2008	858	35	90	52
2009	867	39	94	4
2010	887	42	94	0
2011	785	38	98	53
2012	811	41	95	56
2013	801	35	88	74
2014	568	27	75	79

Uncertainties and Time-Series Consistency:

As 2006 IPCC guideline recommended default uncertainty values is used as 10% for EF and AD based on expert judgment and table 3.7 in 2006 IPCC Guideline Volume 3.

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were conducted according to the Turkish QA/QC plan, which is consistent with 2006 IPCC Guidelines (Volume 1, Chapter 6. QA/QC and Verification). In this scope, these activities mainly focused on completeness and consistency of data from different sources.

Although there seem to be some methanol production in Turkey, the production data and production process checked with the Tobacco and Alcohol Market Regulatory Authority (TADPK) of Turkey and it is verified that methanol production processes in Turkey base mostly on recycling and do not cause GHG emission in means of IPPU.

Recalculation:

There is some methanol production in Turkey. This methanol is either obtained by recycling the solvents or obtaining byproduct from a distillation process during the manufacture of poppy plant. These result in no CO_2 emission. However in the previous NIR CO_2 emissions were calculated as a result of methanol production according to IPCC Guidelines. Besides that 2005-2009 production data for carbon black is revised and CO_2 emissions are recalculated accordingly.

4.3.9. Fluorochemical production (Category 2.B.9)

There is no florochemical production in Turkey.

4.4. Metal Industry (Category 2.C)

4.4.1. Iron and steel production (Category 2.C.1)

Source Category Description:

Crude steel in iron and steel industry is produced by 2 different processes using different technologies: integrated facilities and EAF. Iron and steel industry consumes energy and raw materials intensively. Currently, 3 integrated facilities and 27 EAF mills are operating in Turkey.

Because of high energy consumption and slow operation, open hearth furnace (OHF) technology was replaced by basic oxygen furnace (BOF) and EAF processes in 1999. Since then, steel production has been realized using latest technologies and under similar conditions of European steel production facilities.

Integrated iron and steel production process begins with the preparation of iron ores by crushing, screening and sintering process or direct charging of lump ore into the blast furnace. Iron ore reduced by the CO formed as the coke burns with blast air and melted with the heat energy, turns into hot metal. During primary steelmaking process, a certain amount of scrap and alloying elements are added to hot metal in converter. In BOF technology, pure oxygen is blown on to the alloy and then the liquid steel is obtained. After refining process in ladle, liquid steel is transformed into the desired size of semi-finished products (billet, bloom, slab) at the continuous casting machine.

In EAF, liquid steel is produced by melting the steel scrap with the help of graphite electrodes. After refining process, liquid steel transferred from the ladle to the continuous casting machine is solidified and finally shaped as the desired size of semi-finished products.

Even though iron and steel makers around the world are being challenged by weak global demand, Turkey's iron and steel industry continues to grow, increasing its presence in the global arena. From 2001 to 2014 iron and steel production increased by %126 overall.

Figure 4.9 Major metal-intensive industries

Methodological Issues:

For the calculation emissions from iron and steel production, sinter production and direct reduced iron, 2006 IPCC T3 method is used. Parameters given below were obtain from each integrated plant; most of the carbon content

For iron and steel production;

- quantity of coke consumed in iron and steel production
- quantity of onsite coke oven by-product a, consumed in blast furnace
- quantity of coal directly injected into blast furnace
- quantity of limestone consumed in iron and steel production
- quantity of dolomite consumed in iron and steel production
- quantity of carbon electrodes consumed in EAFs
- quantity of other carbonaceous and process material b, consumed in iron and steel production, such as sinter or waste plastic

- quantity of coke oven gas consumed in blast furnace in iron and steel production
- quantity of steel produced
- quantity of iron production not converted to steel
- quantity of blast furnace gas transferred offsite
- and carbon content of material input or output;

CO_2 emissions from steel production in EAF is calculated by using total steel produced in those EAF and default EF given in Table 4.1 in 2006 IPCC Guidelines. These emissions are added to the total iron and steel emissions from integrated plants.

For sinter production;

- quantity of purchased and onsite produced coke breeze used for sinter production
- quantity of coke oven gas consumed in blast furnace in sinter production
- quantity of blast furnace gas consumed in sinter production
- quantity of other process material a, other than those listed as separate terms, such as natural gas, and fuel oil, consumed for coke and sinter production in integrated coke production and iron and steel production facilities
- quantity of sinter off gas transferred offsite either to iron and steel production facilities or other facilities
- and carbon content of material input or output

Emission form steel production in EAF is based on electrode consumption and included total emissions from iron and steel.

CH_4 emissions from sinter production, blast furnace production of pig iron and direct reduced iron are calculated by using default 2006 IPCC Guideline values.

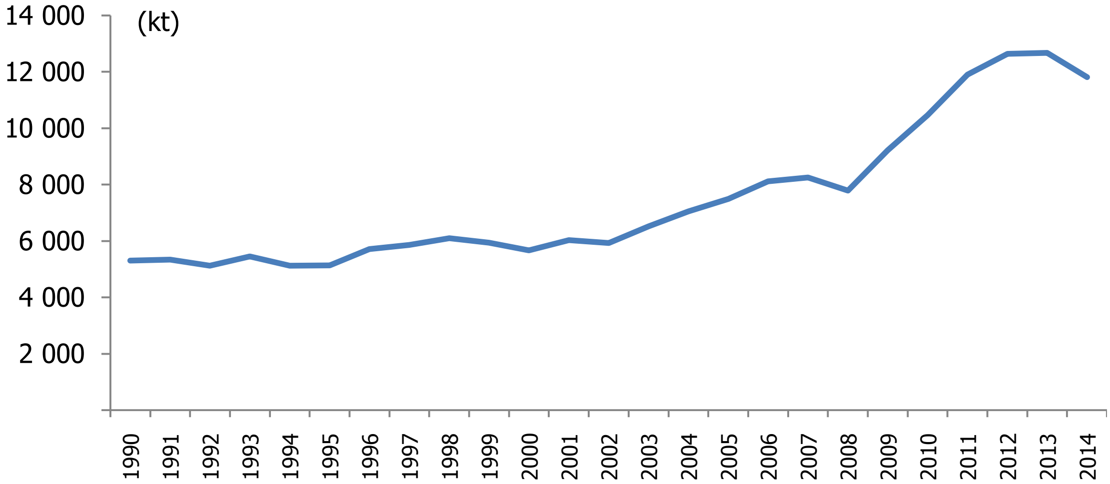
In Turkey; metallurgical coke is produced iron and steel facility (‘onsite’). Emission from coke production is considered under Energy sector.

Table 4.16 Raw material consumption and iron and steel production, 1990-2014

(kt)

Year	Coke consumption	Coke breeze	Steel production (BOF)	Steel production (EAF)	Total steel production
1990	3 166	175	4 431	4 955	9 386
1991	3 200	155	4 360	4 991	9 351
1992	2 815	161	4 154	6 110	10 264
1993	2 802	169	4 150	7 283	11 433
1994	2 518	170	4 429	7 680	12 109
1995	2 581	165	4 695	8 501	13 196
1996	2 814	192	5 095	8 337	13 432
1997	2 768	195	5 450	8 918	14 368
1998	2 695	193	5 259	8 992	14 251
1999	2 649	201	5 271	9 171	14 442
2000	2 563	231	5 372	9 096	14 468
2001	2 542	209	5 400	9 703	15 104
2002	2 426	174	5 274	11 334	16 608
2003	2 848	196	5 903	12 546	18 449
2004	2 787	206	6 003	14 646	20 649
2005	2 831	253	6 254	14 847	21 101
2006	2 946	239	6 300	17 252	23 553
2007	2 944	251	6 512	19 362	25 874
2008	2 809	269	7 180	19 771	26 951
2009	3 100	262	7 717	17 741	25 458
2010	3 430	293	8 444	20 905	29 349
2011	3 724	377	9 023	25 275	34 298
2012	3 722	361	9 500	26 560	36 059
2013	3 802	392	10 110	24 723	34 834
2014	4 066	413	10 483	23 752	34 236

Figure 4.10 Total CO_2 emission from iron and steel production, 1990-2014



Turkey maintained significant iron and steel industry growth rates between 2003 and 2009. The dip in 2009 indicates weak market conditions due to the global economic crisis, but the industry quickly recovered and continued growing strongly after the global economic crisis. In 2012, the iron and steel industry's contribution to the GDP was 1.08%, up from approximately 1% in 2006. The iron and steel industry's share in the GDP is expected to continue to increase as new opportunities arise in the industry and is projected to gain a share of 1.35% by 2023.

The iron and steel industry is one of the pillars of Turkey's foreign trade. It had the second largest export share coming in after the automotive industry in 2013.

Turkey has performed spectacularly in the iron and steel trade and is now among the top producers. It is the 6th largest net exporter of iron and steel coming in after Russia and South Korea with 7.2 Mt of net exports in 2012.

Table 4.17 CO_2 emissions from iron and steel production, 1990-2014

(kt)

Year	Iron and steel production	Sinter production	Total
1990	4 685	619	5 304
1991	4 779	556	5 335
1992	4 545	575	5 120
1993	4 533	914	5 448
1994	4 190	936	5 126
1995	4 203	929	5 132
1996	4 673	1 034	5 707
1997	4 795	1 061	5 856
1998	5 014	1 082	6 096
1999	4 876	1 065	5 941
2000	4 482	1 185	5 668
2001	4 922	1 110	6 031
2002	4 974	952	5 926
2003	5 471	1 043	6 514
2004	5 947	1 107	7 054
2005	6 209	1 287	7 496
2006	6 863	1 252	8 115
2007	6 948	1 309	8 257
2008	6 424	1 362	7 786
2009	7 909	1 307	9 215
2010	9 032	1 429	10 462
2011	10 220	1 691	11 911
2012	10 994	1 650	12 644
2013	10 928	1 750	12 678
2014	10 089	1 730	11 819

Turkey has enjoyed an uninterrupted annual growth of crude steel production from 2007 to 2012. Turkey's crude steel production growth has been impressive with a compound annual growth rate (CAGR) of 6.8% during this period. Turkey experienced the third highest growth rate among the top 10 steel producers after China and India within this period. However this fast growth is ceased in 2013 and 2014 and the production decreased 3.4% and 1.7% respectively.

Uncertainties and Time-Series Consistency:

Uncertainty values of T3 EF is expected 5% due to plant specific carbon content and mass rate data usage as provided with Table 4.4 in 2006 IPCC guideline.

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables according to QA/QC plan. There are three integrated iron and steel plant in Turkey and plant specific data are gathered from these plants. These data, their indicators and ratios derived from raw material/production are compared to each other. In addition to quality control checks described in Turkish QA/QC plan, which is consistent with 2006 IPCC Guidelines (Volume 1, Chapter 6. QA/QC and Verification), expert review of emission estimates conducted. Aggregated national EFs and carbon contents are compared with IPCC default values.

Recalculation:

The blast furnace gas sent off site was not considered in the previous NIR therefore a recalculation is made. The CO_2 emissions resulting from sinter production are recalculated due to revision of the coke breeze consumption data.

Planned Improvement:

A site visit is planned to one of the integrated iron and steel plants of Turkey. How the activity data is collected on the site will be asked and comments of experts from the field will be asked for uncertainties.

4.4.2. Ferroalloys production (Category 2.C.2)

Source Category Description:

Ferroalloy is the term used to describe concentrated alloys of iron and one or more metals such as silicon, manganese, chromium, molybdenum, vanadium and tungsten. Silicon metal production is usually included in the ferroalloy group because silicon metal production process is quite similar to the ferrosilicon process. These alloys are used for deoxidising and altering the material properties of steel. Ferroalloy facilities manufacture concentrated compounds that are delivered to steel production plants to be incorporated in alloy steels. Silicon metal is used in aluminum alloys, for production of silicones and in electronics. Ferroalloy production involves a metallurgical reduction process that results in significant CO_2 emissions.

In this category; emissions from ferro-manganese, silicon-manganese and ferrochromium production is considered.

Methodological Issues:

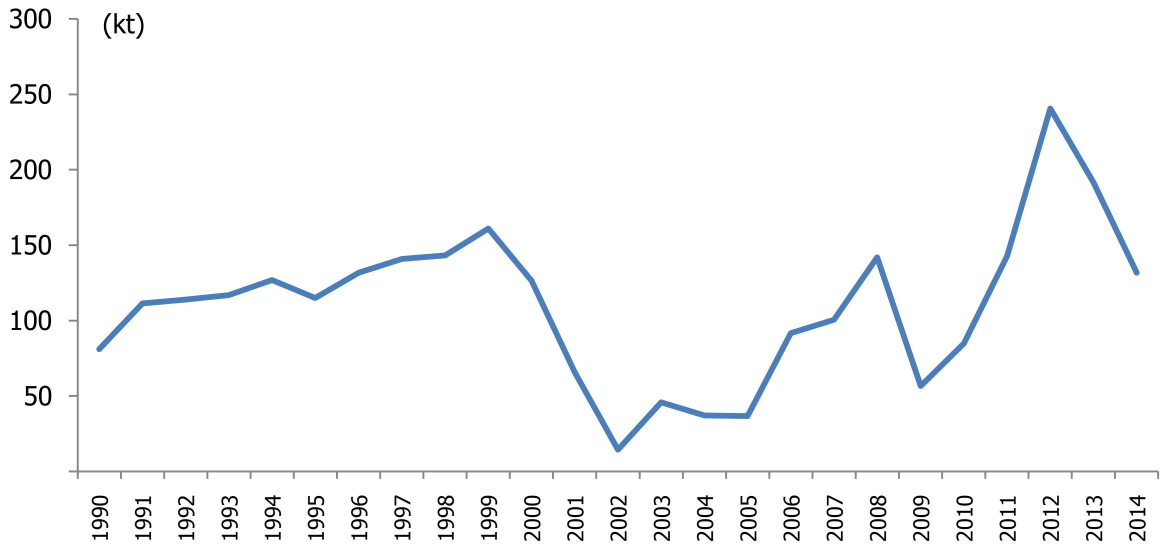
AD are obtained from Turkish Industrial Production Survey from TurkStat and with T1 approach, default EFs are applied and emissions are calculated.

Table 4.18 Ferroalloys production and emissions, 1990-2014

(kt)

Year	Ferroalloys production	CO_2	CH_4
1990	62.4	81.2	NO
1991	85.7	111.4	NO
1992	87.6	113.9	NO
1993	90.0	117.0	NO
1994	97.5	126.8	NO
1995	88.6	115.1	NO
1996	101.5	131.9	NO
1997	108.3	140.8	NO
1998	110.2	143.2	NO
1999	123.9	161.1	NO
2000	97.2	126.4	NO
2001	50.7	66.0	NO
2002	11.2	14.6	NO
2003	35.4	46.0	NO
2004	28.7	37.3	NO
2005	28.1	36.9	1.9
2006	70.3	91.7	1.5
2007	77.3	100.6	1.5
2008	109.0	141.9	2.2
2009	43.5	56.7	1.6
2010	65.3	84.9	0.0
2011	100.7	142.8	8.0
2012	125.8	240.5	41.2
2013	143.8	191.6	4.7
2014	101.2	131.8	3.0

Figure 4.11 CO_2 emissions from ferroalloys production, 1990-2014



Uncertainties and Time-Series Consistency:

Uncertainty values of T1 EF and AD are considered 20% as recommended in Table 4.9 of 2006 IPCC Guideline due to calculations are based on default EFs and national production data.

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were conducted according to the Turkish QA/QC plan, which is consistent with 2006 IPCC Guidelines (Volume 1, Chapter 6. QA/QC Control and Verification). In this scope, these activities mainly focused on completeness and consistency of data from different sources.

Recalculation:

The 2013 ferromangan production data was revised and therefore the emission was recalculated accordingly.

4.4.3. Aluminum Production (Category 2.C.3)

Source Category Description:

From primary aluminum production CO_2 and PFCs (CF_4 and C_2F_6) emissions are estimated. Primary aluminum is aluminum tapped from electrolytic cells or pots during the electrolytic reduction of metallurgical alumina (aluminum oxide). It thus excludes alloying additives and recycled aluminum.

Primary aluminum production is defined as the quantity of primary aluminum produced in a defined period. It is the quantity of molten or liquid metal tapped from the pots and that is weighed before transfer to a holding furnace or before further processing.

Eti Aluminum is Turkey's only producer of liquid aluminum and it is the country's only fully integrated producer which takes in untreated ore downstream and then has the capacity to fulfill every process requirement to the finished product. The company has its own bauxite ore mines located just 20 kilometers away from the factory and this is the starting point of its operations—the chemistry of aluminum means it is always found combined in other minerals, most frequently bauxite ore.

Eti Aluminyum's Seydişehir Aluminum Plant, located in the Central Anatolia region of Turkey, is an integrated primary aluminum production plant. From here the company is able to convert aluminum ore into metallic aluminum by first processing the ore and then shaping it through the use of casting, rolling and extrusion systems.

The integrated production process itself consists of five main production phases. These are bauxite mining, aluminum production, liquid aluminum production, the alloying and casting of the liquid aluminum, and the last but by no means least, the production of semi and/or end products through the use of the aforementioned casting, rolling and extrusion processes.

Methodological Issues:

CO_2 emissions from primary aluminum production calculated by T2 method formulated as equation 4.24 in 2006 IPCC guideline. Parameters below are obtained from producer which is use Vertical StudSøderberg cells for primary aluminum production;

- total metal production
- paste consumption, tonnes
- binder content in paste
- sulphur content in pitch
- ash content in pitch
- hydrogen content in pitch
- sulphur content in calcined coke
- ash content in calcined coke
- carbon in skimmed dust from Søderberg cells

Due to confidentiality reason AD and the factor used could not be provided. But the trend in aluminum production and the CO_2 emission can be seen from Table 4.19 below.

Table 4.19 Aluminum productions and CO_2 emissions, 1990-2014

Year	Aluminum production (1990=100)	CO_2 (kt)
1990	100.0	99.16
1991	102.6	101.70
1992	98.5	97.65
1993	54.5	54.08
1994	111.3	110.32
1995	115.4	114.44
1996	109.2	108.24
1997	109.2	108.23
1998	116.4	115.45
1999	114.9	113.90
2000	113.7	112.74
2001	112.3	111.35
2002	111.9	110.94
2003	112.3	111.31
2004	112.4	111.48
2005	111.6	104.43
2006	106.6	105.45
2007	113.7	115.58
2008	109.6	110.05
2009	72.7	68.23
2010	126.6	123.91
2011	120.8	118.17
2012	90.9	87.55
2013	67.6	63.92
2014	54.6	54.87

PFCs are formed during a phenomenon known as the 'anode effect'. PFCs emissions have been estimated from the primary aluminum production multiplied for the relative EF (CF_4, C_2F_6), following a T3 IPCC methodology. In fact, the company yearly supply data for the following parameters, from 1990:

- Primary aluminum production (tonnes);
- Anode effect (minute/day);
- CF_4 Slope coefficient;
- C_2F_6 Slope coefficient;
- CF_4 EF (kg CF_4/tonnes aluminum);
- C_2F_6 EF (kg C_2F_6/tonnes aluminum).

In the following Table 4.20, PFCs EF is reported (1990 = 100); because C_2F_6 emissions are calculated as a fraction of CF_4 emissions, the index is equal for both gases.

Table 4.20 PFCs emission factor, 1990-2014

Year	PFCs EFs (1990=100)
1990	100.0
1991	134.6
1992	117.3
1993	118.2
1994	102.1
1995	84.7
1996	84.6
1997	84.1
1998	84.5
1999	84.2
2000	84.5
2001	84.3
2002	83.8
2003	82.9
2004	82.5
2005	82.0
2006	68.1
2007	79.6
2008	75.9
2009	76.0
2010	75.0
2011	74.9
2012	72.3
2013	74.0
2014	74.8

In the Table 4.20, PFCs EF is reported (1990=100); because C_2F_6 emissions are calculated as a fraction of CF_4 emissions, the index is equal for both gases.

In Table 4.21 the emission trend of F-gases from metal production (2C3) is given. Fluctuations in the trend are due to Anode Effect parameter changes as well as primary aluminum production trend. CF_4 and C_2F_6 emissions are reported as well in the Table 4.12.

Data is being collected from the aluminum production plant will be reflected to National Inventory on following years. For year 2006, PFCs emissions from the aluminum production plant are estimated using T3 methodology. Emissions from this plant starting from 2007 could not be included in the inventory due to confidentiality reason.

Eti Aluminum have communicated that after privatization in 2005, there has been great savings in energy consumption in 2006, at the same time there has been a decreasing trend in the number of anode effects. As it seen from the table below, reductions in PFCs emissions have occurred in 2006.

Table 4.21 PFCs, CF_4 and C_2F_6 emissions from primary aluminum production, 1990-2014

Year	PFCs (kt CO_2 eq.)	CF_4 (tonnes)	C_2F_6 (tonnes)
1990	692.77	87.380	3.855
1991	854.54	107.785	4.755
1992	781.92	98.624	4.351
1993	786.58	99.213	4.377
1994	693.65	87.491	3.860
1995	592.88	74.781	3.299
1996	597.28	75.336	3.324
1997	593.33	74.837	3.302
1998	593.87	74.906	3.305
1999	591.07	74.552	3.289
2000	591.38	74.592	3.291
2001	592.20	74.695	3.295
2002	595.92	75.164	3.316
2003	595.33	75.090	3.313
2004	600.78	75.777	3.343
2005	559.97	70.629	3.116
2006	450.06	57.206	2.238
2007	NE	NE	NE
2008	NE	NE	NE
2009	NE	NE	NE
2010	NE	NE	NE
2011	NE	NE	NE
2012	NE	NE	NE
2013	NE	NE	NE
2014	NE	NE	NE

Uncertainties and Time-Series Consistency:

Uncertainty values of T3 are considered 5% for EF and 2% for AD as recommended in 2006 IPCC Guideline Volume 3 (page 4.56).

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables according to QA/QC plan. Aggregated national EFs are compared with IPCC default values.

Recalculation:

Recalculation was made due to a formulation mistake for 1990 to 2012.

4.4.4. Magnesium production (Category 2.C.4)

There is no magnesium production in Turkey.

4.4.5. Lead production (Category 2.C.5)

Source Category Description:

There are two primary processes for the production of rough lead bullion from lead concentrates. The first type is sintering/smelting, which consists of sequential sintering and smelting steps and constitutes roughly 78% of the primary lead production. The second type is direct smelting, which eliminates the sintering step and constitutes the remaining 22% of primary lead production in the developed world.

Methodological Issues:

CO_2 emissions from lead production are calculated by T1 method. Total lead production is used as AD which is provided by Turkish Industrial Production Survey by TurkStat. Default EF was applied to total lead production due to no information is available on the relative amounts of lead produced from primary and from secondary materials.

For the years 1990-2004 no information were gathered. In the next year; deeply investigation will conducted for unavailable data and process type. The following table 4.22 shows the lead production and resulting CO_2 emissions, 1990 to 2014.

Table 4.22 Lead production and CO_2 emissions, 1990-2014

(kt)

Year	Lead production	CO_2
1990	3.7	1.9
1991	3.7	1.9
1992	3.7	1.9
1993	3.7	1.9
1994	3.7	1.9
1995	3.7	1.9
1996	3.7	1.9
1997	3.7	1.9
1998	3.7	1.9
1999	3.7	1.9
2000	3.7	1.9
2001	3.7	1.9
2002	3.7	1.9
2003	3.7	1.9
2004	3.7	1.9
2005	3.7	1.9
2006	9.2	4.8
2007	7.4	3.9
2008	27.3	14.2
2009	7.1	3.7
2010	22.4	11.7
2011	26.0	13.5
2012	10.4	5.4
2013	18.2	9.5
2014	14.5	7.5

Uncertainties and Time-Series Consistency:

Uncertainty values of AD and EF are considered 30% and 10% respectively as recommended in 2006 IPCC Guideline Volume 3 Table 4.23 due to the default EF and national statistics use.

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables according to QA/QC plan. The AD gathered from PRODCOM and these data were produced according to the EU Code of Practice. TurkStat conducts its own quality control procedure for these data.

Recalculation:

The 2013 lead production data was revised and therefore the emission was recalculated accordingly.

4.4.6. Zinc production (Category 2.C.6)

Source Category Description:

There are three different types of primary zinc production. The first method is a metallurgical process called electro-thermic distillation. The process is used to combine roasted concentrate and secondary zinc products into a sinter feed that is burned to remove zinc, halides, cadmium, and other impurities. The resulting zinc oxide-rich sinter is combined with metallurgical coke in an electric retort furnace that reduces the zinc oxides and produces vaporized zinc which is captured in a vacuum condenser. The reduction results in the release of non-energy CO_2 emissions. The electro-thermic distillation process is used in the United States and in Japan.

Methodological Issues:

The simplest estimation method T1 is applied to calculate CO_2 by multiplying default EFs to zinc production data. For the years 2005-2012; total zinc production data are obtain from Turkish Industrial Production Survey conducted by TurkStat while data for 1990-1996 are taken from Turkish Zink Inventory (Yüce, 1998). Data for the years for 1997-2004 are gathered from material flow account study of Turkey. The following table 4.23 shows the zinc production and resulting CO_2 emissions, 1990 to 2014.

Table 4.23 Zinc production and CO_2 emissions, 1990-2014

(kt)

Year	Zinc production	CO_2
1990	0.15	0.26
1991	0.11	0.20
1992	0.24	0.42
1993	0.23	0.40
1994	0.30	0.51
1995	0.79	1.36
1996	0.77	1.33
1997	0.84	1.44
1998	0.95	1.64
1999	1.07	1.84
2000	1.19	2.04
2001	1.30	2.24
2002	1.42	2.44
2003	1.54	2.64
2004	1.65	2.85
2005	1.88	3.23
2006	4.99	8.58
2007	10.64	18.31
2008	12.76	21.94
2009	18.50	31.82
2010	17.35	29.85
2011	13.24	22.78
2012	11.35	19.52
2013	23.02	39.59
2014	19.11	32.87

Uncertainties and Time-Series Consistency:

Uncertainty values of AD and EF are considered 10% and 50% respectively as recommended in 2006 IPCC Guideline Volume 3 Table 4.23 due to the default EF and national statistics use.

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables according to QA/QC plan. The AD gathered from PRODCOM and these data were produced according to the EU Code of Practice. TurkStat conducts its own quality control procedure for these data.

Recalculation:

The 2013 zinc production data was revised and therefore the emission was recalculated accordingly.

4.5. Non-Energy Products from Fuels and Solvent Use (Category 2.D)

4.5.1. Lubricant use (Category 2.D.1)

Source Category Description:

Lubricants are mostly used in industrial and transportation applications. Lubricants are produced either at refineries through separation from crude oil or at petrochemical facilities. They can be subdivided into (a) motor oils and industrial oils, and (b) greases, which differ in terms of physical characteristics (e.g., viscosity), commercial applications, and environmental fate.

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

Methodological Issues:

CO_2 emissions calculation is based on the amount of lubricant consumption in a country which is obtain from energy balances table of Turkey. Having only total consumption data for all lubricants (i.e. no separate data for oil and grease), the weighted average oxidised during use (ODU) factor and default carbon content factor for lubricants as a whole is used as default value for the calculation. T1 method which is formulated by Equation 5.2 in 2006 IPCC Guideline is used to calculate CO_2 emission. The amount of lubricant consumed in term of kt mass unit converted to the unit TJ by multiplying 40.2. The following table 4.24 shows the amount of lubricant used and resulting CO_2 emissions, 1990 to 2014.

Table 4.24 The Amount of lubricant used and CO_2 emissions, 1990-2014

(kt)

Year	Lubricant use	CO_2
1990	297	175.1
1991	310	182.8
1992	270	159.2
1993	287	169.2
1994	290	171.0
1995	339	199.9
1996	371	218.7
1997	406	239.4
1998	340	200.5
1999	420	247.6
2000	460	271.2
2001	335	197.5
2002	447	263.6
2003	437	257.7
2004	571	336.7
2005	667	393.3
2006	747	440.4
2007	733	432.2
2008	591	348.5
2009	652	384.4
2010	713	420.4
2011	1 416	834.9
2012	998	588.4
2013	894	527.1
2014	654	385.6

Uncertainties and Time-Series Consistency:

Because the default ODU factors developed are very uncertain, as they are based on limited knowledge of typical lubricant oxidation rates. Expert judgment suggests using a default uncertainty of 50%. The carbon content coefficients are based on two studies of the carbon content and heating value of lubricants, from which an uncertainty range of about ±3 percent is estimated (EPA, 2004). AD uncertainty is considered as 10%.

For AD uncertainty value 15% and EF uncertainty 5% are considered in the light of information above and as 2006 IPCC Guidelines recommended.

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables according to QA/QC plan.

4.5.2. Paraffin wax use (Category 2.D.2)

Source Category Description:

The category, as defined here, includes such products as petroleum jelly, paraffin waxes and other waxes, including ozokerite (mixtures of saturated hydrocarbons, solid at ambient temperature). Paraffin waxes are separated from crude oil during the production of light (distillate) lubricating oils. Paraffin waxes are categorized by oil content and the amount of refinement.

Waxes are used in a number of different applications. Paraffin waxes are used in applications such as: candles, corrugated boxes, paper coating, board sizing, food production, wax polishes, surfactants (as used in detergents) and many others. Emissions from the use of waxes derive primarily when the waxes or derivatives of paraffin are combusted during use (e.g., candles), and when they are incinerated with or without heat recovery or in wastewater treatment (for surfactants).

Methodological Issues:

CO_2 emissions calculation is based on the amount of paraffin waxes consumed in a country which is obtain from energy balances table of Turkey. T1 method formulated as Equation 5.4 in 2006 IPCC Guideline is used with default carbon content and ODU factor. The following Table 4.25 shows the amount of paraffin wax used and resulting CO_2 emissions, 1990 to 2014.

Table 4.25 The Amount of paraffin wax used and CO_2 emissions, 1990-2014 (kt)

Year	Paraffin wax use	CO_2
1990	14	1.65
1991	13	1.53
1992	7	0.83
1993	8	0.94
1994	5	0.59
1995	5	0.59
1996	8	0.94
1997	5	0.59
1998	5	0.59
1999	4	0.47
2000	10	1.18
2001	28	3.30
2002	33	3.89
2003	29	3.42
2004	38	4.48
2005	89	10.49
2006	53	6.25
2007	29	3.42
2008	19	2.24
2009	20	2.36
2010	19	2.24
2011	32	3.77
2012	29	3.42
2013	11	1.30
2014	23	2.71

Uncertainties and Time-Series Consistency:

Uncertainty values of AD and EF are considered 15% and 5% respectively as recommended in 2006 IPCC Guideline Volume 3 (page 5.13) for the countries which energy statistics are not well developed.

Source-Specific QA/QC and Verification:

During the preparation of the inventory submission activities related to source specific quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables according to QA/QC plan.

4.6. Electronics Industry (Category 2.E)

The emissions from this sub-category are not estimated due to the data availability. Studies on data collection are undergoing.

4.7. Product Use as Substitutes for ODS (Category 2.F)

Source Category Description:

This section is prepared by the MoEU. Production of fluorochemicals does not exist in Turkey. Therefore all demand for these gases is met by imports.

The sub sector emissions of fluorinated substitutes for ODS consist of the following sub application;

- 2F3 emissions from fire protection
- 2F6 emissions from other applications

Methodological Issues:

The methodology used to estimate HFCs emissions from the sub-sector has been based on the 2006 IPCC Guidelines, using the model provided by the IPCC, which calculate emissions following T1 method. Inventory calculations have been based on the raw trade data (import and export) provided for each gas by TurkStat.

It should be noted that HFCs are being used as alternatives to CFCs since 1999. Since then it is thought that HFCs are used in different industrial sectors. However due to lack of information, it is assumed that most of HFCs gases, excluding HFC-227ea that is used only in fire extinguishers, are used in refrigeration and air conditioning sector. Due to this reason, these gases are calculated according to the calculation assumptions for refrigeration and air conditioning but calculation results are reported under “Other Applications” title in 2F category.

As it is written in 2006 IPCC Guidelines, following assumptions are used in a hybrid Tier 1a/b approach for calculations;

- Servicing of equipment containing the refrigerant does not commence until 3 years after the equipment is installed.
- Emissions from banked refrigerants average 15% annually across the whole refrigeration and air conditioning application area.

- In a market, two thirds of the sales of a refrigerant are used for servicing and one third is used to charge new equipment.
- The average equipment lifetime is 15 years.
- The complete transition to a new refrigerant technology will take place over a 10 year period.

For calculation of HFC-227ea, expert judgments are considered. According to the information which is obtained from discussion with experts who are working under the Protection of Ozon Layer Division of MoEU, HFC-227ea is mostly consumed in fire protection application in Turkey. Regarding to this information, this gas is reported under "2F3 Fire Protection" category. As it is stated in the 2006 IPCC Guideline, HFCs in this application area, are emitted over a period longer than one year. To consider this, spreadsheet which is proposed by guideline is used for calculation.

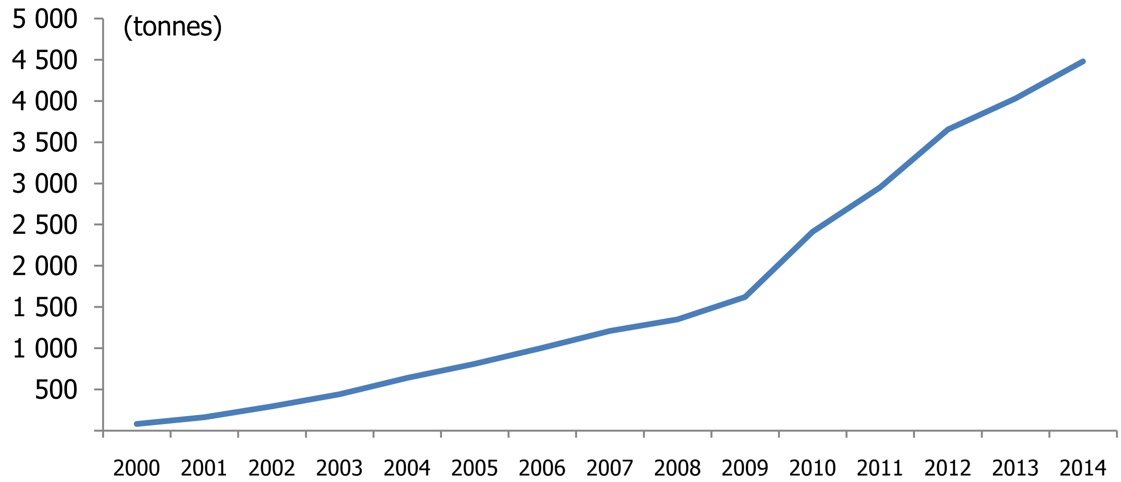
Uncertainties and Time-Series Consistency:

Table 4.26 and Figure 4.12 present total HFCs emissions from 2000 to 2014. Increasing trend in emissions is clearly observed from these presentations. The reason behind this can be explained by the prohibition of CFCs in the country. Since 1999, HFCs have been used as substitution of CFCs.

Table 4.26 Total HFCs emissions, 2000-2014

Year	HFCs Emissions (tonnes)	HFCs Emissions (kt CO_2 eq.)
2000	81.3	115.66
2001	163.4	232.00
2002	293.9	417.19
2003	443.2	628.80
2004	640.8	909.37
2005	808.6	1 146.88
2006	1 004.4	1 424.19
2007	1 208.4	1 713.19
2008	1 348.1	1 896.14
2009	1 621.3	2 111.28
2010	2 412.4	3 054.34
2011	2 949.9	3 432.69
2012	3 654.4	4 256.86
2013	4 029.9	4 470.25
2014	4 478.5	4 916.55

Figure 4.12 Total HFCs emissions, 2000-2014



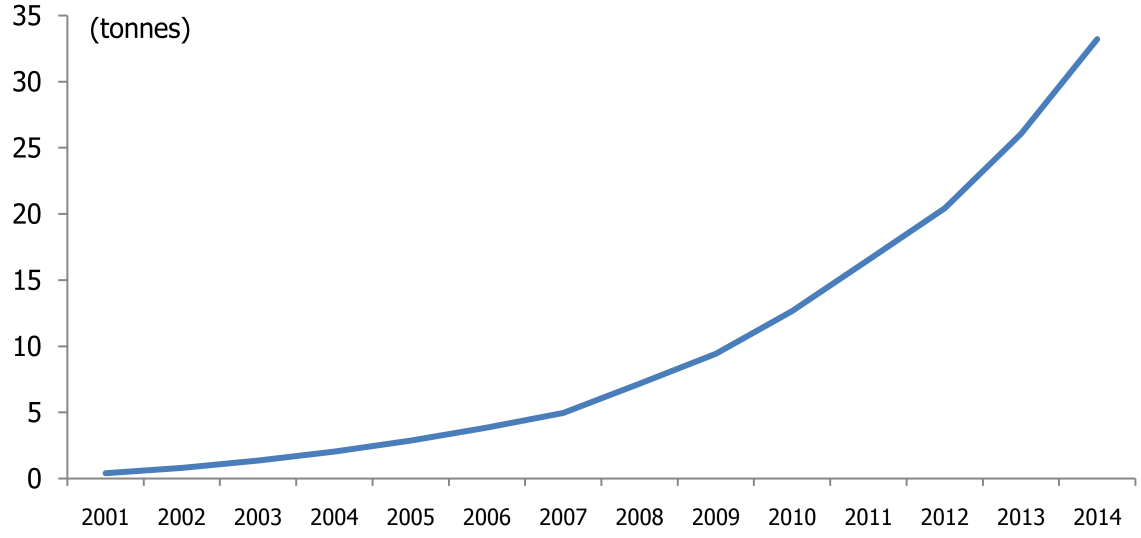
Above presentation shows aggregated emissions caused by HFCs including HFC-23, HFC-32, HFC-41, HFC-43-10mee, HFC-125, HFC-134, HFC-134a, HFC-143, HFC-143a, HFC-152a, HFC-227ea, HFC-236fa, HFC-245ca, and HFC-365mfc. Moreover, table below separately indicates emissions from these gases for specific years. All emission values are presented in tonnes and for each gas emissions are calculated related to Tier 1a/1b method of IPCC.

Table 4.27 HFCs Emissions

(tonnes)

Substance	2000	2005	2010	2011	2012	2013	2014	Calculation method
HFC-23	0.02	0.29	0.57	0.63	5.40	4.64	4.05	IPCC T1
HFC-32	-	-	-	-	0.01	0.01	0.48	IPCC T1
HFC-41	-	-	0.026	0.022	0.030	0.026	0.022	IPCC T1
HFC-43-10mee	-	-	-	0.04	0.08	0.07	0.15	IPCC T1
HFC-125	-	-	0.71	1.20	3.55	6.68	15.26	IPCC T1
HFC-134	-	-	-	0.0002	0.006	0.005	0.005	IPCC T1
HFC-134a	80.35	791.38	2 066.27	2 285.44	2 770.35	2 877.47	3 143.27	IPCC T1
HFC-143	-	-	0.001	0.001	0.001	0.001	0.001	IPCC T1
HFC-143a	-	-	-	-	0.002	0.001	0.001	IPCC T1
HFC-152a	0.78	14.07	331.36	642.15	849.39	1 109.14	1 274.49	IPCC T1
HFC-236fa	-	-	0.68	1.66	3.07	4.12	4.11	IPCC T1
HFC-245ca	-	-	0.02	1.14	0.97	0.82	2.65	IPCC T1
HFC-365mfc	-	-	0.12	1.10	1.08	0.92	0.78	IPCC T1
HFC-227ea	0.13	2.87	12.67	16.55	20.45	26.06	33.23	IPCC T1

Figure 4.13 HFC-227ea Emissions, 2001-2014



Recalculation:

Since calculation method change for this year, emissions are recalculated for each gas. Table below compare the previous calculation results with latest results.

Table 4.28 Recalculations made in HFCs emissions

(tonnes)

Year	Total HFCs emissions (2015 Submission)	Total HFCs emissions (2016 Submission)
2000	818	81.3
2001	871	163.4
2002	1 419	293.9
2003	1 807	443.2
2004	2 229	640.8
2005	2 379	808.6
2006	2 730	1 004.4
2007	3 174	1 208.4
2008	2 669	1 348.1
2009	2 839	1 621.3
2010	4 009	2 412.4
2011	4 083	2 949.9
2012	4 681	3 654.4
2013	4 272	4 029.9
2014	-	4 478.5

Planned Improvement:

For the future inventory submissions, improvements in the sector data will be done within the scope of *Technical Assistance for Support to Mechanism for Monitoring Turkey's Greenhouse Gas Emissions (TASK-GHG) Project* which has started in December 2014 and will last in April 2017.

4.8. Other Product Manufacture and Use (Category 2.G)

Source Category Description:

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

- 2.G.1- SF_6 Emissions from electrical equipment
- 2.G.2- SF_6 Emissions used in fire extinguishers and other products

Methodological Issues:

A major portion of SF_6 is used in electrical instruments. The increase in the import data from 2004 is mainly because of the increasing amount of circuit breakers being installed in Turkey.

Unfortunately there's no reliable data source on SF_6 imports, both for amounts coming as gas and inside electrical equipment. However, MoEU have begun working on collection of the data together with related institutions. After a licensing and data collection system is established more reliable data will be obtained and previous years' data will be recalculated if possible.

The only available data for electrical equipment is the imported SF_6 data. There is no information about the number and the capacity of the used, imported or exported equipment and the number of destroyed equipment. The imported amount has been assumed as completely emitted. Since, electrical equipment production is the main consumer of SF_6, this assumption has led to high emission rates which thought to be less in practice.

SF_6 data has been classified according to the company's name and the activity. When necessary, companies have been asked (i.e. leather industry) to clarify the emission rates.

Also, use of SF_6 in fire extinguisher is a source of error due to lack of information whether it is used in fixed or portable systems.

Leather industry is a new sector which uses SF_6 and not listed in guidelines. It has been determined that SF_6 is used to prevent wrinkling during processing of leathers. In the same way as metal, all SF_6 used in leather industry has been taken as equal to amount emitted.

SF_6 imported by laboratories, universities, medical industries have also been calculated in the same way and it has been assumed that all SF_6 is emitted in two years in equal amounts as suggested in guidelines. Amounts imported by unidentified users have also been calculated in the same way.

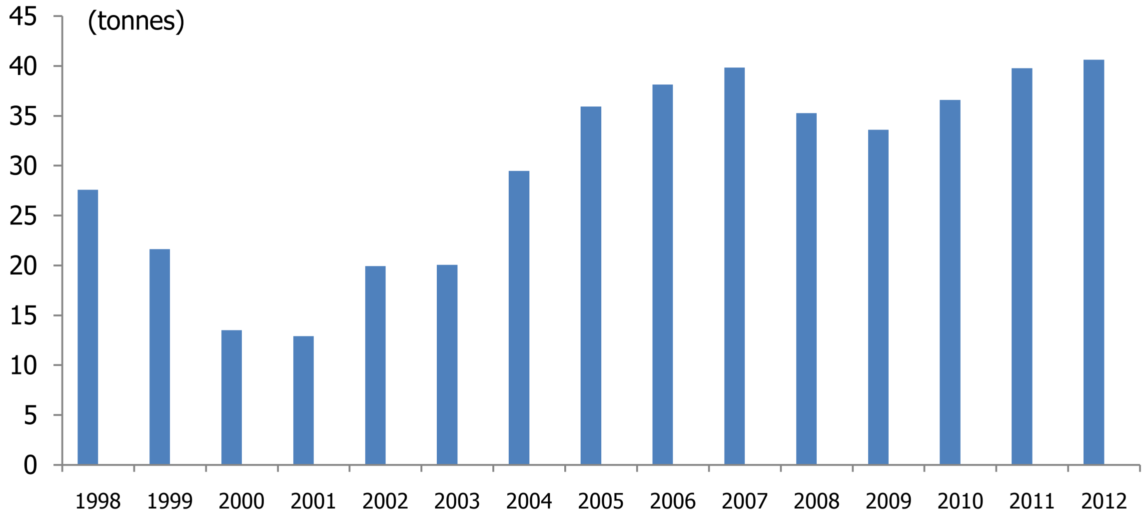
SF_6 used in "fire extinguishers" has been calculated by contacting the importing company. EF of fire extinguishers depends on whether they are used is fixed systems or portable systems. Since there is no data about the place, according to the interview with the importer, it has been assumed that 2/3 of the imported amount is used in fixed systems and 1/3 is used in portable systems. EFs have been taken as 60% and 35% for portable and fixed systems respectively.

For year 2006 to 2010 emissions from SF_6 are estimated using annual growth rates of Turkey due to lack of import data. Table 4.29 and Figure 4.14 show the SF_6 emission trends.

Table 4.29 SF_6 emissions, 1996-2014

Year	Actual SF_6 emissions (tonnes)
1996	15.64
1997	25.57
1998	27.60
1999	21.62
2000	13.51
2001	12.91
2002	19.95
2003	20.06
2004	29.48
2005	35.93
2006	38.12
2007	39.84
2008	35.30
2009	33.60
2010	36.60
2011	39.76
2012	40.63
2013	NE,IE
2014	NE,IE

Figure 4.14 SF_6 emissions, 1998-2012



Uncertainties and Time-Series Consistency:

Uncertainties of HFCs, PFCs and SF_6 were estimated using expert judgment as described in IPCC Good Practice Guidance and Uncertainty Management (2000) Reference.

Source-Specific QA/QC and Verification:

Import data of HFCs are cross-checked between import data available in TurkStat and import licenses available in MoEU.

Recalculation:

SF_6 emissions are assumed to increase by the same percentage with overall economic growth of Turkey. Overall economic growth data is taken from TurkStat. There was no recalculation. However, the empty cells in CRF are filled with appropriate notation keys.

Planned Improvement:

For the future inventory submissions, improvements in the sector data will be done within the scope of *Technical Assistance for Support to Mechanism for Monitoring Turkey's Greenhouse Gas Emissions (TASK-GHG) Project*which has started in December 2014 and will last in April 2017.

5. AGRICULTURE (CRF Sector 3)

5.1. Sector Overview

The overall emission value for the agriculture sector is calculated as 49.5 Mt CO_2 eq. for the year 2014 which is 12.1% of the entire emission value including LULUCF and 10.6% of all emissions excluding LULUCF for Turkey. The agriculture sector is structured into ten categories classified from 3.A to 3.J in the CRF. These categories were listed below briefly including GHGs emitted from each of these sources.

Table 5.1 Categories of the agriculture sector and emitted gases

CRF Categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_x
3.A Enteric fermentation		x					
3.B Manure management		x	x	x[2]		x[2]	
3.C Rice cultivation		x					
3.D Agricultural soils	x[1]		x	x[2]		x[2]	
3.E Prescribed burning of savannas		x	x	x[3]	x[3]	x[3]	x[3]
3.F Field burning of agricultural residues		x	x	x[2]	x[2]	x[2]	x[2]
3.G Liming	x						
3.H Urea application	x						
3.I Other carbon-containing fertilizers	x						
3.J Other							

[1] to be reported under LULUCF Sector.

[2] Emissions of this gas from this category are likely to be emitted and a methodology is provided in the EMEP/EEA Guidebook.

[3] Emissions of this air pollutant from this category are likely to be emitted and the methodology may be included in the EMEP/EEA Guidebook in the future.

The percentage of emissions from this sector as a percentage of total national GHG emissions (excluding LULUCF), gradually declined in most of the years between 1990-2008, from 19.8% to 9.3%, before levelling off. In 2014, the agriculture sector was responsible for 10.6% of national emissions. The following table aims to give a clear view regarding the weights of the categories within the sector presenting emissions and percentage values and a short overview is presented below in Table 5.2 quantitatively describing agriculture sector emissions. All emission data given in this agriculture sector, unless otherwise indicated, are stated either in kt CO_2 eq. or Mt CO_2 eq.

Table 5.2 Agriculture sector emissions and overall percentages by categories, 2014

	CH_4 (kt CO_2 eq)	N_2O (kt CO_2 eq)	CO_2 (kt CO_2 eq)	Total (kt CO_2 eq)	%
3 Agriculture	**31 053.5**	**17 680.6**	**787.7**	**49 521.8**	**100.0**
A. Enteric fermentation	27 434.3			27 434.3	55.4
B. Manure management	3 178.4	2 513.5		5 691.9	11.5
C. Rice cultivation	191.1			191.1	0.4
D. Agricultural soils		15 089.9		15 089.9	30.5
E. Prescribed Burning of Savannas				NO	
F. Field burning of agricultural residues	249.7	77.2		326.8	0.7
G. Liming				NE	
H. Urea application			787.7	787.7	1.6
I. Other Carbon-containing fertilizers				NE	

Table 5.3 clearly presents the developments of the emissions for the agriculture sector. The overall emission for the sector increased from 41.2 Mt CO_2 eq. to 49.5 Mt CO_2 eq. during the 25 years after 1990 showing an increase of 20.1%. The biggest increase among the categories in absolute terms for the emissions is observed in the agricultural soils category where the emission increased by 3.6 Mt CO_2 eq. (30.9%) from 11.5 Mt CO_2 eq. to 15.1 Mt CO_2 eq. for the same period. The primary reason for this increase is owing to the change in activity data. Other significant increases are seen in enteric fermentation, manure management, and urea application where the figures are 2.5 Mt CO_2 eq. (10.2%), 1.8 Mt CO_2 eq. (44.6%), and 0.3 Mt CO_2 eq. (71.3%) respectively. The increase in emissions from enteric fermentation and manure management is largely a result of activity data developments. Emissions for rice cultivation increased by 0.1 Mt CO_2 eq. (109.2%) whereas the emissions of 1990 and 2014 for field burning of agricultural residues were nearly the same showing only a slight decrease of 0.1%. It is clear that the emissions peaked in 2014 with respect to increases in enteric fermentation and manure management.

In relative terms the biggest category in the agriculture sector is enteric fermentation having a 55.4% share for 2014, hence being the dominant category. In all of the reported years, 1990-2014, this category had a share either over 50% or close to 50% of total agriculture emissions, though the trend clearly indicates a slight decline from 60.4% to 55.4%. The second biggest category is agricultural soils having a proportion of 30.5% for 2014 (increasing from 28% in 1990) and had achieved shares higher than 30% in some of the years. Manure management's share is more stable showing an increasing trend, though in smaller percentage points starting from 9.5% of agricultural emissions in 1990 and reaching 11.5% in 2014. The remaining categories rice cultivation, field burning of agricultural residuals, and urea application had emission shares of 0.4%, 0.7%, and 1.6% respectively for 2014 in the sector. Though the percentage increases of emissions for rice cultivation and urea application are significantly high between 1990 and 2014, the absolute terms and relative weights for these two categories are still small. Despite these increasing values, the share for field burning of agricultural residues is highly similar for 1990 and 2014, thus having a small decreasing percentage of 0.1% from 0.8% in 1990 to 0.7% in 2014.

Furthermore it should be noted that prescribed burning of savannas (CRF Category 3.E) does not occur in Turkey and is not therefore further reported in this inventory report whereas liming (CRF Category 3.G) and other carbon-containing fertilizers (CRF Category 3.I) are not reported because category-specific emission values are not estimated due to lack of activity data. The final category other (CRF Category 3.J) in the agriculture sector is an option to be used only if necessary.

Table 5.3 An Overview of the agriculture sector, 1990-2014

Year	A. Enteric fermentation (kt CO_2 eq.)	(%)	B. Manure management (kt CO_2 eq.)	(%)	C. Rice cultivation (kt CO_2 eq.)	(%)	D. Agricultural soils (kt CO_2 eq.)	(%)	F. Field burning of agricultural residues (kt CO_2 eq.)	(%)	H. Urea application (kt CO_2 eq.)	(%)	Agriculture total (kt CO_2 eq.)	(%)
1990	24 888	60.4	3 937	9.5	91	0.2	11 524	28.0	327	0.8	460	1.1	41 227	100
1991	25 762	61.5	4 159	9.9	70	0.2	11 107	26.5	336	0.8	436	1.0	41 871	100
1992	25 546	60.7	4 064	9.7	74	0.2	11 648	27.7	318	0.8	459	1.1	42 110	100
1993	25 182	58.6	4 177	9.7	77	0.2	12 591	29.3	343	0.8	627	1.5	42 997	100
1994	24 855	61.7	4 409	10.9	70	0.2	10 214	25.3	299	0.7	453	1.1	40 299	100
1995	24 366	61.3	4 202	10.6	86	0.2	10 388	26.1	306	0.8	426	1.1	39 773	100
1996	24 412	59.8	4 260	10.4	95	0.2	11 188	27.4	316	0.8	534	1.3	40 804	100
1997	22 818	58.4	3 948	10.1	95	0.2	11 388	29.1	319	0.8	532	1.4	39 100	100
1998	22 396	54.9	4 183	10.2	103	0.3	13 134	32.2	351	0.9	658	1.6	40 825	100
1999	22 514	54.5	4 251	10.3	112	0.3	13 379	32.4	310	0.8	733	1.8	41 300	100
2000	21 647	54.6	4 028	10.2	100	0.3	12 914	32.6	343	0.9	617	1.6	39 650	100
2001	21 042	56.9	4 039	10.9	102	0.3	10 956	29.6	318	0.9	527	1.4	36 983	100
2002	19 378	54.3	3 641	10.2	103	0.3	11 731	32.9	328	0.9	527	1.5	35 709	100
2003	19 901	53.6	3 793	10.2	112	0.3	12 440	33.5	325	0.9	565	1.5	37 137	100
2004	19 254	52.1	3 698	10.0	121	0.3	12 927	34.9	355	1.0	632	1.7	36 986	100
2005	19 911	52.5	3 881	10.2	147	0.4	13 013	34.3	371	1.0	613	1.6	37 936	100
2006	20 597	52.9	4 050	10.4	171	0.4	13 177	33.8	349	0.9	592	1.5	38 937	100
2007	20 804	54.0	4 104	10.7	162	0.4	12 574	32.6	301	0.8	566	1.5	38 511	100
2008	20 280	55.6	3 981	10.9	172	0.5	11 162	30.6	299	0.8	565	1.5	36 458	100
2009	19 854	52.2	3 953	10.4	167	0.4	13 092	34.5	340	0.9	593	1.6	37 998	100
2010	21 159	53.8	4 401	11.2	171	0.4	12 622	32.1	331	0.8	645	1.6	39 329	100
2011	23 149	56.4	4 537	11.0	171	0.4	12 308	30.0	354	0.9	558	1.4	41 078	100
2012	26 051	56.9	5 155	11.3	206	0.5	13 385	29.2	333	0.7	640	1.4	45 770	100
2013	27 196	55.1	5 540	11.2	191	0.4	15 218	30.9	368	0.7	807	1.6	49 320	100
2014	27 434	55.4	5 692	11.5	191	0.4	15 090	30.5	327	0.7	788	1.6	49 522	100

GHG emission values and their shares in the agriculture sector, CH_4, N_2O and CO_2, are given in Table 5.4. Emission values for CH_4 decreases mainly - after its initial increase - in the first twelve years after 1991, but shows then mainly an increasing trend starting around 2004. The percentage share of CH_4 decreased from 66.9% in 1990 to 62.7% in 2014.

The share of N_2O emissions with respect to yearly total values were around 35%. The emission values for N_2O were 13 186 kt CO_2 eq. (32%) in 1990 whereas it increased to 17 681 kt CO_2 eq. (35.7%) in 2014 mainly due to the emissions of manure management and agricultural soils.

CO_2 emissions from agricultural activities have the smallest share in total emissions of the agriculture sector. CO_2 emissions result only from urea application in this sector and its shares range between 1% and 1.8% for the period 1990-2014. The highest value of CO_2 emissions occurred in 2013 with 807 kt while it has the smallest value in 1995 with 426 kt depending on the amount of urea applied. The corresponding value for 2014 is 788 kt with a share of 1.6%.

Table 5.4 An Overview of GHGs in the agriculture sector, 1990-2014

Year	CH_4 (kt CO_2 eq.)	(%)	N_2O (kt CO_2 eq.)	(%)	CO_2 (kt CO_2 eq.)	(%)	Total (kt CO_2 eq.)
1990	27 580.9	66.9	13 186.0	32.0	459.9	1.1	41 226.9
1991	28 529.2	68.1	12 905.1	30.8	436.2	1.0	41 870.5
1992	28 193.2	67.0	13 457.6	32.0	458.7	1.1	42 109.6
1993	27 942.1	65.0	14 428.5	33.6	626.7	1.5	42 997.3
1994	27 810.8	69.0	12 035.8	29.9	452.6	1.1	40 299.2
1995	27 211.4	68.4	12 135.9	30.5	425.9	1.1	39 773.2
1996	27 302.4	66.9	12 967.9	31.8	534.1	1.3	40 804.4
1997	25 463.5	65.1	13 104.1	33.5	532.0	1.4	39 099.6
1998	25 245.0	61.8	14 922.4	36.6	657.9	1.6	40 825.3
1999	25 417.3	61.5	15 149.3	36.7	733.3	1.8	41 299.9
2000	24 342.7	61.4	14 689.8	37.0	617.5	1.6	39 650.0
2001	23 800.2	64.4	12 655.6	34.2	527.1	1.4	36 982.9
2002	21 749.5	60.9	13 433.1	37.6	526.9	1.5	35 709.5
2003	22 491.2	60.6	14 080.2	37.9	565.4	1.5	37 136.8
2004	21 516.3	58.2	14 837.3	40.1	632.2	1.7	36 985.8
2005	22 299.8	58.8	15 022.9	39.6	613.2	1.6	37 935.9
2006	23 085.5	59.3	15 259.4	39.2	592.3	1.5	38 937.2
2007	23 378.1	60.7	14 566.2	37.8	566.3	1.5	38 510.6
2008	22 788.1	62.5	13 105.3	35.9	564.8	1.5	36 458.2
2009	22 418.0	59.0	14 987.6	39.4	592.7	1.6	37 998.3
2010	24 053.3	61.2	14 630.2	37.2	645.0	1.6	39 328.5
2011	26 043.6	63.4	14 476.4	35.2	557.5	1.4	41 077.6
2012	29 349.5	64.1	15 781.2	34.5	639.8	1.4	45 770.5
2013	30 784.7	62.4	17 728.1	35.9	807.3	1.6	49 320.2
2014	31 053.5	62.7	17 680.6	35.7	787.7	1.6	49 521.8

The AD used for the compilation of the GHG inventory is provided by TurkStat (https://biruni.tuik.gov.tr/hayvancilikapp/hayvancilik_ing.zul).

The total number of livestock is highly important for the agriculture sector and an input for required calculations. Animal population numbers are given in Table 5.5 and Table 5.6 for our geographically wide country and are provided directly by TurkStat for the entire time series, 1990-2014. There are differences among size populations (cattle, sheep and swine), between the numbers used for the estimations of GHG emissions and official numbers submitted to the Food and Agriculture Organization of the United Nations (FAO). The FAO data are slightly older and not based on the most recent TurkStat data, which is used for the inventory submission. Therefore the AD of the GHG inventory is more recent and accurate compared to FAO. Moreover, FAO applies some assumptions to the TurkStat data. Although, the data is updated in each year by TurkStat, FAO has still continued to use their assumptions. Therefore the data sent by TurkStat which is also used for GHG inventory is the most accurate data available for inventory calculations.

Data on animal production have been collected from District Offices of the Ministry of Food, Agriculture and Livestock at the end of the year. Starting from 2014 data on livestock numbers have been started to be collected and published two times a year. The data entered to web by the district offices have been analyzed together with the Ministry of Food, Agriculture and Livestock. Data prepared to be controlled have been sent to the Ministry for checking process. The data controlled again have been analyzed by Agricultural Production Statistics Group at TurkStat and will then became ready for publishing after last analysis and controls.

Livestock population numbers are given in eleven columns in Table 5.5. As the numbers display, both dairy and non-dairy cattle, domestic sheep, poultry and goats have significantly high population numbers. Three columns, non-dairy cattle, sheep merinos, and poultry, have positive differences between 1990 and 2014 with the population increasing around 3.1 million (57.1%), 1.3 million (150.2%), and 195.8 million (191.5%) respectively. It is remarkable that poultry numbers had almost tripled in 25 years from around 102 million to 298 million. Contrary to these developments, the livestock categories shown in the remaining columns in the table present decreasing figures ranging from - 4.8% as for dairy cattle to - 82.1% as seen in the category mules and asses. Similarly other decreasing percentages observed for categories goats, domestic sheep, camels, buffalo, horses, and swine are -5.3%, -26.9%, -27.9%, -67.1%, -74.4%, -77.9% respectively. Decreasing livestock population numbers of nearly 10.7 million in domestic sheep, around 0.28 million in dairy cattle, almost a quarter million in buffalo, and a little more than 0.58 million in goats have important consequences for the agriculture sector in our country.

Table 5.5 Livestock population numbers in Turkey, 1990-2014

(thousand)

Year	Dairy cattle	Non-Dairy cattle	Sheep domestic	Sheep merinos	Swine	Buffalo	Poultry	Camels	Horses	Mules and asses	Goats
1990	5 892.6	5 484.5	39 711.0	842.0	12.0	370.9	102 254.7	2.0	513.0	1 187.0	10 926.2
1991	6 119.0	5 853.9	39 590.5	841.8	10.3	366.2	145 050.7	1.9	495.5	1 135.6	10 764.2
1992	6 070.2	5 880.7	38 575.8	840.1	11.8	352.4	158 770.1	1.9	483.3	1 075.3	10 453.9
1993	6 032.0	5 878.0	36 709.0	832.0	9.0	316.0	184 459.8	2.0	450.0	1 013.0	10 133.0
1994	6 082.2	5 818.8	34 628.4	818.7	8.0	304.9	188 115.7	1.7	426.8	951.5	9 449.0
1995	5 885.6	5 903.4	32 985.0	806.0	5.0	255.0	135 250.5	2.0	415.0	900.0	9 111.0
1996	5 968.2	5 917.8	32 234.0	838.0	5.0	235.0	158 756.3	2.0	391.0	843.0	8 951.0
1997	5 594.3	5 590.7	29 376.0	862.0	4.6	194.0	175 223.4	1.4	345.0	782.0	8 376.0
1998	5 489.0	5 542.0	28 560.0	875.0	5.0	176.0	243 913.8	1.4	330.0	736.0	8 057.0
1999	5 537.9	5 516.1	29 425.0	831.0	3.4	165.0	246 476.2	1.4	309.0	680.0	7 774.0
2000	5 279.6	5 481.4	27 719.0	773.0	3.0	146.0	264 450.7	1.0	271.0	588.0	7 201.0
2001	5 085.8	5 462.2	26 213.0	759.0	2.7	138.0	223 140.5	0.9	271.0	559.0	7 022.0
2002	4 392.6	5 410.9	24 473.8	699.9	3.6	121.1	251 101.0	0.9	249.0	512.1	6 780.1
2003	5 040.4	4 747.7	24 689.2	742.4	7.1	113.4	283 674.4	0.8	227.4	489.6	6 771.7
2004	3 875.7	6 193.6	24 438.5	762.7	4.4	103.9	302 799.5	0.9	212.4	451.6	6 609.9
2005	3 998.1	6 528.3	24 552.0	752.4	1.9	105.0	322 917.2	0.8	207.8	423.1	6 517.5
2006	4 187.9	6 683.4	24 801.5	815.4	1.4	100.5	349 402.1	1.0	204.4	404.5	6 643.3
2007	4 229.4	6 807.3	24 491.2	971.1	1.8	84.7	273 548.5	1.1	188.6	364.3	6 286.4
2008	4 080.2	6 779.7	22 955.9	1 018.7	1.7	86.3	249 043.7	1.0	179.9	335.8	5 593.6
2009	4 133.1	6 590.8	20 721.9	1 027.6	1.9	87.2	234 082.2	1.0	166.8	285.7	5 128.3
2010	4 361.8	7 008.0	22 003.3	1 086.4	1.6	84.7	238 973.0	1.3	154.7	259.6	6 293.2
2011	4 761.1	7 625.2	23 811.0	1 220.5	1.8	97.6	241 498.5	1.3	151.2	247.7	7 278.0
2012	5 431.4	8 483.5	25 892.6	1 532.7	3.0	107.4	257 505.3	1.3	141.4	236.0	8 357.3
2013	5 607.3	8 808.0	27 485.2	1 799.1	3.1	117.6	270 202.0	1.4	136.2	227.2	9 225.5
2014	5 609.2	8 613.9	29 034.0	2 106.3	2.7	122.1	298 029.7	1.4	131.5	211.9	10 344.9

A detailed table on cattle population in our country is given in Table 5.6. Livestock production can result in CH_4 emissions from enteric fermentation and both CH_4 and N_2O emissions from livestock manure management systems. Cattle as a livestock category is a significant source of CH_4 in our country because of their large population and high CH_4 emission rate due to their ruminant digestive system.

The numbers of cattle population with its subcategories are given in Table 5.6. In Turkey there are three dairy cattle types categorized as culture cattle, hybrid cattle and domestic cattle. Culture dairy cattle is a dairy cattle type having higher milk yields compared to domestic dairy cattle whereas milk yields of hybrid cattles are between them. Hybrid cattles are breeds of culture and domestic dairy cattles. As it is seen in the table, culture cattle population is increasing by years except for the years 1997, 2002 and 2004. But in general it has a positive trend for the period 1990-2014. For hybrid cattle population there is not a big increase or decrease in the 1990-2014 series. It was around 2.4 million in 2014 while it was 1.9 million in 1990. The share of domestic cattle among dairy cattle was 58.1% in 1990 and this ratio reduced to 13.4% in 2014. The number of non-dairy cattle increased by 3.1 million from around 5.5 million in 1990 to 8.6 million in 2014 and its share among total cattle increased from 48.2% to 60.6% between 1990 and 2014. Furthermore, Figure 5.1 shows three types of dairy cattle's as well as non-dairy cattle's population numbers for the period 1990-2014 in a straightforward chart.

Figure 5.1 Population numbers for Turkey's cattle categories, 1990-2014

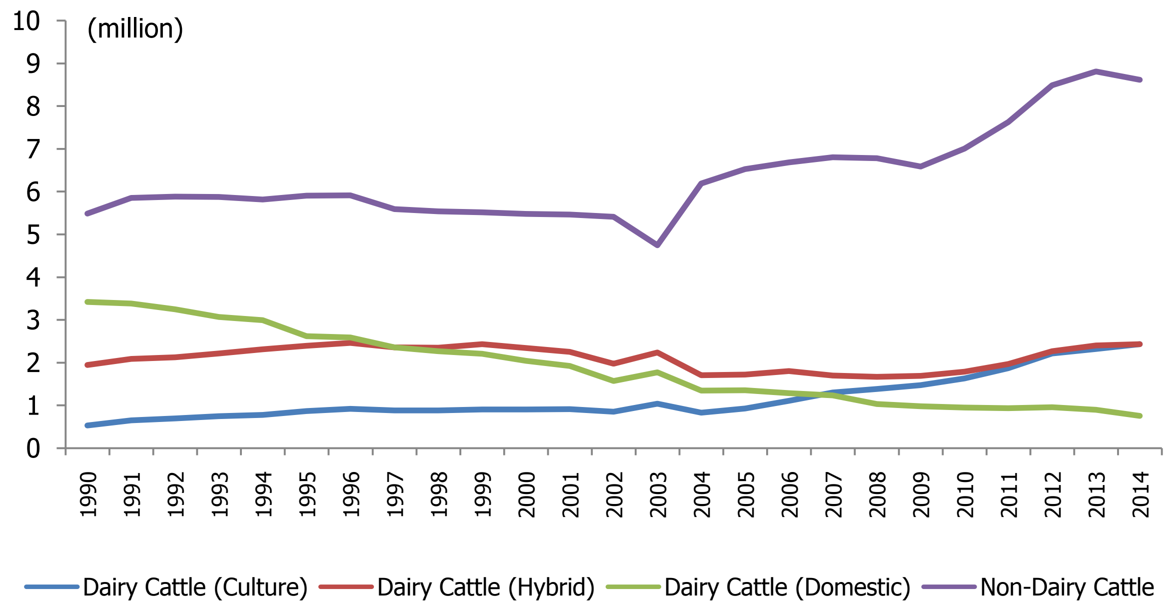


Table 5.6 Subcategories of cattle population in Turkey, 1990-2014

	Dairy cattle								Non-dairy cattle		Cattle
	Culture		Hybrid		Domestic		Total		Total		Total
Year	(population)	(%)	(population)	(%)	(population)	(%)	(population)	(%)	(population)	(%)	(population)
1990	530 330	4.7	1 941 170	17.1	3 421 050	30.1	5 892 550	51.8	5 484 507	48.2	11 377 057
1991	650 739	5.4	2 087 014	17.4	3 381 244	28.2	6 118 997	51.1	5 853 926	48.9	11 972 923
1992	698 223	5.8	2 124 103	17.8	3 247 849	27.2	6 070 175	50.8	5 880 732	49.2	11 950 907
1993	750 254	6.3	2 214 725	18.6	3 066 975	25.8	6 031 954	50.6	5 878 046	49.4	11 910 000
1994	779 690	6.6	2 308 308	19.4	2 994 180	25.2	6 082 178	51.1	5 818 822	48.9	11 901 000
1995	870 248	7.4	2 392 621	20.3	2 622 717	22.2	5 885 585	49.9	5 903 415	50.1	11 789 000
1996	920 185	7.7	2 457 923	20.7	2 590 102	21.8	5 968 210	50.2	5 917 790	49.8	11 886 000
1997	879 779	7.9	2 355 541	21.1	2 358 974	21.1	5 594 293	50.0	5 590 707	50.0	11 185 000
1998	879 841	8.0	2 346 093	21.3	2 263 109	20.5	5 489 042	49.8	5 541 958	50.2	11 031 000
1999	903 499	8.2	2 424 629	21.9	2 209 764	20.0	5 537 892	50.1	5 516 108	49.9	11 054 000
2000	904 849	8.4	2 335 119	21.7	2 039 601	19.0	5 279 569	49.1	5 481 431	50.9	10 761 000
2001	912 411	8.7	2 248 877	21.3	1 924 526	18.2	5 085 814	48.2	5 462 186	51.8	10 548 000
2002	850 725	8.7	1 971 740	20.1	1 570 103	16.0	4 392 568	44.8	5 410 930	55.2	9 803 498
2003	1 034 817	10.6	2 236 680	22.9	1 768 865	18.1	5 040 362	51.5	4 747 740	48.5	9 788 102
2004	832 711	8.3	1 699 804	16.9	1 343 206	13.3	3 875 722	38.5	6 193 624	61.5	10 069 346
2005	925 618	8.8	1 717 309	16.3	1 355 170	12.9	3 998 097	38.0	6 528 343	62.0	10 526 440
2006	1 106 679	10.2	1 799 409	16.6	1 281 843	11.8	4 187 932	38.5	6 683 432	61.5	10 871 364
2007	1 299 750	11.8	1 698 801	15.4	1 230 889	11.2	4 229 440	38.3	6 807 313	61.7	11 036 753
2008	1 385 730	12.8	1 665 189	15.3	1 029 324	9.5	4 080 242	37.6	6 779 700	62.4	10 859 942
2009	1 470 886	13.7	1 686 064	15.7	976 198	9.1	4 133 148	38.5	6 590 810	61.5	10 723 958
2010	1 626 412	14.3	1 787 012	15.7	948 417	8.3	4 361 840	38.4	7 007 960	61.6	11 369 800
2011	1 868 274	15.1	1 962 713	15.8	930 155	7.5	4 761 142	38.4	7 625 195	61.6	12 386 337
2012	2 211 242	15.9	2 263 400	16.3	956 758	6.9	5 431 400	39.0	8 483 512	61.0	13 914 912
2013	2 314 282	16.1	2 395 898	16.6	897 098	6.2	5 607 278	38.9	8 807 979	61.1	14 415 257
2014	2 427 915	17.1	2 428 709	17.1	752 625	5.3	5 609 249	39.4	8 613 860	60.6	14 223 109

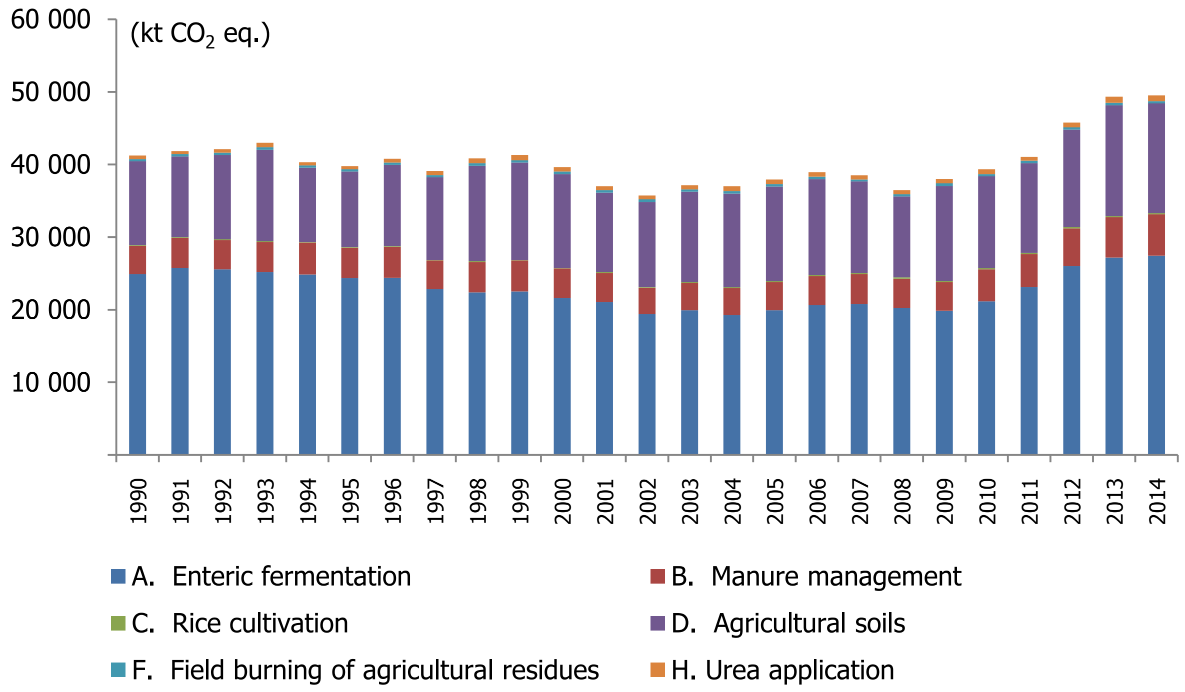
Table 5.7 A Detailed perspective on the agriculture sector, 1990-2014

(kt CO_2 eq.)

	A.Enteric fermentation	B.Manure management			C.Rice cultiva-tion	D.Agricultural soils			F.Field burning of agricultural residues			H.Urea applica-tion	Agri-culture
Year	CH_4	CH_4	N_2O	Total	CH_4	Direct N_2O	Indirect N_2O	Total	CH_4	N_2O	Total	CO_2	Total
1990	24 888	2 352	1 585	3 937	91	8 779	2 745	11 524	250	77	327	460	41 227
1991	25 762	2 440	1 719	4 159	70	8 464	2 642	11 107	257	79	336	436	41 871
1992	25 546	2 330	1 734	4 064	74	8 866	2 782	11 648	243	75	318	459	42 110
1993	25 182	2 420	1 756	4 177	77	9 585	3 006	12 591	262	81	343	627	42 997
1994	24 855	2 658	1 751	4 409	70	7 772	2 442	10 214	228	71	299	453	40 299
1995	24 366	2 526	1 676	4 202	86	7 912	2 476	10 388	234	72	306	426	39 773
1996	24 412	2 554	1 705	4 260	95	8 524	2 664	11 188	241	75	316	534	40 804
1997	22 818	2 307	1 641	3 948	95	8 684	2 704	11 388	244	75	319	532	39 100
1998	22 396	2 478	1 705	4 183	103	10 015	3 119	13 134	268	83	351	658	40 825
1999	22 514	2 554	1 697	4 251	112	10 174	3 206	13 379	237	73	310	733	41 300
2000	21 647	2 334	1 694	4 028	100	9 835	3 080	12 914	262	81	343	617	39 650
2001	21 042	2 414	1 625	4 039	102	8 342	2 614	10 956	243	75	318	527	36 983
2002	19 378	2 017	1 624	3 641	103	8 930	2 801	11 731	251	78	328	527	35 709
2003	19 901	2 230	1 563	3 793	112	9 459	2 981	12 440	248	77	325	565	37 137
2004	19 254	1 871	1 827	3 698	121	9 832	3 094	12 927	271	84	355	632	36 986
2005	19 911	1 959	1 922	3 881	147	9 911	3 102	13 013	283	88	371	613	37 936
2006	20 597	2 051	2 000	4 050	171	10 025	3 152	13 177	267	82	349	592	38 937
2007	20 804	2 183	1 922	4 104	162	9 548	3 025	12 574	230	71	301	566	38 511
2008	20 280	2 108	1 873	3 981	172	8 490	2 672	11 162	228	71	299	565	36 458
2009	19 854	2 138	1 815	3 953	167	9 965	3 126	13 092	260	80	340	593	37 998
2010	21 159	2 471	1 930	4 401	171	9 605	3 017	12 622	253	78	331	645	39 329
2011	23 149	2 452	2 084	4 537	171	9 366	2 942	12 308	271	84	354	558	41 078
2012	26 051	2 837	2 317	5 155	206	10 174	3 211	13 385	254	79	333	640	45 770
2013	27 196	3 117	2 423	5 540	191	11 604	3 614	15 218	281	87	368	807	49 320
2014	27 434	3 178	2 513	5 692	191	11 545	3 545	15 090	250	77	327	788	49 522

GHG emissions from livestock are released as CH_4 in enteric fermentation and as CH_4 and N_2O in manure management. Rice cultivation leads to CH_4 emissions, agricultural soils to N_2O emissions, field burning of crop residues to CH_4 and N_2O emissions. Urea application is the only single category reported under the agriculture sector in Turkey directly resulting in CO_2 emissions. A figure showing cumulative emission distribution for all twenty-five reporting years is prepared with the objective of presenting a clear overview regarding overall trends in the agriculture sector.

Figure 5.2 Cumulative emissions of agricultural categories, 1990-2014



Methane

Emissions from enteric fermentation, manure management, rice cultivation and field burning of agricultural residues include CH_4. The agriculture sector in our country produced 1 242.14 kt CH_4 (31.1 Mt CO_2 eq.) emissions or 62.7% of agricultural emissions, 54.3% of Turkey's CH_4 emissions and 6.6% of Turkey's total emissions in 2014. CH_4 emissions had increased by 3 473 kt CO_2 eq. (12.59%) from its 1990 level of 27 581 kt CO_2 eq. to 31 054 kt CO_2 eq. This increase is mainly a result of increases of CH_4 emissions in enteric fermentation of 2 547 kt CO_2 eq., in manure management of 826 kt CO_2 eq., and rice cultivation of 100 kt CO_2 eq. This total increase of 3 473 kt CO_2 eq. is closely responsible for the 41.9% total increase (8 295 kt CO_2 eq.) in emissions from the agricultural sector between 1990 and 2014.

Enteric fermentation is the single dominant category leading to 90.2% and 88.3% of all CH_4 emissions of agriculture sector for the years 1990 and 2014 respectively. Enteric fermentation was followed by manure management with 8.5% and 10.2%, field burning of agricultural residues with 0.9% and 0.8% and rice cultivation with 0.3% and 0.6% for 1990 and 2014 respectively.

Nitrous Oxide

Nitrous oxide is a GHG which contributes to global warming and climate change. N_2O emissions accounted for 5% of Turkey's GHG emissions in 2014. Emissions from manure management, agricultural soils, and field burning of agricultural residues include N_2O gas. Agriculture produced 59.33 kt N_2O emissions (17.7 Mt CO_2 eq.) or 35.7% of agricultural emissions, 75.9% of Turkey's N_2O emissions and 3.8% of Turkey's total emissions in 2014. N_2O emissions have increased by 4 495 kt CO_2 eq. (34.1%) from the 1990 level of 13 186 kt CO_2 eq. to 17 681 kt CO_2 eq.

Agricultural soils is the dominant source of N_2O emissions, responsible for 87.4% and 85.3% of total agricultural N_2O emissions for the years 1990 and 2014 respectively. Agricultural soils were followed by manure management with 12.0% and 14.2%, respectively, and field burning of agricultural residues with 0.6% and 0.4%, respectively.

Whereas a percentage as high as 79.3% of this enhancement is a result of increases of N_2O emissions in agricultural soils by 3 566 kt CO_2 eq. (30.9%), manure management is almost responsible for the remaining increase of 20.7% with 929 kt CO_2 eq. (58.6%) in N_2O emissions. N_2O emissions of field burning of agricultural residues shows a tiny decrease - 0.08% (0.06 kt CO_2 eq.) between 1990 and 2014. The net increase of 4 495 kt CO_2 eq. added up to 54.2% of the overall increase of 8 295 kt CO_2 eq. emissions in the agriculture sector between 1990 and 2014.

5.2. Enteric Fermentation (Category 3.A)

Source Category Description:

Enteric fermentation is a digestive process whereby carbohydrates are broken down by micro-organisms into simple molecules. The main product is CH_4 gas. All type of animals produce CH_4 during and/or after feed intake. The largest source of CH_4 emissions in the agricultural sector in Turkey is coming from enteric fermentation. Enteric fermentation was the biggest source of total carbon equivalent emissions in the agriculture sector with 60.4% (24.9 Mt CO_2 eq.) in 1990 and with 55.4% (27.4 Mt CO_2 eq.) in 2014.

In 2014, enteric fermentation contributed 27 434 kt CO_2 eq., responsible for more than half of agricultural emissions as stated above and 5.9% of Turkey's total CO_2 eq. emissions. Dairy and non-dairy cattle contributed 21 888 kt CO_2 eq. (79.8%) of emissions from the enteric fermentation category and sheep (domestic and merinos) contributed 3 972 kt CO_2 eq. (14.5%) of emissions from this category. The increased emissions from the enteric fermentation category in 2014 resulted in a value of 2 547 kt CO_2 eq. (10.2%) compared to 1990 levels (24 888 kt CO_2 eq.).

CH_4 emissions from enteric fermentation, which are presented by main livestock category sources in Table 5.8, fluctuate over the time series (also shown in Table 5.7). This source category is a key category in terms of CH_4 emissions. Enteric fermentation emissions declined by 22.1% (5.5 Mt CO_2 eq.) between 1990 and 2002. The decline in emissions in the early 1990s was principally driven by a fall in cattle and sheep numbers, however by late 2002 the emissions had begun to increase as the numbers of cattle began to rise, reflecting changing relative returns to each industry. Due to governmental support, the number of animals, except for horses and mules and asses has been increasing since 2009, thereby resulting in increasing CH_4 emissions for these subcategories in recent years. Between 2002 and 2014, emissions from enteric fermentation increased by 41.6% (8.1 Mt CO_2 eq.).

There have been changes in the relative sources of emissions within enteric fermentation (Table 5.8) since 1990. The largest increase came from emissions from non-dairy cattle due to increase in its population numbers. In 2014 non-dairy cattle were responsible for 10 121 kt CO_2 eq., increased by 3 677 kt CO_2 eq. (57.1%) from the 1990 level of 6 444 kt CO_2 eq. Despite the decrease of 4.8% in dairy cattle population for the period 1990-2014, this subcategory is responsible for 11 767 kt CO_2 eq. in 2014, still an increase of 830 kt CO_2 eq. (7.6%) above its 1990 level of 10 937 CO_2 eq. A closer look at the changes of the composition structure of dairy cattle - culture, hybrid, and domestic cattle - for the same period revealed a reasonable explanation. The EFs used for culture cattle, hybrid cattle, and domestic cattle were 92.5, 80.3, and 68.0 kg CH_4/head/year respectively. The dairy cattle population was 5.9 million in total for 1990 consisted of culture cattle (0.53 million), hybrid cattle (1.94 million), and domestic cattle (3.42 million). The respective figures for the year 2014 were 5.6 million in total for dairy cattle consisting of culture cattle (2.43 million), hybrid cattle (2.43 million), and domestic cattle (0.75 million). The share of dairy cattle types with higher EFs had increased significantly in numbers while domestic cattle, having the lowest EF among dairy cattle types, experienced a reduction both in absolute and relative terms as can be seen in Table 5.6. Moreover decreases in emissions are also a result from the reduction of population numbers of other animal types - domestic sheep, buffalo, camels, goats, horses, swine, and mules and asses - in the period 1990-2014 as given in Table 5.5.

Table 5.8 CH_4 emissions of enteric fermentation in livestock categories, 1990 - 2014

Year	Dairy cattle (kt CO_2 eq.)	Dairy cattle (%)	Non-dairy cattle (kt CO_2 eq.)	Non-dairy cattle (%)	Domestic sheep (kt CO_2 eq.)	Domestic sheep (%)	Merinos sheep (kt CO_2 eq.)	Buffalo (kt CO_2 eq.)	Horses (kt CO_2 eq.)	Goats (kt CO_2 eq.)	Swine, camels, mules& assses (kt CO_2 eq.)	Total (kt CO_2 eq.)
1990	10 937	43.9	6 444	25.9	4 964	19.9	137	510	231	1 366	299	24 888
1991	11 440	44.4	6 878	26.7	4 949	19.2	137	503	223	1 346	286	25 762
1992	11 397	44.6	6 910	27.0	4 822	18.9	137	485	217	1 307	271	25 546
1993	11 392	45.2	6 907	27.4	4 589	18.2	135	435	203	1 267	256	25 182
1994	11 524	46.4	6 837	27.5	4 329	17.4	133	419	192	1 181	240	24 855
1995	11 271	46.3	6 937	28.5	4 123	16.9	131	351	187	1 139	227	24 366
1996	11 462	47.0	6 953	28.5	4 029	16.5	136	323	176	1 119	213	24 412
1997	10 771	47.2	6 569	28.8	3 672	16.1	140	267	155	1 047	197	22 818
1998	10 589	47.3	6 512	29.1	3 570	15.9	142	242	149	1 007	186	22 396
1999	10 710	47.6	6 481	28.8	3 678	16.3	135	227	139	972	172	22 514
2000	10 245	47.3	6 441	29.8	3 465	16.0	126	201	122	900	148	21 647
2001	9 893	47.0	6 418	30.5	3 277	15.6	123	190	122	878	141	21 042
2002	8 592	44.3	6 358	32.8	3 059	15.8	114	166	112	848	129	19 378
2003	9 887	49.7	5 579	28.0	3 086	15.5	121	156	102	846	123	19 901
2004	7 619	39.6	7 278	37.8	3 055	15.9	124	143	96	826	114	19 254
2005	7 890	39.6	7 671	38.5	3 069	15.4	122	144	94	815	107	19 911
2006	8 348	40.5	7 853	38.1	3 100	15.1	133	138	92	830	102	20 597
2007	8 506	40.9	7 999	38.4	3 061	14.7	158	116	85	786	92	20 804
2008	8 295	40.9	7 966	39.3	2 869	14.1	166	119	81	699	85	20 280
2009	8 444	42.5	7 744	39.0	2 590	13.0	167	120	75	641	73	19 854
2010	8 959	42.3	8 234	38.9	2 750	13.0	177	116	70	787	66	21 159
2011	9 839	42.5	8 960	38.7	2 976	12.9	198	134	68	910	63	23 149
2012	11 281	43.3	9 968	38.3	3 237	12.4	249	148	64	1 045	61	26 051
2013	11 684	43.0	10 349	38.1	3 436	12.6	292	162	61	1 153	58	27 196
2014	11 767	42.9	10 121	36.9	3 629	13.2	342	168	59	1 293	55	27 434

Methodological Issues:

Turkey applies a T1 method to estimate CH_4 emissions from enteric fermentation for all animal populations. Although IPCC (2006) calls for the more detailed T2 method to be used in cases in which a country has listed CH_4 emissions from animal husbandry as a key source for its inventories, the detailed data required by the T2 approach cannot be obtained. The CS EF estimation by experts is almost the same as IPCC T1 factors.

The annual population for each livestock category is included in Tables 5.5 and 5.6 above. The AD (the population of animals) provider is TurkStat livestock statistics. TurkStat collects livestock data as explained in the Sector Overview.

The CH_4 EFs are default IPCC T1 factors. In Turkey there are three dairy cattle types categorized as culture cattle, hybrid cattle and domestic cattle. The average milk production of culture cattle is around of 3 866 kg head^{-1} yr^{-1}. The EF for culture cattle is taken as the average of EFs of Western Europe and Asia with respect to milk yield of these cattle and the average of milk production of Western Europe (6 000 kg head^{-1} yr^{-1}) and Asia (1 650 kg head^{-1} yr^{-1}) is 3 825. In a similar manner, domestic cattle's EF is taken as Asia EF and hybrid cattle's EF is taken as the average of culture and domestic cattle EF. The average milk production of domestic cattle is 1 312 kg head^{-1} yr^{-1} and this value is closer to the Asia average milk production value of 1 650 kg head^{-1} yr^{-1}. The average milk production of Hybrid cattle is 2 726 kg head^{-1} yr^{-1} and this value is close to the average of 3 825 and 1 650 kg head^{-1} yr^{-1} which is 2 737. Furthermore domestic dairy cattle have almost similar properties with Asian cattle like milk yield.

Another animal type sheep is categorized as merinos and domestic sheep for similar reasons regarding dairy cattle. For domestic sheep IPCC default EF for developing countries (5.0 kg CH_4 head^{-1} year^{-1}) is used. The merinos are also a kind of domestic sheep breaded for its plumage. The weight is more compared to domestic sheep and their feeding rate is more than domestic ones. For that reason its EF is chosen as a higher value compared to domestic sheep. The EF of merinos sheep is taken as an average value (6.5 kg CH_4 head^{-1} year^{-1}) from the IPCC default EF for developing countries (5.0 kg CH_4 head^{-1} year^{-1}) and developed countries (8.0 kg CH_4/head/year).

Uncertainties and Time-Series Consistency:

The AD for this sector are gathered from agricultural statistics of TurkStat. Uncertainties in the EF and activity data are determined by TurkStat experts. CH_4 emissions are calculated and then it is converted to the CO_2 eq. by multiplying it with the global warming potential. Uncertainty values of AD is considered 14.1% and EFs estimated using the T1 method are unlikely to be known more accurately than +30% and may be uncertain to +50% as recommended in 2006 IPCC Guidelines.

Source category	Gas	Comments on time series consistency
3.A	CH_4	All EFs are constant over the entire time series.

Source-Specific QA/QC and Verification:

The IPCC 2006 Guidelines are used for the QA/QC procedures of the National GHG emission inventory. A National Inventory System QA/QC Plan prepared by TurkStat is also a significant tool for implementing QA/QC principles for the Inventory. AD for this source category is gathered mainly from the Agricultural Statistics Department of TurkStat. The respective AD used for calculations are published also as official statistics by TurkStat which have their own QA/QC procedures. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculations are re-examined. A detailed overview on QC procedures with respect to each principle of GHG inventory is presented in Table 1.2.

Recalculation:

There is no recalculation.

Planned Improvement:

All data and methodologies are kept under review. It is planned to estimate emissions regarding significant livestock categories (i.e. cattle and sheep) using the T2 method with respect to the 2006 IPCC Guidelines. Turkey is currently evaluating the application of T2 levels. Collaboration with the MFAL is ongoing in particular on the availability of detailed data on the disagregration of animals by characteristics like age, type etc. Additionally, information on milk production regarding dairy cattle types is searched for.

5.3. Manure Management (Category 3.B)

Source Category Description:

In Turkey, manure management systems (MMS) typically used in animal production include solid storage and dry lot, daily spread, and pasture and paddock. To a lesser extent MMS also include other systems such as composting, bio-digesters, poultry manure and deep bedding.

This source category contains two types of emissions, CH_4 and N_2O. For the former, the source category is a key category according to both level and trend analysis, while for the latter it is only a key category with respect to level analysis.

In 2014, emissions including CH_4 and N_2O from the manure management category reached 5 692 kt CO_2 eq. This number represented 11.5% of emissions of the agriculture sector. Emissions in 2014 from this source category increased by 1 755 kt CO_2 eq., nearly 44.6% above its 1990 level of 3 937 kt CO_2 eq. Similarly, the increase is calculated as 826 kt CO_2 eq. for CH_4 emissions and 929 kt CO_2 eq. for N_2O emissions and increasing percentages are 35.1% and 58.6% respectively for the same period, 1990-2014.

Methane Generation

Livestock manure is primarily composed of organic material and water. Anaerobic and facultative bacteria decompose the organic material under anaerobic conditions. Several biological and chemical factors influence methane generation from manure. The amount of CH_4 produced during decomposition is influenced by the climate and the manner in which the manure is managed. The management system determines key factors that affect CH_4 production including contact with oxygen, water content, pH, and nutrient availability. Climate factors include temperature and rainfall. Optimal conditions for CH_4 production include an anaerobic, water-based environment, a high level of nutrients for bacterial growth, a neutral pH (close to 7.0), warm temperatures, and a moist climate.

CH_4 emissions contributed 3 178 kt CO_2 eq. (55.8% of the manure management category) which represented 6.4% of agricultural emissions (Table 5.7) in 2014 whereas the respective share in 1990 was 5.7%, less than one per cent below the current reporting value.

With respect to all CH_4 emissions of the agriculture sector, the second highest CH_4 emission source category was manure management for all reporting years with percentage values of 8.5% and 10.2% for 1990 and 2014 respectively.

Nitrous Oxide Generation

Production of N_2O reported in the manure management category occurs during storage and treatment of manure before it is applied to land.

N_2O emissions contributed 2 513 kt CO_2 eq. (44.2% of the manure management category) which represented 5.1% of agricultural emissions in 2014 (Table 5.7) whereas the respective share in 1990 was 3.8%, less than the current reporting percentage of 2014.

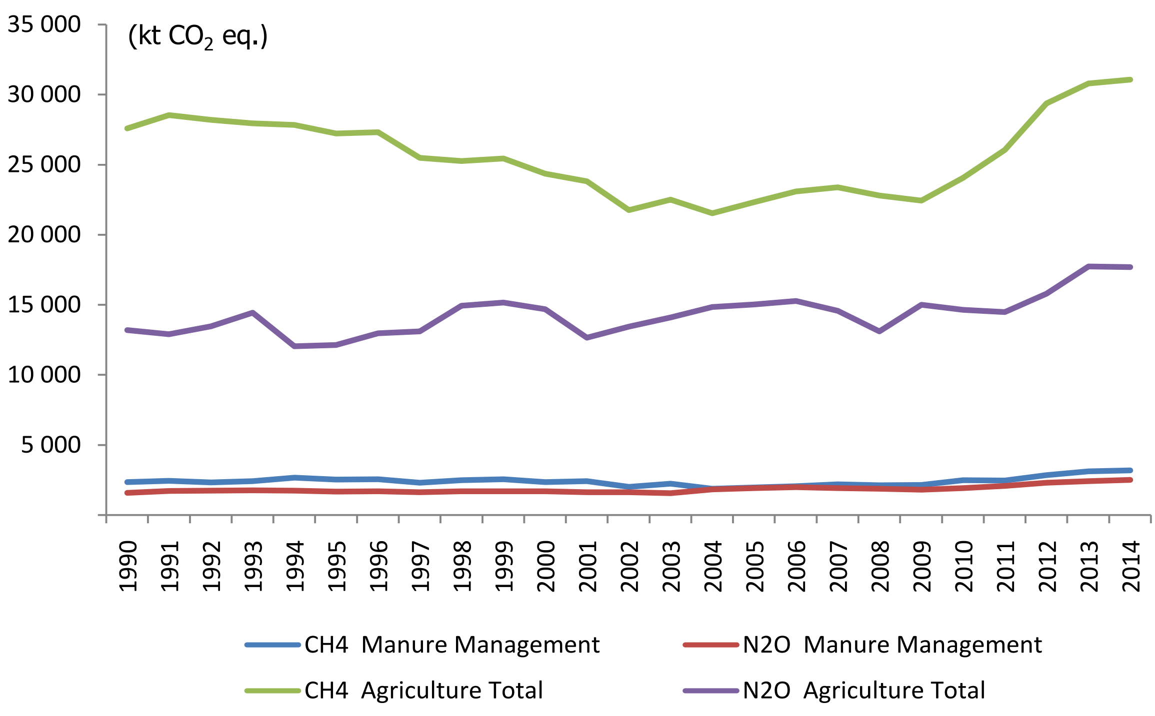
With respect to all N_2O emissions of the agriculture sector, the second highest N_2O emission source category was manure management for all reporting years. N_2O emissions of manure management accounted for 12.0% and 14.2% of all N_2O emissions in the agriculture sector in 1990 and 2014 respectively.

Direct N_2O emissions from MMS can occur via combined nitrification (under aerobic conditions) and denitrification (an anaerobic process) of nitrogen contained in the manure. The emission of N_2O from manure during storage and treatment depends on the nitrogen and carbon content of manure, on the duration of the storage and type of treatment.

Indirect N_2O emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and NO_x. Indirect emissions occur from the deposition of volatilized nitrogen from manure management systems and via runoff and leaching of nitrogen into soils.

The following figure on CH_4 and N_2O emissions of manure management and the agriculture sector gives a view on trend developments. As indicated above, CH_4 and N_2O from manure management are only a fraction of total CH_4 and N_2O emissions from the agriculture sector (10.2% and 14.2%, respectively) and therefore are not a key driver in the overall trends in the agriculture sector. However, the trends for these gases generally mirror the overall trend. CH_4 emissions from manure management were fairly stable between 1990 and 2005 before steadily increasing until 2009. Between 2009 and 2014 CH_4 emissions increased by 48.6% from 2 138 kt CO_2 eq. to 3 178 kt CO_2 eq. Similarly, N_2O emissions were fairly stable before increasing by 16.9% between 2003 (1 563 kt CO_2 eq.) and 2004 (1 827 kt CO_2 eq.) and then again between 2011 (2 084 kt CO_2 eq.) and 2012 (2 317 kt CO_2 eq.).

Figure 5.3 Comparing CH_4 and N_2O emission trends, 1990-2014



Methodological Issues:

Turkey applies a T1 method to estimate methane and nitrous oxide emissions from manure management for all livestock types. The T1 methodology was updated to reflect the reporting requirements for national inventories in the IPCC (2006) guidelines, in line with the UNFCCC Conference of the Parties decision (24/CP.19). CH_4 emissions from manure management are a key category according to both level and trend assessment.

The annual population for each livestock category is included in Tables 5.5 and 5.6 above. The AD (the population of animals) provider is TurkStat livestock statistics for the entire time series 1990-2014. TurkStat collects livestock data as explained in the Sector Overview. In addition, our country uses the national animal population numbers and allocates the population for each animal subcategory into cool, temperate and warm climate regions in the following manner. First, the animal population numbers are listed according to their respective provinces in our country. Second, all provinces are allocated to one of the three mentioned climate regions concerning their yearly average temperature values. Finally, all population numbers of each animal subcategory are added up before calculating the weighted average with respect to the total animal subcategory population numbers.

In order to select appropriate EFs, animal population data collected from TurkStat databases is categorized according to their provinces with respective annual temperature figures. CH_4 and N_2O emissions factors are default IPCC 2006 T1 factors.

The annual average temperatures of the provinces are taken into account in order to select the EFs for manure management. All temperature data are taken directly from the General Directorate of Meteorology (http://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik.aspx?k=A). Table 5.9 shows default EFs for cattle types and swine for each region according to temperature classification. Considering annual average air temperature, provinces are categorized between cool (0^oC - 14^oC) or temperate (15^oC - 25^oC) climate region. Similar to the methods applied in enteric fermentation, the IPCC default emission factors selected for cattle were based on the IPCC default factors for Western Europe and Asia (see Table 10.14 of the 2006 IPCC Guidelines). The EF for domestic cattle and non-dairy cattle were assumed to equal that of similar cattle in Asia because their milk yield values were similar. The EF for culture cattle was estimated as the average of the emission factors for dairy cattle from Western Europe and Asia, for the same temperature zone (e.g., at <10^o C Turkey estimates that culture cattle have an EF of 15 kg CH4/head/year, which is the average of 21 kg CH4/head/year and 9 kg CH4/head/year from Western Europe and Asia, respectively). The EF for hybrid cattle is the average of domestic and culture cattle.

For swine, the EFs for Asia from the 2006 IPCC Guidelines (Table 10.14 of volume 4, chapter 10) were selected because the body weights are similar.

The EFs for sheep and other livestock are also broken into two climate regions and shown in Table 5.10. Turkey has not a single province with an annual average temperature above 25°C, therefore the warm climate region is not present.

Table 5.9 Manure management CH_4 emission factors for cattle and swine

(kg CH_4/head/year)

	Cool EF (< 15)					Temperate EF (15-25)										
(°C)	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1.Cattle																
Dairy Cattle (Culture)	15.0	16.5	17.5	19.5	20.5	23.5	25.5	27.5	29.5	32.0	34.5	37.5	40.0	43.5	47.0	50.5
Dairy Cattle (Hybrid)	12.0	13.3	13.8	15.0	16.3	18.3	19.8	21.3	22.8	24.5	26.3	28.8	30.5	33.3	35.5	38.3
Dairy Cattle (Domestic)	9	10	10	11	12	13	14	15	16	17	18	20	21	23	24	26
Non-Dairy Cattle	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3.Swine	2.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	4.0	4.0	4.0	5.0	5.0	5.0	6.0

Table 5.10 Manure management CH_4 emission factors for sheep and other livestock

(kg CH_4/head/year)

(°C)	Cool EF (< 15)	Temperate EF (15-25)
2. Sheep		
Sheep (Domestic)	0.100	0.150
Sheep (Merinos)	0.145	0.215
4. Other livestock		
Buffalo	1.00	2.00
Camels	1.28	1.92
Goats	0.11	0.17
Horses	1.09	1.64
Mules and asses	0.60	0.90
Poultry	0.01	0.02

Uncertainties and Time-Series Consistency:

The AD for this sector are gathered from agricultural statistics of TurkStat. Uncertainties in the EF and production data are determined by TurkStat experts. The CH_4 and N_2O emissions are calculated and then they are converted to the CO_2 eq. by multiplying the values with the respective global warming potentials.

The approach to produce quantitative uncertainty estimates was used as described in the 2006 IPCC Guideline for determining uncertainties of that category in total emissions.

Uncertainty values of AD are considered 14.1%. The uncertainty range for the default factors is estimated to be +30% for the CH_4 as recommended in the 2006 IPCC Guideline.

Furthermore uncertainty ranges for default Nitrogen (N) excretion rates are estimated at about ±50%. There are large uncertainties associated with the default EFs for this category – direct N_2O emissions (–50% to +100%) and uncertainty ranges for default N losses due to volatilization of NH_3 and NO_x and total N losses from manure management systems are presented in the Tables 10.22 and 10.23 in the 2006 IPCC Guideline Volume 4, respectively. The uncertainty associated with the default EF for nitrogen volatilization and re-deposition (EF_4) is given in Table 11.3 of Chapter 11 as recommended in the same Guideline.

Source category	Gas	Comments on time series consistency
3.B	CH_4, N_2O	All EFs are constant over the entire time.

Source-Specific QA/QC and Verification:

The 2006 IPCC Guidelines were used for the QA/QC procedures of National GHG emission inventory. A National Inventory System QA/QC Plan prepared by TurkStat is also a significant tool for implementing QA/QC principles for the Inventory. AD for this source category is gathered mainly from the Agricultural Statistics Department of TurkStat. The respective AD used for calculations are published also as official statistics by TurkStat which have their own QA/QC procedures. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined. A detailed overview on QC procedures with respect to each principle of GHG inventory is presented in Table 1.2.

Recalculation:

As a result of QA/QC activities in this category a series of recalculations are done mainly because of transaction errors. CH_4 and N_2O emissions from manure management have been recalculated for the years 1990-2012. The current reported calculations reflect the up-to-date emission values for all twenty-five reporting years starting from 1990.

Planned Improvement:

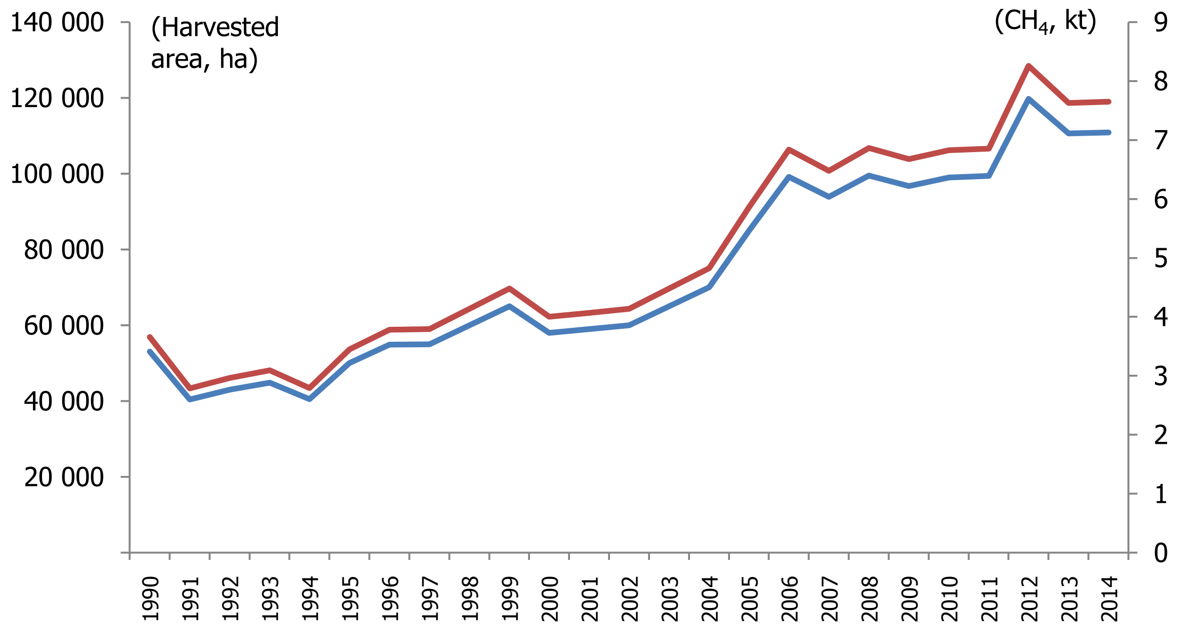
All data and methodologies are kept under review and an upgrade from T1 to T2 might be considered in the future. The update of the distribution of MMS for all relevant animal types in our country is also considered in the first place and results from the upgrading efforts of tier level in enteric frementation will be considered for this category. Efforts to collect detailed information on manure management systems in Turkey will be undertaken. Contacts with the MoEU have also been established in order to evaluate the methodology to estimate NH_3 emissions from housing and storing system to calculate indirect emissions.

5.4. Rice Cultivation (Category 3.C)

Source Category Description:

Anaerobic decomposition of organic material in flooded rice fields produces CH_4, which escapes to the atmosphere primarily by transport through the rice plants. The annual amount of CH_4 emitted from a given area of rice is a function of the number and duration of crops grown, water regimes before and during cultivation period, and organic and inorganic soil amendments. Soil type, temperature, and rice cultivar also affect CH_4 emissions. All emission values between 1990 and 2014 occurring as a result of rice cultivation are given in Table 5.7. CH_4 emissions from rice cultivation is not a key category. Figure 5.4 presents annual harvested area in hectare (line shown in dark red - left axis) and CH_4 emissions emitted in kt (line shown in blue - right axis) for rice cultivation covering the period 1990-2014.

Figure 5.4 Harvested area and emitted CH_4 for rice cultivation, 1990-2014



Rice cultivation contributed 7.65 kt CH_4 (191.1 kt CO_2 eq.) emissions or 0.39% of total agricultural emissions in 2014. Emissions are almost similar for the years 2013 and 2014 having increased less than 1 kt. Between 1990 and 2014, emissions from rice cultivation increased by 99.8 kt CO_2 eq. (109.2%).

Rice cultivation is the lowest contributor to CH_4 emissions in the agriculture sector for each of the reported twenty-five years, ranging from 0.24% (1991) to 0.75% (2008) respectively. The respective percentage value for 2014 is calculated as 0.62%.

Methodological Issues:

CH_4 emissions are calculated by using the IPCC T1 approach. The rice harvested area data are taken from agricultural statistics of TurkStat. An irrigated rice cultivation (intermittently flooded- single aeration) method is practiced in our country. The CH_4 EFs are default IPCC T1 factors. The IPCC default baseline EF of 1.3 kg CH_4/ha/day is applied. Over an average 130 day growing season this gives an emission rate of 69 kg CH_4/ha for Turkey.

Uncertainties and Time-Series Consistency:

The AD for this sector are gathered from agricultural statistics of TurkStat. Uncertainties in the EF and production data were determined by TurkStat experts. CH_4 emissions are calculated and then it is converted to the CO_2 eq. by multiplying it with the global warming potential.

The uncertainty value is considered to be 7.07% for AD and 55% for EF, the latter value being within the range for the CH_4 as recommended in 2006 IPCC Guidelines.

Time series consistency of emission factor for (3.C)

Source category	Gas	Comments on time series consistency
3.C	CH_4	All EFs are constant over the entire time series

Source-Specific QA/QC and Verification:

The 2006 IPCC Guidelines were used for the QA/QC procedures of National GHG emission inventory. A National Inventory System QA/QC Plan prepared by TurkStat is also a significant tool for implementing QA/QC principles for the Inventory. AD for this source category is gathered mainly from the Agricultural Statistics Department of TurkStat. The respective AD used for calculations are published also as official statistics by TurkStat which have their own QA/QC procedures. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined. A detailed overview on QC procedures with respect to each principle of GHG inventory is presented in Table 1.2.

Recalculation:

There is no recalculation.

Planned Improvement:

All data and methodologies are kept under review and there are no further planned improvements in this source.

5.5. Agricultural Soils (Category 3.D)

Source Category Description:

This source contains N_2O emissions from synthetic fertilizers, organic fertilizers (deposited manure and sewage sludge) and crop residue. This source category is a key category. In this section the N_2O emissions from pasture, range and paddock manure (3.D.a.3) and indirect emission (3.D.b), which consists of atmospheric deposition (3.D.b.1) and nitrogen leaching and run-off (3.D.b.2), are also calculated. The complete time series regarding emissions are submitted in this submission.

Agriculture soils produced 50.6 kt N_2O (15.1 Mt CO_2 eq.) emissions in 2014 and agriculture soils is the largest source category of N_2O emissions in Turkey. This represented 85.3% of N_2O emissions in the Agriculture sector, 64.8% of Turkey's N_2O emissions, and 30.5% of agricultural emissions. Emissions were 3 566 kt CO_2 eq. (30.9%) above the 1990 level of 11 524 kt CO_2 eq. in the year 2014. Direct N_2O emissions increased by 2 766 kt CO_2 eq. whereas indirect N_2O emissions increased by 800 kt CO_2 eq. for the given period 1990-2014. The increase is a result of the emission changes of direct and indirect N_2O emissions from managed soils. The total increase of direct N_2O emissions is divided into inorganic N fertilizers, organic N fertilizers, urine and dung deposited by grazing animals, crop residues, and mineralization/immobilization related to loss/gain of soil organic carbon.

Several subcategories contribute to emissions from agricultural soils from direct and indirect pathways (Table 5.11). Direct N_2O emissions occur directly from the soils to which N has been added or released; indirect emissions arise from volatilization (evaporation or sublimation) and subsequent redeposition of NH_3 or NO_x, or result from leaching and runoff of soil N within water (IPCC, 2006).

A precise overview is also given in Table 5.12 for direct and indirect N_2O emissions and the calculated subcategories of organic N fertilizers, including amounts and percentage data.

Table 5.11 Categories of N_2O emissions of agricultural soils, 1990-2014

(kt CO_2 eq.)

Year	Total N_2O emissions from managed soils	Direct N_2O emissions from managed soils: Total	Inorganic N fertilizers	Organic N fertilizers	Urine and dung deposited by grazing animals	Crop residues	Mineralization/ immobilization associated with loss/gain of soil organic matter	Indirect N_2O emissions from managed soils: Total	Atmospheric deposition	Nitrogen leaching and run-off
1990	11 524	8 779	5 618	743	502	1 905	10.5	2 745	792	1 953
1991	11 107	8 464	5 169	813	515	1 957	10.5	2 642	762	1 881
1992	11 648	8 866	5 649	827	509	1 871	10.5	2 782	811	1 971
1993	12 591	9 585	6 253	852	497	1 973	10.5	3 006	874	2 132
1994	10 214	7 772	4 714	851	483	1 714	10.5	2 442	717	1 725
1995	10 388	7 912	4 934	770	462	1 734	10.5	2 476	719	1 757
1996	11 188	8 524	5 374	810	460	1 869	10.5	2 664	770	1 894
1997	11 388	8 684	5 465	800	431	1 978	10.5	2 704	772	1 931
1998	13 134	10 015	6 532	854	429	2 190	10.5	3 119	889	2 230
1999	13 379	10 174	6 957	894	431	1 880	10.5	3 206	940	2 266
2000	12 914	9 835	6 456	911	414	2 047	6.7	3 080	890	2 190
2001	10 956	8 342	5 304	847	397	1 787	6.7	2 614	759	1 855
2002	11 731	8 930	5 615	974	378	1 956	6.7	2 801	813	1 988
2003	12 440	9 459	6 279	950	379	1 845	6.7	2 981	874	2 107
2004	12 927	9 832	6 400	1 037	389	1 999	6.7	3 094	905	2 189
2005	13 013	9 911	6 427	974	399	2 105	6.7	3 102	896	2 206
2006	13 177	10 025	6 587	1 017	410	2 004	6.7	3 152	922	2 231
2007	12 574	9 548	6 349	1 039	401	1 750	8.9	3 025	901	2 124
2008	11 162	8 490	5 306	997	384	1 793	8.9	2 672	786	1 886
2009	13 092	9 965	6 621	968	364	2 004	8.9	3 126	908	2 219
2010	12 622	9 605	6 292	977	389	1 938	8.9	3 017	880	2 137
2011	12 308	9 366	5 897	1 055	423	1 981	8.9	2 942	862	2 081
2012	13 385	10 174	6 706	1 071	470	1 918	8.9	3 211	952	2 259
2013	15 218	11 604	7 419	1 103	496	2 577	8.9	3 614	1 034	2 580
2014	15 090	11 545	6 961	1 187	510	2 878	8.9	3 545	994	2 551

Table 5.12 Overview of agricultural soils and organic N fertilizers, 1990 - 2014

		Agricultural soils					Organic N Fertilizers				
	Agriculture total	Total	Direct N_2O		Indirect N_2O		Total	Animal manure applied to soils		Other organic fertilizers applied to soils	
Year	(kt CO_2 eq.)	(kt CO_2 eq.)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)
1990	41 227	11 524	8 779	76.2	2 745	23.8	743	611	82.2	133	17.8
1991	41 871	11 107	8 464	76.2	2 642	23.8	813	680	83.7	133	16.3
1992	42 110	11 648	8 866	76.1	2 782	23.9	827	694	84.0	133	16.0
1993	42 997	12 591	9 585	76.1	3 006	23.9	852	719	84.4	133	15.6
1994	40 299	10 214	7 772	76.1	2 442	23.9	851	719	84.4	133	15.6
1995	39 773	10 388	7 912	76.2	2 476	23.8	770	661	85.8	110	14.2
1996	40 804	11 188	8 524	76.2	2 664	23.8	810	686	84.8	123	15.2
1997	39 100	11 388	8 684	76.3	2 704	23.7	800	675	84.4	124	15.6
1998	40 825	13 134	10 015	76.3	3 119	23.7	854	739	86.6	115	13.4
1999	41 300	13 379	10 174	76.0	3 206	24.0	894	739	82.6	156	17.4
2000	39 650	12 914	9 835	76.2	3 080	23.8	911	746	81.9	165	18.1
2001	36 983	10 956	8 342	76.1	2 614	23.9	847	696	82.2	151	17.8
2002	35 709	11 731	8 930	76.1	2 801	23.9	974	710	72.9	264	27.1
2003	37 137	12 440	9 459	76.0	2 981	24.0	950	725	76.3	225	23.7
2004	36 986	12 927	9 832	76.1	3 094	23.9	1 037	795	76.7	242	23.3
2005	37 936	13 013	9 911	76.2	3 102	23.8	974	837	85.9	137	14.1
2006	38 937	13 177	10 025	76.1	3 152	23.9	1 017	883	86.8	134	13.2
2007	38 511	12 574	9 548	75.9	3 025	24.1	1 039	809	77.8	230	22.2
2008	36 458	11 162	8 490	76.1	2 672	23.9	997	778	78.0	219	22.0
2009	37 998	13 092	9 965	76.1	3 126	23.9	968	751	77.5	217	22.5
2010	39 329	12 622	9 605	76.1	3 017	23.9	977	797	81.6	180	18.4
2011	41 078	12 308	9 366	76.1	2 942	23.9	1 055	854	81.0	201	19.0
2012	45 770	13 385	10 174	76.0	3 211	24.0	1 071	947	88.5	124	11.5
2013	49 320	15 218	11 604	76.3	3 614	23.7	1 103	993	90.0	110	10.0
2014	49 522	15 090	11 545	76.5	3 545	23.5	1 187	1 028	86.6	159	13.4

Direct N_2O emissions from agricultural soils are a result of addition of nitrogen in the form of: inorganic nitrogen fertilizers, organic nitrogen fertilizers (predominantly in the form of animal manure), inputs from above- and below-ground crop residues and from forages during pasture renewal, mineralization of cropland soil organic matter loss, urine and dung deposited by grazing animals. These combined direct N_2O soil emissions contributed 11 545 kt CO_2 eq. (76.5%) to emissions from the Agricultural soils category and 23.3% of emissions under the total Agriculture sector in 2014. This is an increase of 2 766 kt CO_2 eq. (31.5%) from the 1990 level of 8 779 kt CO_2 eq.

A major direct source of N_2O emissions from agricultural soils is the use of synthetic fertilizer. Nearly 40% of the increase in emissions from agricultural soils observed between 1990 and 2014 is due to the increase from emissions from application of synthetic fertilizers. Widespread increase in the use of such nitrogen-based fertilizers has been driven by the need for greater crop yields and more intensive farming practices. In 2014, N_2O emissions from synthetic nitrogen fertilizers contributed 6 961 kt CO_2 eq. (46.1%) to emissions from the managed soils category. This is an increase of 1 344 kt CO_2 eq. (23.9%) from the 1990 level of 5 618 kt CO_2 eq. Nitrogen emissions of synthetic fertilizer contributed 14.1% to the total emissions under the agriculture sector.

In 2014, N_2O emissions from organic N fertilizers contributed 1 187 kt CO_2 eq. (7.9%) to emissions from the agricultural soils category and 2.4% of emissions under the total agriculture sector. An increase of 443 kt CO_2 eq. (59.7%) is observed from the 1990 level of 743 kt CO_2 eq.

As observed from Table 5.11, N_2O emissions from urine and dung deposited by grazing animals contributed 510 kt CO_2 eq. (3.4%) to emissions from the agricultural soils category and 1% of emissions under the total agriculture sector. This is an increase of 8 kt CO_2 eq. (1.5%) from the 1990 level of 502 kt CO_2 eq. Moreover, N_2O emissions from crop residues contributed 2 878 kt CO_2 eq. (19.1%) to emissions from the agricultural soils category and 5.8% of emissions under the total agriculture sector. This is an increase of 973 kt CO_2 eq. (51.1%) from the 1990 level of 1 905 kt CO_2 eq.

Indirect N_2O emissions were calculated as 3 545 kt CO_2 eq. for 2014. Indirect N_2O emissions through atmospheric depositon contributed 994 kt CO_2 eq. (6.6%) to emissions from the agricultural soils category and 2.0% of emissions under the total agriculture sector in 2014. This is an increase of 202 kt CO_2 eq. (25.5%) from the 1990 level of 792 kt CO_2 eq. Indirect N_2O emissions through leaching and runoff added 2 551 kt CO_2 eq. (16.9%) to emissions from the Agricultural soils category in 2014 and 5.2% of emissions under the total Agriculture sector.

Briefly, agricultural soils emissions have increased by 30.9% (3.6 Mt CO_2 eq.) between 1990 and 2014. The increase is a result of the emission changes of direct and indirect N_2O emissions from managed soils. The former increased by 2.8 Mt CO_2 eq. and the latter by 0.8 Mt CO_2 eq. for the given period 1990-2014. The total increase of 2.8 Mt CO_2 eq. of direct N_2O emissions is divided into inorganic N fertilizers, organic N fertilizers, urine and dung deposited by grazing animals, crop residues, and mineralization/immobilization related to loss/gain of soil organic carbon. The related figures of changes for 1990-2014 concerning these five subcategories are 1 344 kt (23.9%), 443 kt (59.7%), 8 kt (1.5%), 973 kt (51.1%), and -2 kt (-14.7%) respectively. Organic N fertilizers are further subdivided into three groups, animal manure, sewage sludge, and other organic fertilizers all applied to soils. Sewage sludge applied to soils is not estimated. The increase in animal manure applied to soils is 417 kt (68.3%) from 611 kt to 1 028 kt whereas the increase in other organic fertilizers applied to soils is 26 kt (19.9%) from 133 kt to 159 kt. On the other hand the total increase of 0.8 Mt CO_2 eq. of indirect N_2O emissions is divided into atmospheric deposition and nitrogen leaching and run-off. The related figures of changes for these subcategories are 202 kt (25.6%) and 598 kt (30.6%) for the period 1990-2014 respectively.

Methodological Issues:

N_2O emissions are calculated by using the IPCC T1 approach. The AD used in emission calculation is taken from agricultural statistics of TurkStat. The N_2O EFs are default IPCC T1 factors. It is important to note that the subcategory of organic N fertilizers - sewage sludge applied to soils - is not estimated because of insufficient AD. The N_2O emissions from crop residues are calculated for plant species given in Table 5.13.

Table 5.13 Crop production data used for the crop residue

Major Crop Types	Grass-clover mixtures	Millet
Grains	**Individual Crops**	Sorghum
Beans & Pulses (N fix)	Maize	Soyabean
Beans & Pulses (non-N fix)	Wheat	Dry bean
Tubers	Winter wheat	Potato
Root crops and Other	Spring wheat	Peanut (w/pod)
N-fixing forages	Rice	Alfalfa
Non-N-fixing forages	Barley	Non-legume hay
Perennial grasses	Oats	

Source category	Gas	Comments on time series consistency
3.D.1	N_2O	All EFs are constant over the entire time series

Uncertainties and Time-Series Consistency:

The AD for this sector are gathered from agricultural statistics of TurkStat. Uncertainties in the EF and production data are determined by TurkStat expert. The N_2O emission is calculated and then it is converted to the CO_2 eq. by multiplying the value with the global warming potential.

Uncertainty values of AD for agricultural soils is considered to be 14.1%. Uncertainties in estimates of direct N_2O emissions from managed soils are caused by uncertainties related to the EFs (see Table 11.1 in Chapter 11.1 of Volume 4 for uncertainty ranges) as recommended in 2006 IPCC Guidelines. The resulting value 135% is calculated by mean of upper and lower of uncertainty values.

Source-Specific QA/QC and Verification:

The 2006 IPCC Guidelines are used for the QA/QC procedures of the National GHG emissions inventory. A National Inventory System QA/QC Plan prepared by TurkStat is also a significant tool for implementing QA/QC principles for the Inventory. AD for this source category is gathered mainly from the Agricultural Statistics Department of TurkStat. Data used for calculations are published also as official statistics by TurkStat which have their own QA/QC procedures. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined. A detailed overview on QC procedures with respect to each principle of GHG inventory is presented in Table 1.2.

Recalculation:

Recalculations done under this category is related first to urine and dung deposited by grazing animals category (3.D.a.3 - CRF Category 3.D.1.3) due to transaction errors related to types of domestic dairy cattle and hybrid dairy cattle for the period 1990-2012, and second to nitrogen leaching and run-off (3.D.b.2-CRF Category 3.D.2.2) due to transaction errors. The overall impact of the recalculations was relatively minor, ranging from -0.03% (1990) to 0.02% (2012) for this category.

Planned Improvement:

All data and methodologies are kept under review and further possible improvements are being considered for the future. The results on improving estimations of manure management emissions will be useful to improve emission estimations from agricultural soils (animal applied to soils).

5.6. Prescribed Burning of Savannas (Category 3.E)

This source category of agriculture emission is not relevant to Turkey.

5.7. Field Burning of Agricultural Residues (Category 3.F)

Source Category Description:

The burning of residual crop material releases CH_4, N_2O, CO, and NO_x emissions. Burning of agricultural residues is not considered as a net source of CO_2 because the carbon released to the atmosphere is reabsorbed during the growing season. This source category is not a key category. Emission values due to field burning of crop residues are given in Table 5.7 for all twenty-five reporting years. The overall emission trends can also be observed in Figure 5.5. CH_4, N_2O and total emissions from this source category have similar patterns showing ups and downs. For the reported years, CH_4 emissions had a minimum value of 228.2 kt CO_2 eq. in 1994 and a maximum value of 283.3 kt CO_2 eq. in 2005 whereas respective values for N_2O emissions were 70.5 kt CO_2 eq. in 1994 and 87.5 kt CO_2 eq. in 2005.

Figure 5.5 Emissions of field burning of agricultural residues, 1990-2014

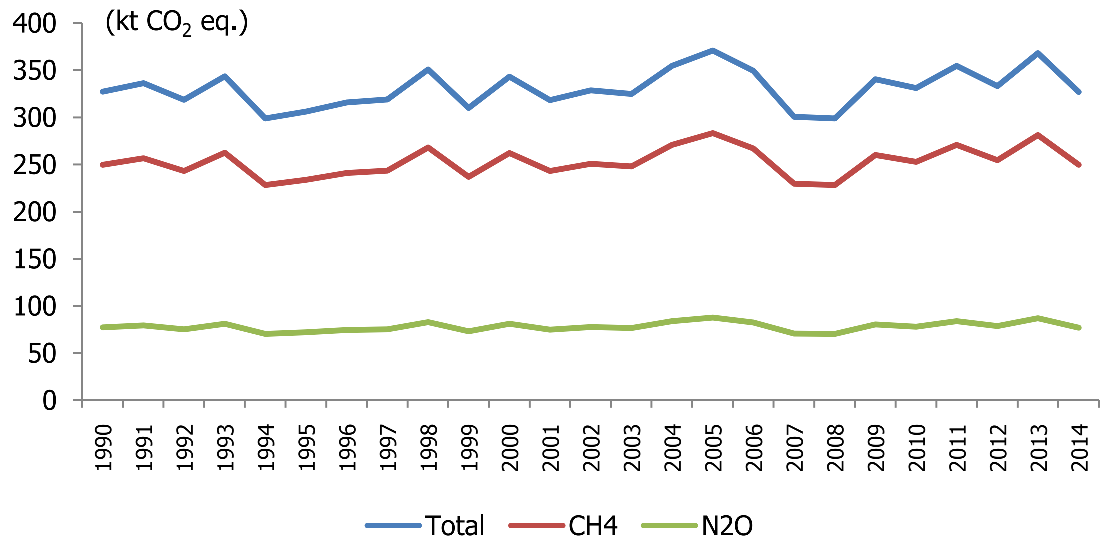


Table 5.14 Field burning of agricultural residues emission, 1990 and 2014

	Emission (kt CO_2 eq.)				Changes from 1990 to 2014		Percentages of agricultural sector (%)	
Category	**1990**	**(%)**	**2014**	**(%)**	**(kt CO_2 eq.)**	**(%)**	**1990**	**2014**
Field burning of agricultural residues	327	100	327	100	- 0.26	- 0.08	0.79	0.66
CH_4	250	76.4	250	76.4	- 0.20	- 0.08	0.61	0.50
N_2O	77	23.6	77	23.6	- 0.06	- 0.08	0.19	0.16

In 2014, field burning of agricultural residues contributed 327 kt CO_2 eq. This emission value represented 0.66% of all agricultural emissions. Total emissions from this source category were highly similar to the level of 1990 showing only a slight decrease of 0.26 kt CO_2 eq. between 1990 and 2014. The respective percentage change is calculated as - 0.08%. More precisely described in Table 5.14, CH_4 and N_2O emissions contributed 250 kt CO_2 eq. and 77 kt CO_2 eq. respectively to this source category in 2014.

Methodological Issues:

Emissions are calculated by using IPCC T1 approach. The estimates are derived from crop production of wheat, barley and maize. The AD used in emission calculation for CH_4 and N_2O is taken from agricultural statistics of TurkStat. Other emission values under this source category, NO_x, CO, and NMVOC, are not estimated.

Most of the farmers obey the rules prohibiting stubble burning by the MoEU leaving some farmers still practicing crop residue burning. As a result, all cultivated areas for grains are assumed to be areas for residual burning because exact area used for this practice is unknown.

Uncertainties and Time-Series Consistency:

The AD for this sector was gathered from agricultural statistics of TurkStat. Uncertainties in EFs and production data are determined by TurkStat experts. The values calculated for CH_4 and N_2O emissions were converted to their CO_2 equivalents by multiplying the values with their respective global warming potential factors. Uncertainty values of AD are considered to be 30.4% and the uncertainty for the EFs is estimated to be 10% both for CH_4 and N_2O.

Source category	Gas	Comments on time series consistency
3.F	CH_4, N_2O	All EFs are constant over the entire time series

Source-Specific QA/QC and Verification:

The 2006 IPCC Guidelines are used for the QA/QC procedures of National GHG emission inventory. A National Inventory System QA/QC Plan prepared by TurkStat is also a significant tool for implementing QA/QC principles for the Inventory. AD for this source category is gathered mainly from the Agricultural Statistics Department of TurkStat. Data used for calculations are published also as official statistics by TurkStat which have their own QA/QC procedures. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined. A detailed overview on QC procedures with respect to each principle of GHG inventory is presented in Table 1.2.

Recalculation:

There is no recalculation.

Planned Improvement:

All data and methodologies are kept under review and there are no further planned improvements regarding this source.

5.8. Liming (Category 3.G)

This category cannot be estimated because of insufficient AD but TurkStat is considering to evaluate possible data sources for this mandatory category.

5.9. Urea Application (Category 3.H)

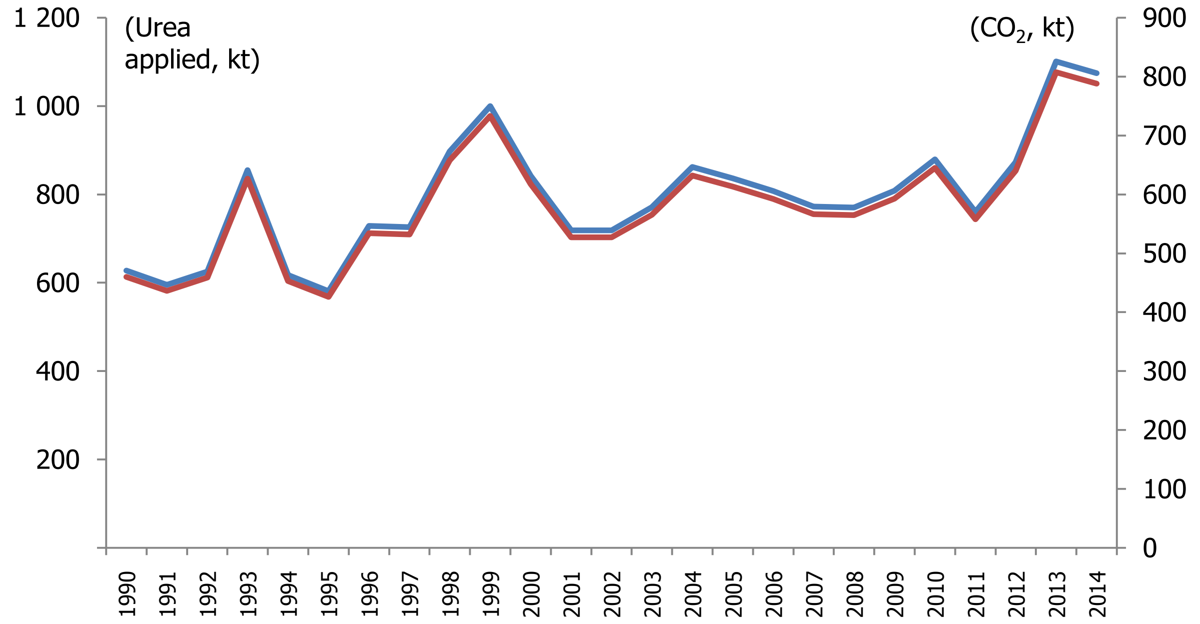
Source Category Description:

Adding urea to soils for fertilization leads to loss of the CO_2 that was fixed during the manufacturing process. Similar to the soil reaction following addition of lime, bicarbonate that is formed evolves into CO_2 and water.

CO_2 emissions from the application of urea produced 787.7 kt CO_2 in 2014. This is an amount representing 1.6% of agricultural emissions. Emissions from the urea application in 2014 were 328 kt CO_2 eq. (71.3%) above its 1990 level of 460 kt CO_2 eq. This source category, CO_2 emission from urea application, is not a key category.

Emissions values due to urea application are given in Table 5.7 for the period 1990-2014. Figure 5.6 presents yearly amount of urea application in kt (line shown in dark red - left axis) and CO_2 emissions emitted in kt (line shown in blue - right axis). A direct relationship between the two values is clear.

Figure 5.6 Urea application and emitted CO_2, 1990-2014



Methodological Issues:

Emissions associated with the application of urea are calculated by using a T1 approach (equation 11.13; IPCC, 2006), using the default EFs for carbon conversion of 0.20. AD used in emission calculations are taken from TurkStat agricultural statistics databases.

Uncertainties and Time-Series Consistency:

Under the IPCC (2006) T1 methodology, the default EFs are used which assume conservatively that all carbon in the urea is emitted as CO_2 into the atmosphere. A default 50% uncertainty is applied regarding the AD used in the emission calculation of urea application, because the default EF is assumed to be the theoretical maximum emissions whereas the uncertainties of the EF is taken as 3%.

Source-Specific QA/QC and Verification:

The 2006 IPCC Guidelines are used for the QA/QC procedures of the National GHG emission inventory. A National Inventory System QA/QC Plan prepared by TurkStat is also a significant tool for implementing QA/QC principles for the Inventory. AD for this source category is received from the MFAL via TurkStat Agricultural Statistics Department, which are part of official statistics. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined. A detailed overview on QC procedures with respect to each principle of GHG inventory is presented in Table 1.2.

Recalculation:

This source was calculated and reported for the first time in the 2013 Inventory submitted in 2015 and there was no recalculation involved in emission estimates for this source category in this reporting year.

Planned Improvement:

All data and methodologies are kept under review. There are no further planned improvements in this source category.

5.10. Other Carbon-Containing Fertilizers (Category 3.I)

This category cannot be estimated because of insufficient AD.

5.11. Other (Category 3.J)

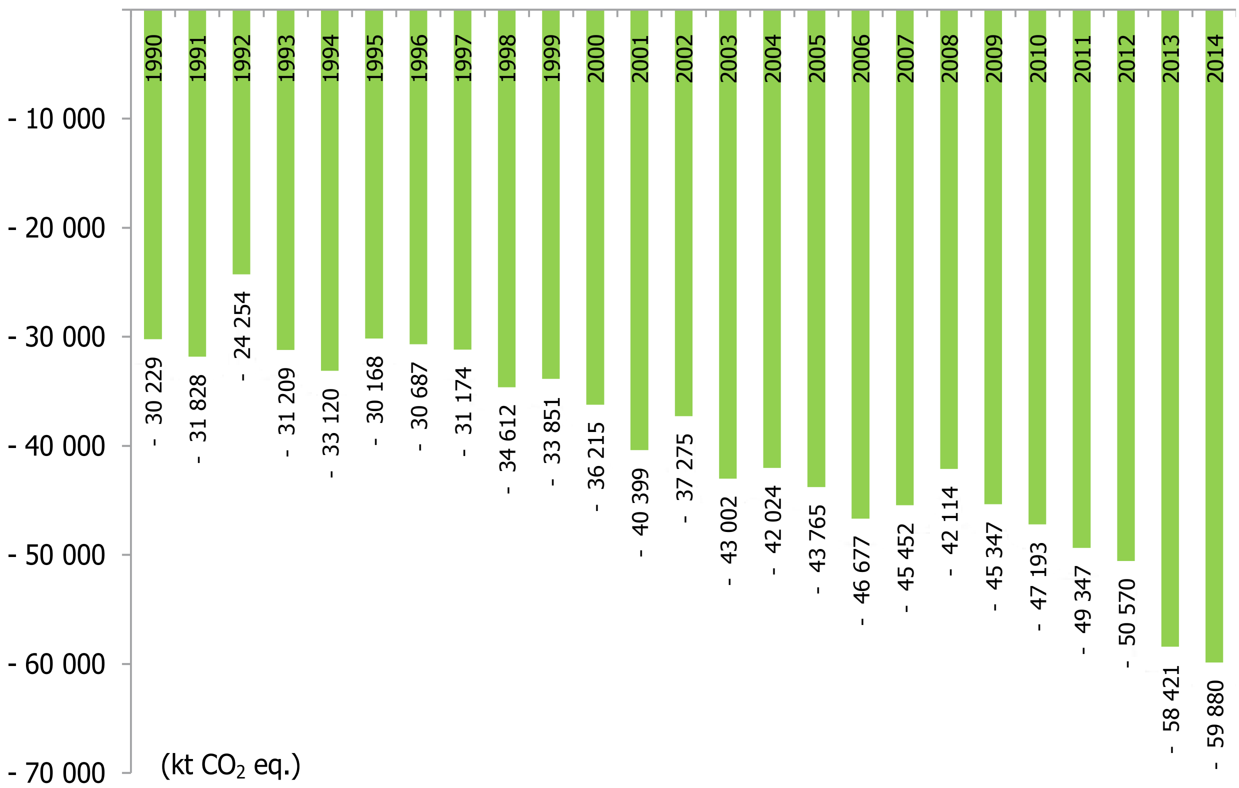
There are no other activities to be considered under this sector.

6. LULUCF (CRF SECTOR 4)

6.1. Sector Overview

This sector comprises GHG emissions and removals arising from LULUCF. The Figure 6.1 presents net removals from this sector for the 1990-2014 period.

Figure 6.1 Net removals from LULUCF, 1990-2014



The figure shows that LULUCF sector has been a net sink in Turkey for the reporting period and the removals increased in time. The key drivers for the rise in removals are improvements in sustainable forest management, afforestation, rehabilitation of degraded forests, reforestations on forest land and conversion of coppices to productive forests in forest land remaining forest land, efficient forest fire management and protection activities, conversions to perennial croplands from annual croplands and grasslands, and conversions to grasslands from annual croplands. The key drivers for the decrease in removals are related to drought and biomass burning as wildfire (e.g. year 2008; 29,749 ha forest area burned), deforestation, conversions to wetlands (flooded land) and settlements.

The following subcategories have been reported as removals;

- Forestland remaining Forestland
- Land converted to Forestland
- Cropland remaining Cropland
- Land converted to Grassland
- Harvested Wood Products

And the following subcategories have been reported as emissions;

- Land converted to Cropland
- Forestland converted to Grassland
- Grassland remaining Grassland
- Land converted to Settlements
- Land converted to Wetlands (no conversion for 2013)

To avoid double counting, CO_2 emissions were not considered here.

The estimations for 1990-2014 were calculated according to equations 2.14 and 2.27 in 2006 IPCC Guidelines for National GHG Inventories-Agriculture, Forestry and Other Land Use (Volume 4). The parameters were chosen described in Section 2.3.1.1 and 2.4. The parameters have been used from Tables 2.4, 2.5 and 2.6.

Table 6.1 Total emissions and removals in Turkey, 1990-2014

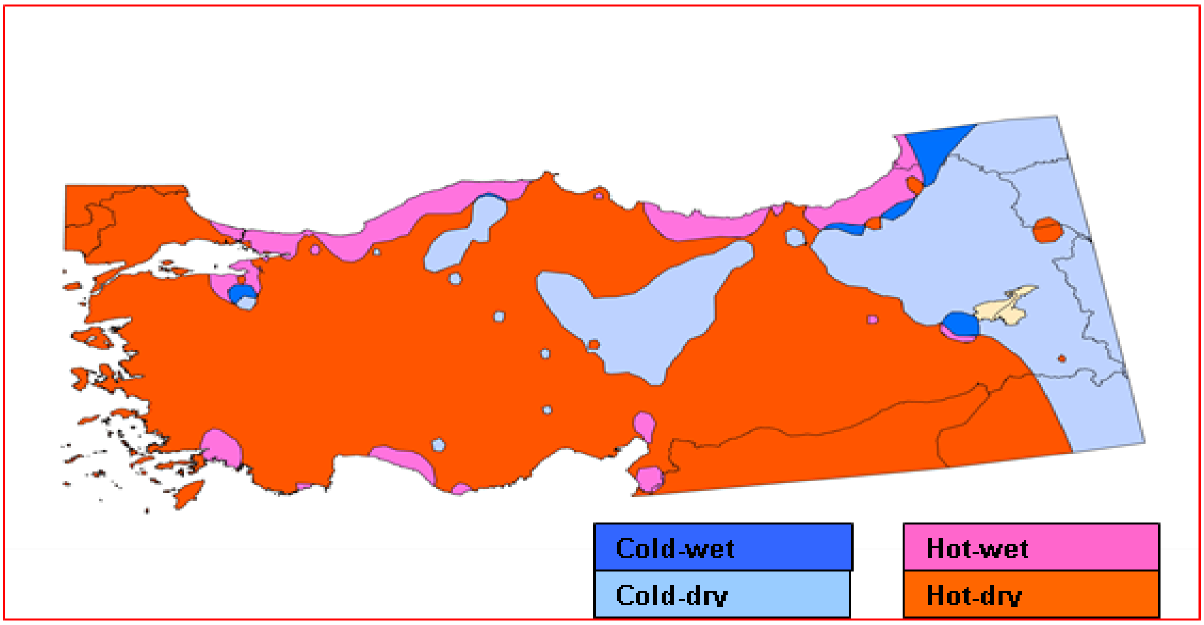
Year	Total GHG emissions (Mt CO_2 eq.)	Removals by LULUCF sector (Mt CO_2 eq.)	Removals by forestland category (Mt CO_2 eq.)	Share of LULUCF sector in total GHG emissions (%)
1990	207.8	-30.2	-28.3	-14.5
1991	214.1	-31.8	-30.0	-14.9
1992	220.8	-24.3	-30.1	-11.0
1993	230.6	-31.2	-30.4	-13.5
1994	224.7	-33.1	-33.1	-14.7
1995	239.0	-30.2	-30.1	-12.6
1996	256.7	-30.7	-30.6	-12.0
1997	269.9	-31.2	-33.3	-11.6
1998	271.8	-34.6	-34.5	-12.7
1999	271.4	-33.9	-35.6	-12.5
2000	296.8	-36.2	-36.1	-12.2
2001	278.8	-40.4	-39.5	-14.5
2002	287.1	-37.3	-39.6	-13.0
2003	303.7	-43.0	-41.9	-14.2
2004	316.9	-42.0	-41.5	-13.3
2005	345.2	-43.8	-42.4	-12.7
2006	371.3	-46.7	-43.8	-12.6
2007	403.4	-45.5	-43.2	-11.3
2008	393.1	-42.1	-39.6	-10.7
2009	382.5	-45.3	-42.7	-11.8
2010	395.3	-47.2	-44.7	-11.9
2011	415.9	-49.3	-45.9	-11.9
2012	447.5	-50.6	-46.5	-11.3
2013	438.8	-58.4	-53.3	-13.3
2014	467.6	-59.9	-54.5	-12.8

As shown in the table above, there is very steep increasing trend in total GHG emissions while the average percentage of net removals from LULUCF was 12.7% during the 1990-2014 periods.

Definition and Background Data

The methodology advised in the 2006 IPCC Guidelines for National GHG Inventories-Agriculture, Forestry and Other Land Use (Volume 4) was followed to estimate removals/emissions from LULUCF. According to the Guidelines, a climate map of Turkey was prepared and used a base for all land use categories.

Figure 6.2 The Climate map of Turkey



The definitions of land uses are explained below. The national forest definition is the legal national definition. For the other land uses technical definitions are applied. The technical definitions are derived from Coordinate Information on the Environment (CORINE) technical guide (http://image2000.jrc.ec.europa.eu/reports/technical_guide.pdf).

Forest Land: Forest definition according to the legislation (Forest Law No: 6831) (GDF, 1956):Tree and woodland communities, which are grown by both human efforts and naturally are regarded as Forest, together with their lands.

According to the Forest Law No: 6831, all natural woody and shrub areas and all plantations are accepted as forest with their lands. But, reed fields; steppes; bramble patches; parks; woody and shrub areas in cemeteries; areas which are in private ownership and covered with exotic tree species; wherever the areas in or next to or out of forest lands, all woody and shrub areas in private ownership which are using for agriculture; all the woody areas having less than 3 ha magnitudes; wherever the areas in or next to or out of forest lands, all fruit tree and shrub areas which are in the use of private ownership including alder trees, chestnut trees, stone pine trees and Turkish oak trees; olive groves in private ownership, wild olive groves separated from forests, areas covered with pistachio trees (*Pistaciavera* L.), mastic (*Pistacialentiscus* L.) and carob trees (*Ceratoniasiliqua* L.); scrubs and maquis are not accepted as forests.

Cropland: The following land uses are included in the croplands.

- Arable land (Non-irrigated arable land, Permanently irrigated land)

- Permanent crops (Vineyards, Fruit trees and berry plantations, Olive groves)
- Poplar plantations in or near the agriculture area

Grassland: Natural grasslands and pastures are defined as grassland. The grasslands cannot be separated into managed and unmanaged technically. Hence, all grasslands are accepted as managed.

Wetlands: Only artificial water bodies (dams, irrigation dams and reservoirs) are included in the definition.

Settlements: Artificial surfaces are reported under Settlements. These include;

- Urban fabric (continuous, discontinuous fabric)
- Industrial, commercial and transport units (Industrial or commercial units, Road and rail networks and associated land, Port areas, Airports)
- Mine, dump and construction sites (Mineral extraction sites, Dump sites, Construction sites,)
- Artificial, non-agricultural vegetated areas (Green urban areas, Sport and leisure facilities)

Otherland: Open spaces with little or no vegetation are defined under Otherland. These include;

- Beaches, dunes, sands
- Bare rocks,
- Sparsely vegetated areas

Activity Data

The land uses and land use changes for Forestland category is provided from Inventory Statistical System for Forests (ENVANIS) database since 2004. The data for 1990-2003 found by interpolation according to 1999 and 1972 forest inventory results. The lands other than Forestland have been determined via CORINE land cover maps belonging to years 1990, 2000, 2006. These maps have been produced by different agencies of the government at different time frames but have the same legend and approach. This enabled us to determine land uses and land use changes more consistent. The land use changes in these periods without Forest Land category are given in Table 6.20. Linear interpolation was performed for the years between and linear extrapolation for the years after 2006. This procedure has been explained in section 6.3.

Forestland and conversions between Forestland and other land uses are determined by using ENVANIS database while other 5 land uses by using CORINE Land cover maps there is an inconsistency between land use types. The ENVANIS is a tabular database that uses national forest definition. The land cover classification in CORINE including forest cover is visual.

Uncertainty

The uncertainty levels of the LULUCF inventory are stated in each land use section.

Completeness

As regards the inventory completeness, sinks and sources that could not be reported in the CRF tables are charted as follows:

Sink/source category	GHG	Explanation
Forest lands, soils	CO_2	Lack of adequate data on annual carbon stock changes in the soil in the Forest Land Remaining Forest Land soil organic matter
Forest lands, dead wood and litter	CO_2	Lack of adequate data on annual carbon stock changes in the litter and deadwood in the Forest Land Remaining Forest Land
Forestlands, Biomass Burning-Controlled Burning	CO_2, CH_4 and N_2O	Does not occur
Forest lands, drained soils	Non-CO_2	Drainage does not occur in the forests
Drained wetlands	Non-CO_2	No available data
Limestone application in croplands and grasslands	CO_2	Limestone application does not occur in the agricultural lands and grasslands.
Croplands, grasslands, wetlands and settlements, biomass burning	CO_2, CH_4 and N_2O	No available data
Croplands, disturbance associated with land use conversion to cropland	N_2O	No available data
Other land	CO_2	No available data

6.2. Forest Land (Category 4.A)

Source/Sink Category Description

According to the figures given by the Forest Management Planning Department of the General Directoriate of Forestry (GDF), Turkey has 22 064 kha forest area approximately with regard to its own forestry legislative. Since all the woody areas having more than 3 ha magnitudes are accepted in forest regime disregarding their crown closure, this figure differs from the figure given in FAO's resources. FAO's figures cover the woody areas having more than 40% crown closure only. Because of forcing situation initiating from the protective rules of constitution and forestry regulations current in Turkey, the figures given by forestry organization were accepted and used during the estimation of net annual amount of carbon uptake or release in the forests in Turkey. The figures concerning forest resources in Turkey for 2014 year are given in Table 6.2.

Table 6.2 Forest inventory results of Turkey, 2014

Area

	High forests (ha)				
	Coniferous	Deciduous	Total high forests (ha)	Coppices (ha)	Total forest area (ha)
Productive[1]	8 053 196	3 354 389	11 407 585	915 366	12 322 951
Degraded[2]	5 490 475	1 961 809	7 452 284	2 288 520	9 740 804
Total	13 543 671	5 316 198	18 859 869	3 203 886	22 063 755

Growing stock

	High forests (m^3)				
	Coniferous	Deciduous	Total high forests (m^3)	Coppices[1] (m^3)	Total forest growing stock (m^3)
Productive[1]	1 048 876 351	462 603 124	1511 479 475	40 638 092	1552 117 566
Degraded[2]	44 290 104	13 778 137	58 068 241	13 601 053	71 669 293
Total	1 093 166 455	476 381 261	1569 547 715	54 239 144	1623 786 859

Annual volume increment

	High forests (m^3)				
	Coniferous	Deciduous	Total high forests (m^3)	Coppices[1] (m^3)	Total forest annual increment (m^3)
Productive[1]	31 260 270	13 056 292	44 316 561	1 895 377	46 211 939
Degraded[2]	1 071 968	357 610	1 429 578	610 849	2 040 427
Total	32 332 238	13 413 902	45 746 139	2 506 226	48 252 365

1. 0.75 coefficient was used in order to convert the stere volume into m^3 volume.

Pinusbrutia, Pinusnigra and, Pinussylvestris are the most important coniferous species among the other coniferous such as 4 kinds of *Abies spp., Piceaorientalis, Cedruslibani* etc. In portion of these three pine species is more than 80% as in totally volume of growing stock. *Fagusorientalis* and 22 *Quercus spp.* have 80% ratio in total volume of the deciduous trees such as *Tilia, Ulmus, Alnus, Castanea* species.

Since 2004, ENVANIS System, a forest resources inventory based on forest management units is used. In this system total forest area changes, total annual increment changes and total growing stock changes can be calculated year by year. Therefore, comparison of forest area, annual increment and growing stock, between two subsequent years, has been possible since 2004. The comparison of removals by forestry sector, according to forest area, annual increment and growing stock changes since 1990 is given in Table 6.3, 6.4 and 6.5.

Table 6.3 Forest area changes in Turkey, 1990-2014

(kha)

	Productive[1]				Degraded[2]				
Year	**Coniferus**	**Decidous**	**Coppices**	**Productive total**	**Coniferus**	**Decidous**	**Coppices**	**Degraded total**	**Total**
1990	6 949	2 039	1 506	10 494	5 492	969	3 614	10 075	20 569
1991	6 956	2 041	1 508	10 504	5 498	970	3 618	10 085	20 590
1992	6 963	2 043	1 509	10 515	5 503	971	3 621	10 095	20 610
1993	6 970	2 045	1 511	10 525	5 509	971	3 625	10 105	20 631
1994	6 977	2 047	1 512	10 536	5 514	972	3 628	10 115	20 651
1995	6 984	2 049	1 514	10 546	5 520	973	3 632	10 125	20 672
1996	6 991	2 051	1 515	10 557	5 525	974	3 636	10 135	20 692
1997	6 998	2 053	1 517	10 567	5 531	975	3 639	10 146	20 713
1998	7 005	2 055	1 518	10 578	5 536	976	3 643	10 156	20 734
1999	7 015	2 058	1 521	10 593	5 544	978	3 648	10 170	20 763
2000	7 048	2 068	1 528	10 643	5 570	982	3 665	10 218	20 861
2001	7 081	2 077	1 535	10 693	5 596	987	3 683	10 266	20 959
2002	6 966	1 767	1 760	10 493	5 642	801	4 121	10 564	21 056
2003	7 029	1 807	1 755	10 592	5 697	804	4 032	10 534	21 125
2004	7 084	1 857	1 681	10 621	5 689	810	4 068	10 568	21 189
2005	7 093	1 887	1 683	10 662	5 687	882	4 017	10 586	21 248
2006	7 117	1 939	1 657	10 714	5 699	944	3 938	10 581	21 295
2007	7 169	2 043	1 562	10 774	5 711	1 026	3 818	10 554	21 329
2008	7 214	2 111	1 530	10 855	5 756	1 041	3 711	10 508	21 363
2009	7 279	2 215	1 478	10 973	5 727	1 084	3 606	10 417	21 390
2010	7 391	2 392	1 420	11 203	5 756	1 124	3 454	10 334	21 537
2011	7 422	2 564	1 375	11 361	5 671	1 231	3 312	10 214	21 575
2012	7 568	2 714	1 277	11 559	5 655	1 324	3 141	10 119	21 678
2013	7 863	3 050	1 078	11 991	5 603	1 550	2 743	9 896	21 887
2014	8 053	3 354	915	12 323	5 490	1 962	2 289	9 741	22 064

1) Crown closure between 0.11–1.00.
2) Crown closure between 0.01–0.10.

Total of 1 494 667 ha areas have been converted to forest land between 1990 and 2014 (See table 6.3). According to these data, the forest area was interpolated to be increasing by 20.54 kha per year between 1972 and 1998 and by 97.73 kha per year between 2000 and 2003. The key driver for the rise in land converted to forest land is afforestation activities. Especially, in 2008, National

Afforestation and Erosion Control Action Plan have been initiated in order to increase forest areas of in Turkey. Various forestry activities (afforestation, reforestation, rehabilitation, erosion control, etc.) have done over 2.4 kha areas in the concept of National Afforestation and Erosion Control Action Plan between 2008 and 2012.

Databases to Identify Forests

There are only two documents (1972 and 1999 inventory) concerning the national forest inventory results in Turkey before 2004. The first document showing 1972 situation was presented in 1980, and the second was prepared at the end of 1999. Because of the absence of regular national forest inventory works in Turkey, both of the results were obtained based on the summaries of management plans data renewed in every 10 years interval. Forest data given in first document is shown in Tables 6.4 and 6.5.

Table 6.4 Forest inventory, 1972

Areas						
	Productive[1]		Degraded[2]		Total	
Type	ha	%	ha	%	ha	%
High forest	6 176 899	30.58	4 757 708	23.55	10 934 607	54.13
Coppice	2 679 558	13.27	6 585 131	32.60	9 264 689	45.87
Total	8 856 457	43.85	11 342 839	56.15	20 199 296	100.00
Growing stock						
	Productive [1]		Degraded[2]		Total	
Type	m^3	%	m^3	%	m^3	%
High forest	758 732 197	81.10	54 349 847	5.81	813 082 044	86.91
Coppice[3]	88 300 818	9.44	34 129 288	3.65	122 430 106	13.09
Total	847 033 015	90.54	88 479 135	9.46	935 512 150	100.00
Annual volume increment						
	Productive [1]		Degraded[2]		Total	
Type	m^3	%	m^3	%	m^3	%
High forest	20 791 672	74.09	1 343 744	4.79	22 135 416	78.88
Coppice[3]	4 813 197	17.15	1 114 592	3.97	5 927 789	21.12
Total	25 604 869	91.24	2 458 336	8.76	28 063 205	100.00

1) Crown closure between 0.11–1.00.
2) Crown closure between 0.01–0.10.
3) 0.75 coefficient was used in order to convert the stere volume into m^3 volume.

Table 6.5 Growing stock, 1990-2014

(thousand m³)

Year	Productive[1] High forest	Productive[1] Coppices[3]	Productive[1] Normal total	Degraded[2] High forest	Degraded[2] Coppices[3]	Degraded[2] Degraded total	Total
1990	984 907	64 986	1 049 893	43 622	12 038	19 976	1 105 553
1991	992 398	65 498	1 057 896	43 966	12 133	20 134	1 113 995
1992	1 000 208	66 032	1 066 240	44 325	12 232	20 298	1 122 797
1993	1 008 536	66 601	1 075 138	44 707	12 337	20 473	1 132 182
1994	1 019 149	67 328	1 086 477	45 195	12 472	20 697	1 144 144
1995	1 028 346	67 957	1 096 303	45 618	12 589	20 890	1 154 509
1996	1 037 873	68 609	1 106 482	46 055	12 710	21 091	1 165 247
1997	1 049 071	69 375	1 118 446	46 570	12 852	21 326	1 177 868
1998	1 061 252	70 209	1 131 461	47 131	13 006	21 583	1 191 598
1999	1 068 215	70 684	1 138 899	47 449	13 094	21 729	1 199 443
2000	1 087 582	72 002	1 159 584	48 334	13 338	22 134	1 221 256
2001	1 102 345	73 003	1 175 349	49 007	13 524	22 442	1 237 879
2002	1 144 383	75 908	1 220 291	50 900	14 046	23 309	1 285 237
2003	1 157 181	74 067	1 231 247	51 155	14 361	23 068	1 296 763
2004	1 171 323	70 491	1 241 814	51 070	14 367	23 654	1 307 251
2005	1 177 849	71 551	1 249 400	51 045	12 661	23 655	1 313 106
2006	1 198 854	70 038	1 268 892	51 233	12 930	23 122	1 333 055
2007	1 214 750	65 956	1 280 706	51 434	13 115	22 609	1 345 255
2008	1 237 057	63 860	1 300 917	51 876	11 947	21 520	1 364 741
2009	1 268 953	61 704	1 330 657	50 922	12 241	20 627	1 393 820
2010	1 328 437	59 097	1 387 534	49 351	12 286	19 415	1 449 171
2011	1 373 843	56 592	1 430 435	47 841	11 932	18 559	1 490 207
2012	1 406 365	52 324	1 406 365	47 327	11 992	17 652	1 465 685
2013	1 457 562	59 589	1 517 151	46 152	12 765	20 905	1 576 068
2014	1 511 479	40 638	1 552 118	58 068	13 601	71 669	1 623 787

1) Crown closure between 0.11–1.00.
2) Crown closure between 0.01–0.10.
3) 0.75 coefficient was used in order to convert the stere volume into m^3 volume.

Table 6.6 Annual volume increment, 1990-2014

(m³)

	Productive[1]			Degraded[2]			
Year	High forest	Coppices[3]	Productive total	High forest	Coppices[3]	Degraded total	Total
1990	28 263 488	3 594 725	31 858 213	1 292 180	761 076	2 053 256	33 911 468
1991	28 408 765	3 615 021	32 023 786	1 299 481	765 376	2 064 857	34 088 643
1992	28 554 845	3 635 432	32 190 277	1 306 823	769 700	2 076 523	34 266 800
1993	28 701 733	3 655 959	32 357 692	1 314 206	774 049	2 088 255	34 445 947
1994	28 849 433	3 676 601	32 526 034	1 321 632	778 422	2 100 054	34 626 089
1995	28 997 951	3 697 360	32 695 311	1 329 099	782 820	2 111 919	34 807 230
1996	29 393 188	3 753 333	33 146 521	1 349 235	794 680	2 143 915	35 290 436
1997	29 794 365	3 810 154	33 604 519	1 369 676	806 720	2 176 395	35 780 915
1998	30 201 624	3 867 836	34 069 460	1 390 426	818 941	2 209 368	36 278 827
1999	30 616 300	3 926 393	34 542 693	1 411 491	831 348	2 242 840	36 785 533
2000	31 047 474	3 985 847	35 033 320	1 432 875	843 943	2 276 819	37 310 139
2001	31 484 957	4 046 201	35 531 157	1 454 583	856 729	2 311 312	37 842 470
2002	32 152 278	4 138 121	36 290 399	1 485 107	874 707	2 359 814	38 650 213
2003	32 676 363	4 148 293	36 824 656	1 515 148	885 870	2 401 018	39 225 674
2004	33 252 614	3 928 988	37 181 602	1 518 086	929 309	2 447 395	39 628 996
2005	33 282 485	4 025 038	37 307 523	1 495 502	922 183	2 417 685	39 725 208
2006	34 023 718	3 897 693	37 921 411	1 517 388	912 471	2 429 859	40 351 270
2007	34 522 580	3 713 731	38 236 311	1 531 418	893 633	2 425 051	40 661 361
2008	34 932 392	3 364 866	38 297 257	1 480 764	855 556	2 336 320	40 633 577
2009	36 057 848	3 252 775	39 310 622	1 481 335	816 592	2 297 927	41 608 549
2010	37 857 085	3 089 208	40 946 293	1 468 070	792 878	2 260 948	43 207 241
2011	39 432 099	3 006 600	42 438 699	1 423 239	780 168	2 203 407	44 642 106
2012	40 537 544	2 721 738	43 259 282	1 411 640	747 296	2 158 936	45 418 218
2013	42 478 157	2 793 233	45 271 390	1 389 327	896 971	2 286 298	47 557 688
2014	44 316 561	1 895 377	46 211 939	1 429 578	610 849	2 040 427	48 252 365

1) Crown closure between 0.11–1.00 (productive forest).
2) Crown closure between 0.01–0.10 (degraded).
3) 0.75 coefficient was used in order to convert the stere volume into m³ volume.

Evaluation of Table 6.3 , 6.5 and 6.6 can be outlined as below:

- Total amount of areas, growing stocks and annual volume increments of the coppice forests reduced while high forests were increasing. Highest amount of decrease has occurred in degraded coppices due to converting the coppices into high forests.
- Total amount of growing stocks and annual volume increment of the coniferous and deciduous tree species have increased. Coniferous tree species have had increase around more than 80%.

Considerable reasons of these changes are:

- Moving from the rural to urban areas,
- Giving up old fashion goat breeding and cattle grazing in the forests and the meadows adjacent to forests, also annual grazing plans have been made and implemented by GDF.
- Changing considerations on forestry applications towards multi-functional use of forest resources in the framework of sustainable forest management concept,
- Converting of coppices into high forests,
- Afforestation activities on the bare lands and degraded forests accomplished by the Forestry Service.
- National Afforestation and Erosion Control Action Plan has been initiated since 2008. In the scope of this action plan GDF has made afforestation, rehabilitation, erosion control activities, and artificial regeneration in degraded forests. By doing these activities GDF was aimed at sequestrating more carbon in the forests and converting degraded forests into high forests.

All the factors focused here played affecting roles on these changes. Almost Turkey's entire forests are natural and categorized in temperate climate zone. In this zone, there are 4 sub-climate types have been identified (Figure 6.2).

Assessment of Forest Land Remaining Forestland (Carbon Stock Changes in Normal and Degraded Forests of Turkey between 1990 and 2014)

According to forest inventory data of GDF 2014, 12 323 kha (55.85%) of forests are considered as normal forests and 9 741 kha (44.15%) of forests are considered as degraded forests. Despite the almost approximate distribution of normal and degraded forest land, growing stock and annual increment values are differs from forest area distribution.

Carbon stock changes (CSC) in normal and degraded forests of Turkey (forestland remaining forestland) were estimated since 1990 (see in Tables 6.7 and 6.8). Annual carbon stock changes have been separated according to the annual biomass increment in normal and degraded forests. The percentage of annual carbon stock changes were low in degraded forests due to low values of growing stock and annual biomass increment in degraded forest.

Table 6.7 Carbon removals (living biomass), 1990-2014

(kt)

	Carbon removals (living biomass)									
	Productive[1]				Degraded[2]					
Year	Coniferous	Decidous	Coppices	Productive total	Coniferous	Decidous	Coppices	Degraded total	Total carbon sequestration	CO_2 eq.
1990	7 635	2 758	1 786	12 179	385	147	378	910	13 089	47 994
1991	7 664	2 772	1 796	12 233	387	148	380	915	13 148	48 208
1992	7 694	2 786	1 806	12 286	389	148	382	920	13 206	48 424
1993	7 733	2 801	1 817	12 350	392	149	385	925	13 275	48 676
1994	7 771	2 816	1 827	12 414	394	150	387	931	13 344	48 930
1995	7 810	2 831	1 837	12 478	396	151	389	936	13 414	49 185
1996	7 915	2 872	1 865	12 652	402	153	395	950	13 602	49 873
1997	8 018	2 913	1 893	12 825	408	156	401	965	13 789	50 560
1998	8 123	2 955	1 922	13 000	414	158	407	979	13 979	51 258
1999	8 227	2 997	1 951	13 175	421	160	413	994	14 169	51 953
2000	8 308	3 037	1 980	13 324	427	163	419	1 009	14 333	52 556
2001	8 390	3 077	2 010	13 477	433	165	426	1 024	14 501	53 170
2002	8 570	3 090	2 055	13 715	443	169	435	1 046	14 761	54 124
2003	8 677	3 154	2 060	13 892	450	174	440	1 064	14 956	54 840
2004	8 748	3 279	1 952	13 980	450	175	462	1 087	15 067	55 245
2005	8 721	3 297	2 000	14 017	451	163	458	1 072	15 089	55 328
2006	8 881	3 406	1 936	14 223	456	167	453	1 077	15 300	56 100
2007	8 995	3 481	1 845	14 321	458	172	444	1 074	15 395	56 449
2008	9 052	3 567	1 672	14 292	459	145	425	1 029	15 321	56 177
2009	9 246	3 786	1 616	14 648	453	154	406	1 012	15 660	57 421
2010	9 514	4 161	1 535	15 209	451	150	394	994	16 204	59 414
2011	9 659	4 645	1 494	15 798	439	142	388	969	16 767	61 481
2012	9 873	4 809	1 352	16 034	439	137	371	947	16 981	62 265
2013	10 289	5 068	1 388	16 744	425	143	446	1 014	17 759	65 115
2014	10 635	5 361	942	16 938	414	178	304	895	17 833	65 389

1) Crown closure between 0.11–1.00.
2) Crown closure between 0.01–0.10.

Table 6.8 Annual carbon stock changes of forestland remaining forest land category, 1990-2014

(kt)

	Removals	Emissions				
Year	Living biomass	Commercial cutting	Fuel wood gathering	Other *(Forest fires)	Net carbon sequestration	CO_2 eq.
1990	13 089.3	6 362.2	36.8	169.2	6 521.0	23 910.5
1991	13 147.7	6 121.1	27.6	100.2	6 898.7	25 295.2
1992	13 206.5	6 164.8	37.9	152.8	6 851.0	25 120.2
1993	13 275.3	6 114.2	42.3	193.7	6 925.1	25 391.9
1994	13 344.5	5 164.5	38.8	484.6	7 656.6	28 074.3
1995	13 414.1	6 436.9	41.8	98.4	6 837.0	25 069.2
1996	13 601.8	6 378.1	52.1	192.9	6 978.7	25 588.4
1997	13 789.2	5 995.2	38.2	82.5	7 673.4	28 135.6
1998	13 979.3	5 881.8	33.1	89.3	7 975.1	29 242.2
1999	14 168.9	5 863.0	26.9	77.0	8 201.9	30 073.7
2000	14 333.5	5 875.7	31.6	354.6	8 071.6	29 595.8
2001	14 501.0	5 624.5	25.5	100.4	8 750.7	32 085.9
2002	14 761.0	6 131.0	23.3	125.4	8 481.3	31 098.1
2003	14 956.4	5 893.0	28.9	98.0	8 936.6	32 767.4
2004	15 066.7	6 334.7	27.1	71.8	8 633.2	31 655.0
2005	15 089.4	6 253.4	19.1	41.1	8 775.7	32 177.5
2006	15 300.0	6 120.9	14.8	114.1	9 050.2	33 184.2
2007	15 395.3	6 375.3	14.6	172.0	8 833.3	32 388.9
2008	15 321.1	7 107.2	11.9	439.0	7 763.0	28 464.3
2009	15 660.4	7 134.0	11.6	69.1	8 445.7	30 967.5
2010	16 203.8	7 542.4	11.2	49.4	8 600.7	31 536.0
2011	16 767.5	7 811.4	9.7	53.9	8 892.5	32 605.9
2012	16 981.4	8 109.2	10.2	156.1	8 705.8	31 921.2
2013	17 758.6	7 603.0	10.2	170.4	9 975.0	36 575.1
2014	17 833.4	7 942.3	26.6	46.1	9 818.4	36 000.9

Assessment of Land Converted to Forest Land

Annual changes from lands converted to forest lands can be determined by ENVANIS system. These changes were showed (See table 6.9). We assume these areas are grassland, because most of these areas in Turkey are not owned privately unlike other areas such as cropland. Annual CSCs (emissions and removals) land converted forestland has been estimated since 1990 in Table 6.10.

Table 6.9 Areas of land converted to forest land in Turkey, 1971-2014

(kha)

Year	Area	Year	Area
1971	0	1993	23 171
1972	0	1994	23 171
1973	20 544	1995	23 171
1974	20 544	1996	23 171
1975	20 544	1997	29 857
1976	20 544	1998	30 189
1977	20 544	1999	38 789
1978	20 544	2000	107 044
1979	20 544	2001	107 044
1980	20 544	2002	107 728
1981	20 544	2003	78 396
1982	20 544	2004	83 765
1983	20 544	2005	64 335
1984	23 171	2006	50 259
1985	23 171	2007	45 723
1986	23 171	2008	55 678
1987	23 171	2009	71 206
1988	23 171	2010	149 565
1989	23 171	2011	37 861
1990	23 171	2012	134 893
1991	23 171	2013	214 710
1992	23 171	2014	182 430

Table 6.10 Annual carbon stock changes of land converted to forest land, 1990-2014

(kt)

	Carbon gains						Carbon losses				
Year	Living biomass (coniferous forests)	Living biomass (deciduous forests)	Living biomass (Total forests)	Dead organic matter	Soil	Total gains	Living biomass (grassland)	Dead organic matter	Soil	Net carbon sequestration	CO_2 eq.
1990	164.4	17.8	182.2	135.2	1 491.9	1 809.3	36.1	1.2	568.7	1 203.4	4 412.4
1991	174.2	18.9	193.0	143.3	1 581.0	1 917.3	38.3	1.2	602.6	1 275.2	4 675.7
1992	184.0	19.9	203.9	151.4	1 670.1	2 025.3	40.4	1.3	636.6	1 347.0	4 939.1
1993	185.1	20.0	205.2	152.3	1 680.2	2 037.6	40.7	1.3	640.4	1 355.2	4 969.0
1994	186.2	20.2	206.4	153.2	1 690.3	2 049.8	40.9	1.3	644.3	1 363.3	4 998.9
1995	187.3	20.3	207.6	154.1	1 700.3	2 062.1	41.1	1.3	648.1	1 371.5	5 028.7
1996	188.5	20.4	208.9	155.0	1 710.4	2 074.3	41.4	1.3	652.0	1 379.6	5 058.6
1997	192.4	20.8	213.2	158.3	1 746.2	2 117.7	42.3	1.4	665.6	1 408.5	5 164.4
1998	196.5	21.3	217.7	161.6	1 783.3	2 162.7	43.2	1.4	679.8	1 438.4	5 274.1
1999	204.2	22.1	226.3	168.0	1 853.4	2 247.7	44.8	1.4	706.5	1 494.9	5 481.4
2000	240.8	26.1	266.9	198.1	2 185.9	2 650.9	52.9	1.7	833.2	1 763.1	6 464.7
2001	277.5	30.0	307.5	228.2	2 518.3	3 054.1	60.9	2.0	959.9	2 031.2	7 447.9
2002	331.1	21.1	352.2	266.3	2 846.4	3 464.9	69.0	2.2	1 087.6	2 306.0	8 455.3
2003	355.8	23.6	379.4	286.5	3 068.7	3 734.6	74.4	2.4	1 172.4	2 485.4	9 113.2
2004	384.1	24.4	408.5	308.8	3 300.5	4 017.8	80.1	2.6	1 261.2	2 673.9	9 804.5
2005	398.6	28.5	427.1	321.8	3 459.9	4 208.8	83.9	2.7	1 321.5	2 800.8	10 269.5
2006	407.4	31.8	439.2	330.0	3 565.2	4 334.4	86.4	2.8	1 361.2	2 884.0	10 574.7
2007	399.8	46.1	445.9	330.0	3 659.0	4 434.9	88.5	2.9	1 394.2	2 949.3	10 814.2
2008	411.7	49.0	460.7	340.5	3 784.7	4 585.9	91.5	3.0	1 441.8	3 049.6	11 181.8
2009	425.4	56.3	481.7	354.2	3 972.1	4 808.0	96.0	3.1	1 512.2	3 196.7	11 721.3
2010	469.1	69.7	538.8	393.7	4 461.9	5 394.5	107.8	3.5	1 697.4	3 585.9	13 148.3
2011	467.6	76.3	544.0	395.3	4 521.6	5 460.9	109.1	3.5	1 718.9	3 629.4	13 307.7
2012	496.8	95.4	592.2	425.9	4 958.6	5 976.8	119.5	3.9	1 882.6	3 970.8	14 559.7
2013	526.3	144.1	670.3	469.0	5 716.3	6 855.6	137.3	4.4	2 163.2	4 550.7	16 686.0
2014	554.5	181.7	736.1	506.5	6 344.8	7 587.4	152.1	4.9	2 396.5	5 033.9	18 457.6

Assessment of Forest Land Converted to Grass Land

Annual changes from forest land converted grass land (deforestation) can be monitor by ENVANIS system. These changes were showed (See table 6.11). We assume these areas are grassland. Annual CSCs (emissions and removals) of forest land converted grass land have been estimated since 1990 in Table 6.12.

Table 6.11 Areas of forest land converted to grass land in Turkey, 1971-2014

(kha)

Year	Area	Year	Area
1971	0	1993	2.6
1972	0	1994	2.6
1973	0	1995	2.6
1974	0	1996	2.6
1975	0	1997	9.3
1976	0	1998	9.3
1977	0	1999	9.3
1978	0	2000	9.3
1979	0	2001	9.3
1980	0	2002	10.0
1981	0	2003	9.8
1982	0	2004	20.1
1983	0	2005	4.6
1984	2.6	2006	3.6
1985	2.6	2007	12.2
1986	2.6	2008	21.2
1987	2.6	2009	44.6
1988	2.6	2010	2.3
1989	2.6	2011	0.0
1990	2.6	2012	31.7
1991	2.6	2013	5.9
1992	2.6	2014	5.6

ENVANIS system have provided total of deforestation areas in the period between year 2001 and 1997 , between year 1996 and 1984. Then the amounts of areas were distributed equally between these years.

Table 6.12 Annual carbon stock changes of forest land converted to grassland, 1990-2014

(kt)

	Carbon gains				Carbon losses					
Year	Living biomass (Grass land)	Dead organic matter	Soil	Total gains	Living biomass (Forest land)	Dead organic matter	Soil	Total losses	Net carbon emission	CO_2 eq.
1990	1.7	0.1	26.9	28.7	7.5	5.2	71.8	84.5	55.8	204.6
1991	2.0	0.1	30.8	32.8	8.6	6.0	82.0	96.6	63.8	233.9
1992	2.2	0.1	34.6	36.9	9.7	6.7	92.3	108.7	71.8	263.1
1993	2.4	0.1	38.5	41.0	10.8	7.4	102.6	120.7	79.7	292.3
1994	2.7	0.1	42.3	45.1	11.8	8.2	112.8	132.8	87.7	321.5
1995	2.9	0.1	46.2	49.2	12.9	8.9	123.1	144.9	95.7	350.8
1996	3.2	0.1	50.0	53.3	14.0	9.7	133.3	157.0	103.6	380.0
1997	4.0	0.1	63.7	67.9	17.8	12.3	169.7	199.8	131.9	483.6
1998	4.9	0.2	77.3	82.4	21.6	14.9	206.0	242.5	160.2	587.2
1999	5.8	0.2	91.0	96.9	25.4	17.6	242.4	285.3	188.4	690.8
2000	6.6	0.2	104.6	111.5	29.2	20.2	278.7	328.1	216.7	794.4
2001	7.5	0.2	118.3	126.0	33.0	22.8	315.1	370.9	244.9	898.0
2002	8.4	0.3	132.9	141.6	37.6	25.4	354.3	417.3	275.7	1 010.7
2003	9.4	0.3	147.2	156.9	41.4	28.3	392.4	462.1	305.2	1 119.2
2004	11.0	0.4	172.8	184.1	48.6	33.2	460.5	542.3	358.2	1 313.5
2005	11.2	0.4	175.7	187.2	49.4	33.8	468.1	551.3	364.1	1 335.1
2006	11.2	0.4	177.1	188.7	49.7	34.1	471.9	555.6	367.0	1 345.6
2007	12.1	0.4	191.0	203.6	53.4	36.9	509.0	599.2	395.7	1 450.8
2008	13.9	0.5	218.2	232.5	60.8	42.3	581.3	684.3	451.8	1 656.5
2009	17.8	0.6	279.8	298.1	77.7	54.3	745.2	877.1	579.0	2 122.9
2010	17.7	0.6	279.2	297.5	77.2	54.3	743.6	875.1	577.6	2 117.7
2011	17.5	0.6	275.4	293.4	76.4	53.5	733.4	863.2	569.8	2 089.3
2012	20.2	0.7	318.0	338.8	87.7	62.0	846.7	996.4	657.5	2 410.9
2013	20.5	0.7	322.8	343.9	88.1	63.4	859.0	1 010.4	666.5	2 443.8
2014	20.8	0.7	327.2	348.6	89.1	64.4	870.6	1 024.0	675.4	2 476.4

Data on Forest Fires and Others

The information about the forest fires was received from the Department of Fighting Forest Fires of General Directorate of Forestry and written on the table 6.13.

Table 6.13 Forest fires in Turkey, 2014

Fire number	Total area (ha)	Fire types: Ground vegetation (ha)	Fire types: Crown (ha)
2 149	3 117	1 311.3	1 806.5

These statistics contain forest area exposed to fire, fire type and standing volume with bark removed from forest because of the fire. Non-CO_2 GHG emitted by wildfire was calculated based on the biomass burned with 44% burning productivity according to Forest Fire Statistics of GDF. This rate was estimated from Combating Forest Fire Department's data.

Existing document concerning the forest resources and forestry activities permitted to second level communication (T2 methods) mainly during the calculation of carbon uptake and the other GHG inventory. Since there was no adequate and baseline data on land use changes concerning the olden time, first level communication (T1 methods) was applied for the estimation of carbon sequestrations and GHG emissions between the years 1990–2014.

The required data on the dead organic matter's annual carbon change for forestland remains forestland because of the absence of specific researches in this scope. Carbon contents in the forest soils were not considered too due to same reason for forestland remains forestland. Thus, both of these carbon pools were not taken into account because of the lack of document suitable for these purposes. Due to the extraordinary peculiarities among the geographical regions in Turkey (southern and western parts of the country have Mediterranean forest conditions while the northern part looks like typical west European forests) default values for these pools given in the Guidance annexes tables could not be used.

The emissions of other GHG changed depending on the burned forest areas (see table 6.14). There is no definite and significant trend throughout the reporting period. Country specific data were used for the amount of burning biomass were entered into Table 4(A.1) of CRF.

Table 6.14 Changes in the other greenhouse gasses caused by forest fires, 1990-2014

(tonnes)

Year	CH_4	N_2O	NO_x	CO
1990	0.00113	0.00006	0.00072	0.02584
1991	0.00067	0.00004	0.00043	0.01530
1992	0.00102	0.00006	0.00065	0.02332
1993	0.00130	0.00007	0.00083	0.02957
1994	0.00325	0.00018	0.00207	0.07398
1995	0.00066	0.00004	0.00042	0.01502
1996	0.00129	0.00007	0.00083	0.02945
1997	0.00055	0.00003	0.00035	0.01259
1998	0.00060	0.00003	0.00038	0.01363
1999	0.00052	0.00003	0.00033	0.01176
2000	0.00238	0.00013	0.00152	0.05413
2001	0.00067	0.00004	0.00043	0.01533
2002	0.00085	0.00005	0.00054	0.01924
2003	0.00066	0.00004	0.00042	0.01504
2004	0.00048	0.00003	0.00031	0.01102
2005	0.00028	0.00002	0.00018	0.00630
2006	0.00077	0.00004	0.00049	0.01748
2007	0.00116	0.00006	0.00074	0.02633
2008	0.00295	0.00016	0.00188	0.06716
2009	0.00046	0.00003	0.00030	0.01057
2010	0.00033	0.00002	0.00021	0.00756
2011	0.00036	0.00002	0.00023	0.00824
2012	0.00105	0.00006	0.00067	0.02385
2013	0.00114	0.00006	0.00073	0.02592
2014	0.00031	0.00002	0.00020	0.00701

Methodology

Annual CSC calculations of forests made by gain and loss method. Annual CSC in living biomass and net carbon stock change in dead organic matter and soil in forest areas were evaluated as three categories divided into 4.A.1 Forest remaining Forest Land, 4.A.2 Land Converted to Forest Land and 4.C.2 Forest Land Converted to Grass Land (Table 6.15).

Table 6.15 Annual changes in carbon stocks in forest areas, 2014

GHG sources and sink categories	Activity data	Changes in carbon stock (kt C)				
		Carbon stock change in living biomass			Net carbon stock change in dead organic matter and soil	Net CO_2 emissions/ removals (kt)
Land-use category	Area (kha)	Gains	Losses	Net change		
Total Forest Land	22 063.8	-18 590.3	8 256.2	-10 334.1	-3 842.8	-51 982.1
1. Forest Land remaining Forest Land	20 063.0	-17 833.4	8 015.0	-9 818.4	0.0	-36 000.9
2. Land converted to Forest Land	1 635.8	-736.1	152.1	-584.0	-4 449.9	-18 457.6
3. Forest Land converted to Grass Land	223.3	-20.8	89.1	68.3	607.1	2 476.4

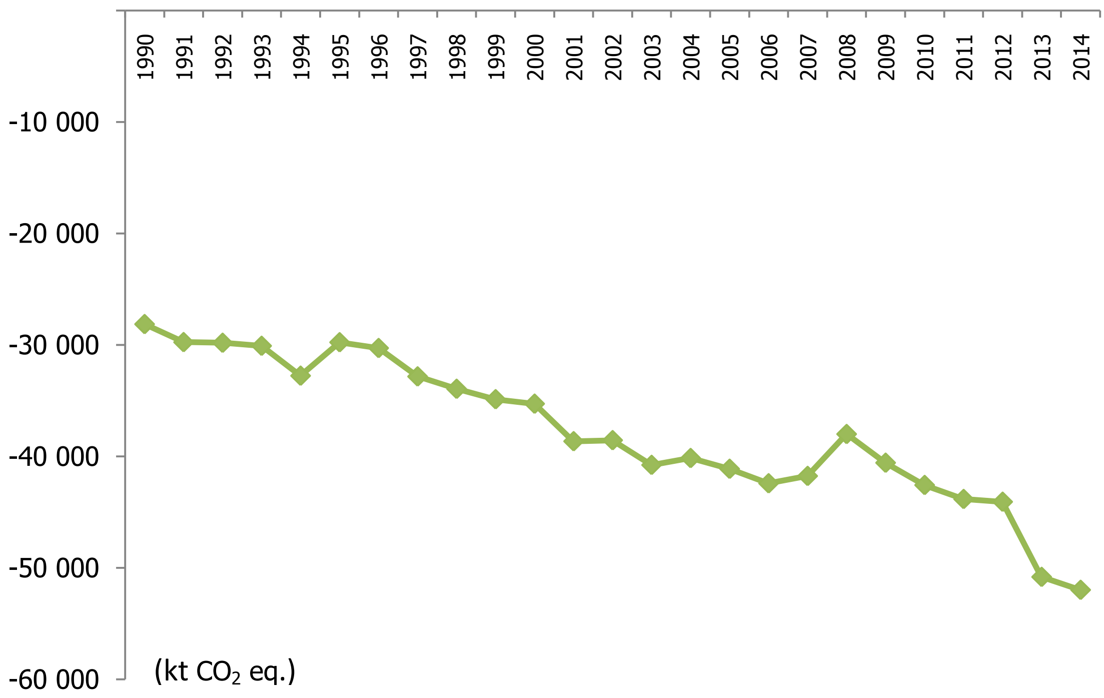
Net carbon sequestration and removals between 1990 and 2014 in the forests of Turkey are outlined in Table 6.16 and shown in Figure 6.3.

Table 6.16 Net carbon emissions and removals in the forests, 1990-2014

Year	Carbon gains (tonnes)	Carbon losses* (tonnes)	Net removals (kt)	CO_2 eq. (kt)
1990	14 927 303	7 258 691	7 668.6	28 118.3
1991	15 097 813	6 987 688	8 110.1	29 737.1
1992	15 268 708	7 142 453	8 126.3	29 796.3
1993	15 353 875	7 153 346	8 200.5	30 068.6
1994	15 439 431	6 507 172	8 932.3	32 751.6
1995	15 525 378	7 412 531	8 112.9	29 747.1
1996	15 729 418	7 474 776	8 254.6	30 267.0
1997	15 974 760	7 024 820	8 949.9	32 816.5
1998	16 224 400	6 971 031	9 253.4	33 929.0
1999	16 513 532	7 005 080	9 508.5	34 864.3
2000	17 095 816	7 477 803	9 618.0	35 266.1
2001	17 681 119	7 144 104	10 537.0	38 635.7
2002	18 367 548	7 855 910	10 511.6	38 542.7
2003	18 847 962	7 731 225	11 116.7	40 761.4
2004	19 268 614	8 319 718	10 948.9	40 146.0
2005	19 485 373	8 273 031	11 212.3	41 111.9
2006	19 823 013	8 255 737	11 567.3	42 413.4
2007	20 033 672	8 646 689	11 387.0	41 752.3
2008	20 139 533	9 778 741	10 360.8	37 989.6
2009	20 766 511	9 703 097	11 063.4	40 565.9
2010	21 895 801	10 286 723	11 609.1	42 566.6
2011	22 521 808	10 569 716	11 952.1	43 824.3
2012	23 296 940	11 277 851	12 019.1	44 070.0
2013	24 958 186	11 098 919	13 859.3	50 817.3
2014	25 769 381	11 592 457	14 176.9	51 982.1

*Other carbon lost from insect and fungus disturbances are not included.
*Fuel wood gathering data was taken from the Turkish Forestry's Statistic 2015 (GDF, 2015).

Figure 6.3 Net CO_2 removals in Turkish forests, 1990-2014



Annual removals and emissions from forest land remaining forest land were calculated by the following Gain and Losses Equation 2.4 of IPCC National GHG Inventories Guidelines 2006 Vol 4 Agriculture, Forestry and Other Land Use (AFOLU):

Equation 2.4

$$\Delta C_B = \Delta C_G - \Delta C_L$$

Annual Increment in Carbon Stocks Due to Living Biomass Increment in Forest Land Remaining Forest Land

Removals (average annual increase in carbon stocks due to biomass growth) were calculated according to the following 2.9 and 2.10 of IPCC National GHG Inventories Guidelines 2006 Vol 4 AFOLU.

Annual Increment in Biomass

Equation 2.9, 2.10

$$G_{TOTAL} = \sum (G_W * (1+R))$$

$$G_{TOTAL} = \sum [(I_V * D * BCEF_I) * (1+R)]$$

$$\Delta C_G = \sum (A_{i,j} * G_{TOTAL} * CF_{i,j})$$

$$\Delta C_G = I_v \times BCEF_I \times (1+R) \times CF$$

For annual increase in carbon stocks, both the national and default data were used. National forestry data was mainly come from the General Directorate of Forestry.

- Area of forest land: It exists for each management class in the forest management plans (T2).
- Average annual net increment in volume suitable for industrial processing (I_V): It exists for each management class in the forest management plans (T2).
- Average basic wood density (BWD) and biomass conversion and expansion factors (BCEF). It was determined for all fundamental tree species and vegetation types which form a stand in the Turkey's forests (Tolunay, 2013) (Table 6.17) (T2).
- Annual increment for young stands (≥20 years old) and land converted to forest land accepted as 1.95 m^3/ha for coniferous, 1.24 m^3/ha for deciduous according to GDF expert judgment.

Table 6.17 The Average basic wood density and national BCEF's factors

Used for coniferous and deciduous

Vegetation type	Basic wood density (tonnes/m³)	$BCEF_I$ (tonnes/m³)	BCEFs (tonnes/m³)	$BCEF_R$ (tonnes/m³)
Coniferous	0.446	0.541	0.563	0.626
Deciduous	0.541	0.709	0.717	0.797

The Basic wood density of Turkey's fundamental tree species

Coniferous		Wood density (g/cm³)	Deciduous		Wood density (g/cm³)
Pinus brutia	Turkish Pine	0.478	*Fagus orientalis*	The Oriental Beech	0.530
Pinus nigra	European Black Pine	0.470	*Quercus ssp.*	Oak	0.570
Pinus sylvestris	Scots Pine	0.426	*Carpinus ssp*	Hornbeam	0.630
Abies ssp.	Fir	0.350	*Alnus ssp.*	Black Alder	0.407
Picea orientalis	Oriental Spruce	0.358	*Populus ssp*	Poplar	0.350
Cedrus libani	Taurus Cedar	0.430	*Castanea sativa*	Sweet Chestnut	0.480
Juniperus ssp	Juniper	0.460	*Fraxinus excelsior*	The Ash	0.562
Pinus pinea	Stone Pine	0.470	*Platanus orientalis*	The Oriental plane	0.580
Pinus halepensis	Aleppo Pine	0.480	*Liquid ambar orientalis*	Turkish Sweetgum	0.468
Pinus pinaster	The Maritime Pine	0.440	*Robiniapseudo acaccia*	The Black Locust	0.680
Pinus radiata	The Monterey Pine	0.380		Other Deciduos	0.550
	Other coniferous	0.431			

- Root-to-shoot ratio (R): Default data used for temperate zone in the IPCC 2006 Guidance Table 4.4 and accounted distinctly for each management class based on the growing stock in hectare (Table 6.18).
- Carbon fraction of dry matter (CF): Default value of IPCC 2006 Guidance Table 4.3 was used for carbon fraction of dry matter (Table 6.18).

Table 6.18 Root/Shoot rates and carbon content used for temperate zone forests

	Above-ground biomass (tonnes/ha)	Root/Shoot	C Content (Fraction) (%)
	< 50	0.40	
Coniferous	50 - 150	0.29	51
	> 150	0.20	
	< 75	0.46	
Deciduous	75 - 150	0.23	48
	> 150	0.24	

Annual Decrease in Carbon Stocks Due to Biomass Loss in Forest Land Remaining Forest Land

Annual biomass loss is a sum of losses from commercial round wood fallings, fuel wood gathering and other losses in forest land was calculated by using the following Equation 2.11 of AFOLU Guidance. In the estimations, biomass gains and biomass losses are calculated separately. For example, commercial round wood falling is being calculated in a different column as well as fuel wood gathering and other losses according to the Equation 2.12, Equation 2.13 and Equation 2.14 respectively. The calculations of biomass losses are consistent with the IPCC 2006 Guidance for AFOLU Vol 4 AFOLU.

Equation 2.11. $\Delta C_L = L_{\text{wood removals}} + L_{\text{fuelwood}} + L_{\text{disturbance}}$

Annual Carbon Loss Due to Wood Removals

Equation 2.12. $L_{\text{wood removals}} = H \bullet BCEF_R \bullet (1+R) \bullet CF$

H: Wood harvesting data includes whole harvested woods as industrial harvesting including planned harvests (m^3/year) (T2).

Annual Carbon Loss Due to Fuelwood Gathering

Equation 2.13. $L_{\text{fuelwood}} = [\{FG_{\text{trees}} \bullet BCEF_R \bullet (1+R)\} + FG_{\text{part}} \bullet D] \bullet CF$

FG: Fuel wood gathering and illegal cutting data obtained from the General Directorate of Forestry (Forestry Statistic 2013) was used here(m^3/year) (T2). According to General Directorate of Forestry’s data illegal cutting percent is 67, fuel wood gathering percent is 33.

Annual Other Losses of Carbon

Equation 2.14. $L_{disturbance} = \{A_{disturbance} \bullet B_W \bullet (1 + R) \bullet CF \bullet fd\}$

$A_{disturbance}$= Forest areas burnt by fires were taken into account(ha/year) (T1).

B_W= average above-ground biomass of land areas affected by disturbances, (tonnes/ha). This biomass cover the dead organic matter. Relevant burning rate was fixed to the Guidance (Tables 2.4, 2.5) (T1).

fd= fraction of biomass lost in disturbance. It was estimated that average biomass in the fired areas could be burned with 44% (0.44) percent of burning productivity (GDF 2014).

Annual Change in Carbon Stocks in Dead Organic Matter in Forest Land Remaining Forest Land

Equation 2.17. $\Delta C_{DOM} = \Delta C_{DW} + \Delta C_{LT}$

There was no sufficient data on the dead organic matter's annual carbon stock change in the Turkey's forests. For this reason the annual carbon stock change in the dead organic matter was assumed as zero according to the Guidance.

Annual Change in Carbon Stocks in Soils in Forest Land Remaining Forest Land

Equation 2.24. $\Delta C_{Soils} = \Delta C_{Mineral} - L_{Organic} + \Delta C_{Inorganic}$

There was no adequate data on the soils annual carbon stock change in the Turkey's forests. For this reason the carbon stock change in the soils was assumed as zero according to the Guidance

Estimation of Non-CO_2 Emissions from C Released

Estimation of GHGs Directly Released in Fires

Equation 2.27. $L_{fire} = A \bullet M_B \bullet C_f \bullet G_{ef} \bullet 10^{-3}$

Where:

L_{fire} = quantity of GHG released due to fire, tonnes of GHG

A= area burnt, ha

M_B= mass of fuel available for combustion, kg d.m. ha^{-1} (GDF data)

C_f= combustion factor (IPCC 2006 Guidance Table 2.6)

G_{ef}= emission factor, g kg^{-1}(IPCC 2006 Guidance Table 2.5)

Annual removals and emissions from land converted to forest land were calculated by the following Equations of IPCC 2006 Guidance Vol 4 AFOLU:

Annual Increment in Carbon Stocks Due to Living Biomass Increment in Land Converted to Forest Land

Equation 2.16. $$\Delta C_{CONVERSION} = \sum \{(B_{AFTERi} - B_{BEFOREi}) * \Delta A_{TO\_OTHERSi}\} * CF$$

The conversion period accepted assumed 20 years according to guidance.

Annual Change in Carbon Stocks in Dead Organic Matter in Land Converted to Forest Land

Equation 2.19. $$\Delta C_{DOM} = \left[A * \frac{(DOM_{t2} + DOM_{t1})}{T}\right] * CF$$

T: 20 years according to guidance.

We used dead organic matter C stock values given by Tolunay and Çömez (2008) :

DOM (tonnes/ha)		
Coniferous	7.51	± 6.61 (n=601)
Deciduous	3.09	± 1.58 (n=368)

Annual Change in Carbon Stocks in Soils in Land Converted to Forest Land

Equation 2.24. $$\Delta C_{Mineral} = \frac{SOC_0 + SOC_{(0-T)}}{D}$$

We used soil carbon stock values given by Tolunay and Çömez (2008) :

Soil organic carbon (tonnes/ha)		
Coniferous	76.37	±51.03 (n=820)
Deciduous	80.40	±58.95 (n=191)

Uncertainty and Time Series Consistency

To estimate the uncertainty levels in parameters and formulas, IPCC 2006 Guidance recommends using the 3.1 and 3.2 equations:

Equation 3.1. $U_{toplam} = \sqrt{U_1^2 + U_2^2 + ... + U_n^2}$

Equation 3.2. $U_E = \frac{\sqrt{(U_1 \bullet E_1)^2 + (U_2 \bullet E_2)^2 + ... + (U_n \bullet E_n)^2}}{|E_1 + E_2 + ... + E_n|}$

Whole calculated uncertainty levels are expressed as follow in Table 6.19:

Table 6.19 Uncertainty estimates of parameters

Parameters	Uncertainty (%)
- BCEFI	
Coniferous	6.2
Deciduous	9.6
-BCEFS	
Coniferous	4.3
Deciduous	6.5
- BCEFR	
Coniferous	4.4
Deciduous	6.6

Uncertainty According to the Expert Judgment

For parameters related the forest areas from the GDF source	0.03%
For parameters related the volume from the GDF source	10%
For parameters related the volume increment from the GDF source	10%
For parameters related the commercial wood volume from SPO	5%
For parameters related the fuel wood gathering from SPO	15%
For parameters related the burned forest areas from SPO	10%

Total uncertainty for Forest Land category is 23.5%.

Time Series Consistency

Since there are two forest inventory carried out by the General Directorate of Forestry for 1972, 1999before 2004, the data on the forest areas, growing stocks and annual volume increments during

1990-2003 period were calculated by interpolation between these three inventory data. Thus, the annual increase of forest areas were assumed as linear as well growing stocks and volume increments were accepted to increase with the compound interest basis. The data for the 2004-2014 were obtained annually from the Management and Planning Department of General Directorate of Forestry.

The statistics on the forest fires and commercial round wood production for the same period and fuel wood gathering data were taken from the same Directorate.

6.3. Croplands (Category 4.B)

Source Category Description:

Cropland remaining Cropland and Land converted to Cropland has been reported under this category.

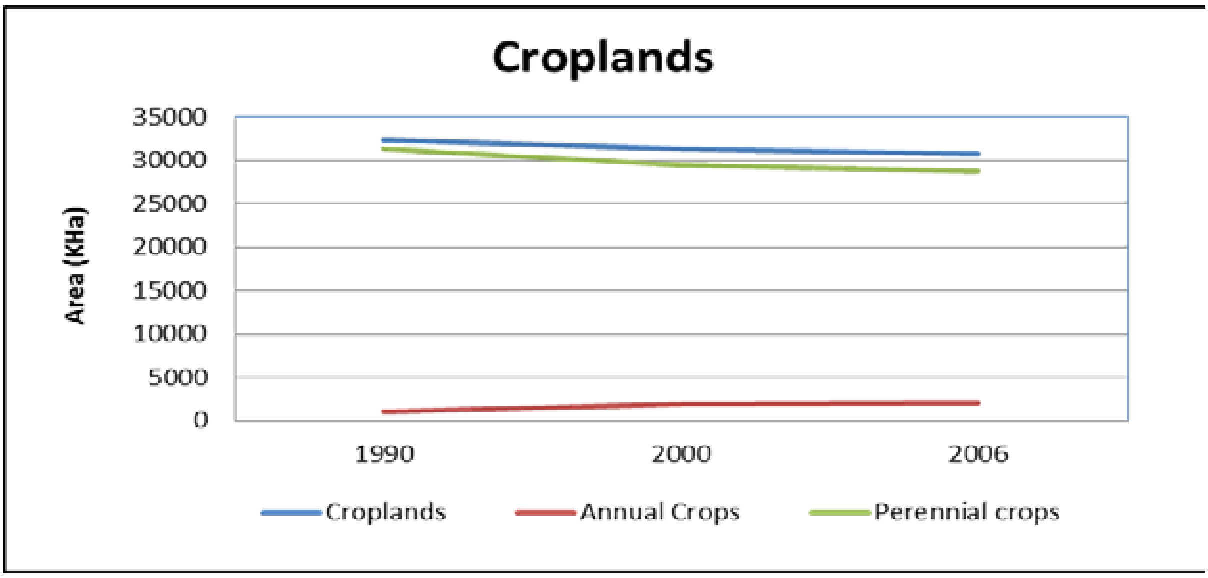
CSC in aboveground, belowground, organic and mineral soil pools have been calculated and reported. The Cropland category was a large source in the last submission but has diminished with the change in EFs and AD.

The Cropland covers all perennial and annual crops in agriculture lands. Orchards and poplars are included in this category.

Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

As explained in the AD section database we have calculated land use changes based on 3 temporal time points: 1990, 2000 and 2006. We had a more compatible and consistent monitoring system with this methodology. In Turkey the cropland areas decreased between 1990 and 2006 as seen in Figure 6.4.

Figure 6.4 The temporal change in croplands in Turkey between 1990 and 2006.



The annual crops have a decreasing trend while the aerial distribution of perennial crops increases. The AD given in CRF table 5B is the cropland areas that are subject to changes in management. The total area of croplands in Turkey was 28 774.21 ha in 2006. In 1990 it was 31 259.93 ha.

Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

Cropland areas have been determined as annual crops and perennial woody crops and disaggregated for IPCC climate and soil types (Table 6.20).

Table 6.20 Land use changes between 1990-2000 and 2000-2006 in Turkey

(ha)

	From	Croplands		Wetlands	Grasslands				Otherlands	
to		Perennial	Annual	Artificial	Green areas	Pastures	Natural grasslands	Settlements	Otherland	Mine areas
1990-2000										
Croplands	Perennial	856 689.75	198 708.98	1 582.76	381.92	2 602.32	22 432.36	14 531.96	5 060.92	387.34
	Annual	882 001.72	26 373 335.18	90 693.18	7 764.88	450 369.22	1 972 403.18	385 765.80	789 549.73	15 162.68
Wetlands	Artificial	2 243.78	54 479.14	1 029 089.77	142.72	10 059.02	19 257.97	864.16	22 341.42	217.05
Grasslands	Green areas	658.73	6 790.47	33.13	11 725.76	560.16	493.71	10 818.87	572.20	1.58
	Pastures	18 346.79	364 130.83	5 724.40	491.70	581 855.28	505 711.75	32 396.84	71 741.68	3 099.09
	Natural gr.	54 448.54	945 734.20	4 899.12	1 250.23	754 991.52	4 982 048.22	25 695.68	908 251.74	5 407.31
Settlements	Settlements	8 607.61	137 248.45	332.76	1 296.28	4 805.81	10 198.36	697 911.13	7 967.80	1 273.54
Otherlands	Otherland	49 599.06	961 362.32	35 568.48	1 737.02	162 085.98	4 225 350.71	15 073.51	6 726 439.73	162 085.98
	Mine areas	551.90	12 470.79	1 575.40	367.00	5 729.20	2 944.23	18 376.83	7 034.63	24 593.83
2000-2006										
Croplands	Perennial	853 417.33	194 964.97	2 275.62	2 706.39	14 993.51	56 268.59	12 054.36	49 113.43	1 741.38
	Annual	877 972.31	26 409 623.93	60 823.36	16 048.75	293 639.93	918 949.16	182 381.16	972 775.63	24 675.68
Wetlands	Artificial	160.41	17 178.87	1 132 367.75	67.03	1 643.64	1 480.69	451.23	17 899.54	677.45
Grasslands	Green areas	115.10	3 042.01	152.22	19 443.06	364.74	554.22	1 844.51	653.34	105.16
	Pastures	3 013.27	444 832.40	10 136.40	863.34	579 302.02	754 034.96	7 246.59	165 544.75	6 993.94
	Natural gr.	22 790.82	1 952 478.31	21 970.61	1 501.85	471 268.97	5 024 595.84	13 500.88	4 267 192.71	7 485.20
Settlements	Settlements	8 028.72	251 153.66	1 194.59	16 634.28	10 607.17	15 129.10	896 344.56	13 993.14	6 569.71
Otherlands	Otherland	4 418.77	767 649.99	20 883.51	2 200.32	62 428.44	879 351.63	9 840.46	6 823 610.72	13 296.10
	Mine areas	212.31	7 297.33	567.26	736.16	1 115.56	3 403.70	4 276.76	9 336.89	43 130.07

Methodological Issues:

New emission/removal factors

The Scientific and Technical Research Council of Turkey (TUBITAK) Project (COST 112Y096) mentioned in the Planned Improvements section of the previous NIR has not been completed but some preliminary results have been provided and used in this NIR (i.e. Table 6.21). This project entitled "*Development of a climate change-ecosystem services software to support sustainable land planning works*" involved in quantification of ecosystem services including C sequestration in urban and peri-urban regions.

The carbon stocks for the pools have been calculated on 59 sample plots in forests, agriculture areas and pastures. The study is conducted in warm-dry high activity clay (HAC) soils that are the dominant climate and soil type in Turkey. The sample size for the soil C stocks for croplands of this study is relatively small therefore a larger scale study has been conducted and reported (Table 6.21) for cropland soils as explained below. Dry organic matter contents have been determined and IPCC (2006) default CF values were used to convert biomass d.m. values to C.

Table 6.21 Carbon stocks calculated for various land uses

	soil (t C/ha)		Litter (t C/ha)		AG (t C/ha)		BG[1] (t C/ha)	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
Pasture	100.56	36.69	0.06	0.07	0.49	0.36	1.37	NA
Croplands (annual)	50.49	NA	0.27	0.36	0.75	0.27	0.00	NA
Coniferous	127.38	127.38	4.43	3.27	130.60	77.32	26.12	15.46
Deciduous	97.29	29.98	2.86	1.65	157.75	125.98	37.86	30.23
Mixed (Con-Dec)	122.70	37.15	4.02	1.77	135.16	71.10	28.23	15.03
Deciduous-Recr.	97.77	21.53	1.49	0.70	157.59	125.72	37.86	30.23

[1]Below ground biomass was calculated using IPCC (2006) default values.

CS Estimation for Land Converted to Settlements Category

The land converted to settlement category has been reported in the previous submission for the first time. The calculated conversions were for cropland converted to settlements (CL-SL) and grasslands converted to settlements (GL-SL). It is a widely accepted fact that most of the sprawl in Turkey occurs on croplands and grasslands around the cities. On the other hand conversion from settlements to other land uses is not a typical occurrence and is not estimated conservatively. To estimate CSC due to conversions of GL-SL and CL-SL, CS in SL has to be determined. The CS of settlements has been calculated based on the below values (Table 6.22) in the context of the TUBITAK 112Y096 project. The following methodology has been applied;

- The study area (740 km^2) has been divided into 500*500 meter grids,
- The land uses in each grid have been determined from SPOT6 2013 satellite image with a 1.5*1.5 meter resolution using supervised classification,
- The accuracy check has been performed with 1000 plots with over 90% accuracy,
- The land use in each grid has been multiplied by carbon stocks given in Table 6.20.
- The impervious areas in each grid has been grouped under 5 classes that are >20%, >40%, >60%, and >80%. The project area has been classified for 4 settlement intensity classes in this way (Table 6.21).

Table 6.22 Total carbon stocks calculated for various settlements intensity classes

Settlement class (SC)	Settlement intensity (% imperviousness)	$\bar{x}$(t C /ha)	σ(t C /ha)	Sample size (#)
1	>20	85.27	74.19	1 145
2	>40	51.87	41.85	697
3	>60	32.04	25.32	438
4	>80	17.26	13.73	258

- Finally, Corine 2006 Land Use map was superposed on this grid layer and average settlement intensity was calculated. In other words the intensity of settlements land cover under CORINE classification was determined. The 10% was in the 2^{nd} SC, 30% in the 3^{rd}, while 60% was in the 4^{th} SC.

The weighted average for CORINE settlement land cover has been calculated as 25.17 t C/ha including all carbon pools (AG, BG, LDW, and S).

The settlement intensity and CS in the study are of the TUBITAK 112Y096 is given in Figure 6.5 and Figure 6.6.

Figure 6.5 Impervious areas in the study area (Alibeyköy, Sazlıdere and Kağıthane watersheds in Istanbul)

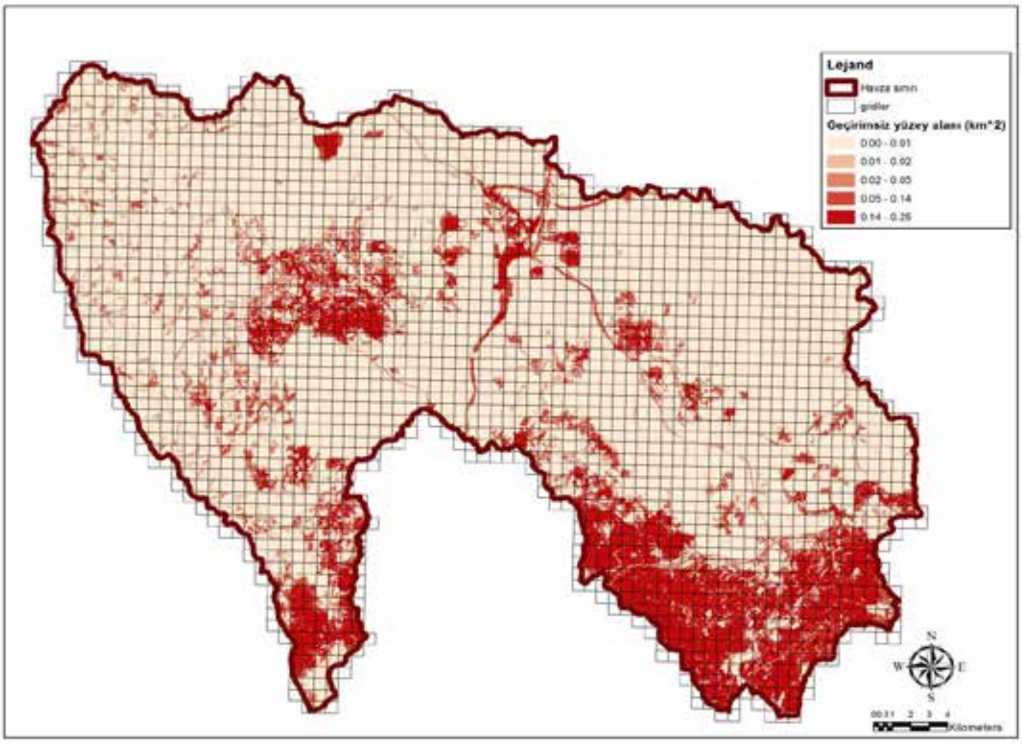
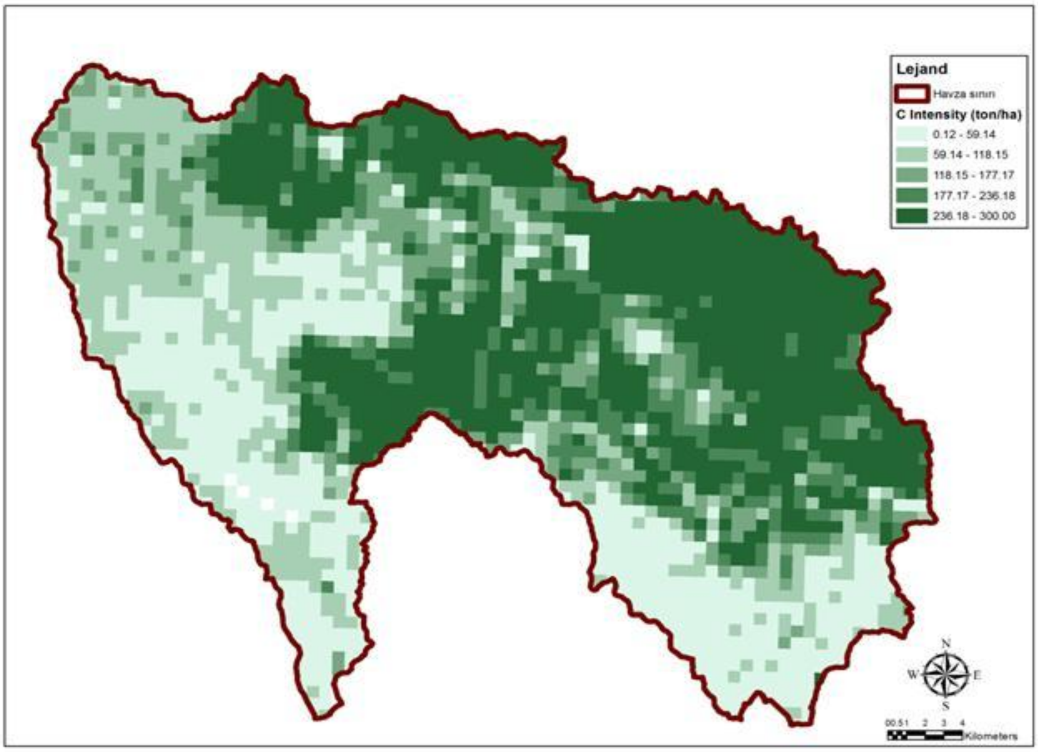


Figure 6.6 Carbon intensity in the study area (Alibeyköy, Sazlıdere and Kağıthane watersheds in Istanbul)



We also established a geospatial soil database and calculated average values for soil C for grasslands and croplands (Table 6.23). This study is performed at the Geographical Information Systems Division of General Directorate of Agriculture Reform (TRGM) under the MFAL. The CS values that have been calculated by various studies have been complied as a layer on Geographical Information System (GIS). They then grouped for climate types and average values have been calculated. We aim to strengthen this database with more values (study results) for the next submission.

Table 6.23 Soil carbon stocks

	Climate region	$\bar{x}$ (t C/ha)	σ (t C/ha)	Sample size
Perennial		33.6	7.7	10
Annual		27.1	16.4	1 787
	Warm-Dry	27.5	16.2	1 555
	Cool-Dry	23.9	17.8	232
Grasslands		29.3	12.9	11

Cropland remaining Cropland

Cropland category includes all annual and perennial crops including orchards and poplar plantations; the change in biomass growth has been estimated only for perennial crops, since, for annual crops, the increase in biomass stocks in a single year is assumed equal to biomass losses from harvest and mortality in that same year. AD for cropland remaining cropland have been subdivided into annual and perennial crops.

The CSC in Cropland remaining Croplands have been estimated for the following pools;

- Biomass growth of perennial crops including Poplar plantations,
- Biomass gain/loss for conversions between annual and perennial crops,
- CSC in mineral soils for conversions between annual and perennial crops,
- Emissions from organic soils in crops,
- CSC in Dead Organic Matter for conversions between annual and perennial crops.

The latter pool has been calculated based on the results from a research study supported by the TUBITAK with the project number 112YO96.

A combination of T1 and T2 has been applied to calculate biomass increase for perennial croplands with Gain-Loss method. The areas of perennial woody cropland were multiplied by a net estimate of biomass accumulation from growth and subtract losses associated with harvest or gathering or disturbance (according to Equation 2.7 in Chapter 2 in IPCC 2006).

A T2 approach was used for the conversions between perennial and annual croplands. T2 methods were used for CSC in organic and mineral soils (spatially explicit classification of these lands and country specific CS for annual croplands).

Concerning woody crops, estimates of carbon stocks changes in living biomass were applied to aboveground biomass (belowground was estimated just for poplars), according to the IPCC (2006).

Biomass accumulation and harvesting

The gain-loss method of was used in calculating CSC in biomass pool. Biomass accumulation rate for perennial crops on Cropland remaining croplands have been taken as 1 Mg C $ha^{-1}yr^{-1}$ based on values used by Italy inventory. Therefore biomass accumulation rate has been assumed to be 1 Mg C $ha^{-1}yr^{-1}$ with a rotation period of 20 years and we also assume 10 years growth and 10 years stable (pruning and slow down of growth) periods similar to the mentioned inventory (NIR 2013 Italy, page 209).

For the estimation of CSC in poplar plantations we used a database that covers the period 2003-2010. These values were extrapolated to 2011 and to the period before 2003. The poplar plantations were disaggregated for soil and default IPCC climate types.

The properties that were used to calculate CSC in poplars were a follows;

Table 6.24 Properties of poplar species

Tree	BWD g/cm^3	Plantation Pattern	Number of trees per ha	Volume increment m^3/ha yr	Rotation period (year)	BEF	R
Common poplar species average (*P. tremula, P. nigra*)	0.40	5x6	333	28	12	1.24	0.21

BWD: Basic wood density, BEF: Biomass expansion factor, R: Root to shoot ratio.

In the calculation procedure we assumed that 8.3% of the poplar plantations are harvested every year considering the rotation period as 12 years.

Conversions between Perennial and Annual Croplands

We used spatially explicit data to calculate conversions between perennial and annual croplands (Table 6.25).

Table 6.25 Conversions between annual and perennial crops within cropland category

		Annual to perennial			Perennial to annual		
	Ha	**1990**	**2000**	**2006**	**1990**	**2000**	**2006**
HAC	W-D	17 661.76	98 952.79	51 135.00	69 373.00	24 767.68	51 006.00
	W-W	606.35	1 1374.78	5 040.40	8 136.99	851.78	5 137.20
	C-D	221.27	3 274.87	1 478.60	2 301.12	303.30	1 478.50
	C-W	52.47	72.85	60.90	51.00	74.96	60.90
LAC	W-D	667.37	2 625.85	1 473.80	1 838.30	901.69	1 452.60
	W-W	248.18	6 144.22	2 676.00	4 399.80	354.54	2 734.10
	C-D	1.38	0.00	0.80	0.00	1.98	0.80
	C-W	0.00	0.68	0.30	0.48	0.00	0.30
SANDY	W-D	366.78	2 901.40	1 410.40	2 045.47	531.45	1 422.00
	W-W	0.00	0.00	0.00	0.00	0.00	0.00
	C-D	0.00	0.15	0.10	0.00	0.00	0.00
	C-W	0.00	0.00	0.00	0.00	0.00	0.00
WET	W-D	45.33	77.00	58.40	53.91	64.76	58.40
	W-W	0.00	0.00	0.00	0.00	0.00	0.00
	C-D	0.00	0.00	0.00	0.00	0.00	0.00
	C-W	0.00	0.00	0.00	0.00	0.00	0.00

We used country specific carbon stock values for mineral soil conversions (Table 6.19 and Table 6.21) and default values for organic soils In case of emissions from organic soils we assumed that all croplands are managed (conservative approach).

Land Converted to Cropland

Grassland converted to Cropland

CSC in biomass and soil pools have been calculated in this category. CSC estimations for

- Grasslands converted to Perennial croplands
- Grasslands converted to Annual croplands

were estimated. We used gain-loss method of IPCC (2006) (Eq2.7).

The default C stock value of 0.75 Mg C/ha (country specific EF) in aboveground biomass were used for annual crops while 10 Mg C/ha was taken for perennial crops.

The aboveground C stock for grasslands have been taken as 0,735 Mg C/ha, and belowground 2.94 Mg C/ha (Aydın and Uzun, 2005; Fırıncıoğlu et al., 2009; Sinoga et al., 2012).

In case of emissions from organic soils we assumed that all grasslands are managed (conservative approach).

The following equations were used;

Grassland converted to Perennial Cropland (EFs used are from Tables 7.23 and 7.25)

- Aboveground CSC =AREA for GL - Perennial CL * 10 Mg C/ha – AREA * 0.49 Mg C/ha
- Belowground CSC=AREA for GL - Perennial CL * 5 Mg C/ha – AREA * 1.37 Mg C/ha
- Litter = AREA for GL - Perennial CL * 0 Mg C/ha – AREA * 0.06 Mg C/ha
- Soil = AREA for GL - Perennial CL * 33.6 Mg C/ha – AREA*29.3 Mg C/ha

Grassland converted to Annual Cropland (EFs used are from Tables 7.23 and 7.25)

- Aboveground CSC =AREA for GL-Annual CL * 0.75 Mg C/ha – AREA * 0.49 Mg C/ha
- Belowground CSC=AREA for GL-Annual CL * 0 Mg C/ha – AREA * 1.37 Mg C/ha
- Litter = AREA for GL-Annual CL * 0.27 Mg C/ha – AREA * 0.06 Mg C/ha
- Soil = AREA for GL-Annual CL * (27.3 Mg C/ha for Warm-Dry, 23.9 Mg C/ha for Cool Dry)– AREA * 29.3 Mg C/ha

6.4. Grasslands (Category 4.C)

Source Category Description:

Grasslands are all lands with non woody vegetation subject to grazing.

Grassland remaining Grassland

CSC in grasslands is assumed to be not changing if management is not changed. Actually, there are grassland rehabilitation projects implemented in the country but conservatively we assumed no change in biomass. We plan to report these projects as the grassland monitoring system becomes available.

Emissions from organic soils are reported assuming that all grasslands are managed. Default EFs are used in this procedure but the AD is disaggregated for climate types.

Forest Land Converted to Grass Land

The information of Forest Land Converted to Grass Land is provided in section 6.2.5.

Croplands converted to grassland

CSC in biomass, soils and litter are reported in this category based on the CS values given in Table 7.23 and 7.25.

CSC due to conversions from perennial and annual croplands are estimated in living biomass. The same C stocks determined for perennial (10 Mg C/ha) and annual crops (country specific value 0.75 Mg C/ha) were used. The below ground CS for annual crops has been accepted as zero. Therefore conversion from perennial and annual crops resulted with C removals.

The following equations were used;

Perennial Cropland converted to Grassland (EFs used are from Tables 7.23 and 7.25)

- Aboveground CSC =AREA for Perennial CL-GL* 0.49 Mg C/ha – AREA * 10 Mg C/ha
- Belowground CSC=AREA for Perennial CL-GL* 1.37 Mg C/ha – AREA * 5 Mg C/ha
- Litter = AREA for Perennial CL-GL* 0.06 Mg C/ha – AREA * 0 Mg C/ha
- Soil =AREA for Perennial CL-GL* 29.3 Mg C/ha – AREA * 33.6 Mg C/ha

Annual Cropland converted to Grassland (EFs used are from Tables 7.23 and 7.25)

- Aboveground CSC =AREA for Annual CL-GL* 0.49 Mg C/ha – AREA * 0.75 Mg C/ha
- Belowground CSC=AREA for Annual CL-GL* 1.37 Mg C/ha – AREA * 0 Mg C/ha
- Litter = AREA for Annual CL-GL* 0.06 Mg C/ha – AREA * 0.27 Mg C/ha
- Soil =AREA for Annual CL-GL* 29.3 Mg C/ha – AREA * (27.3 Mg C/ha for Warm-Dry, 23.9 Mg C/ha for Cool Dry)

6.5. Wetlands (Category 4.D)

Source Category Description:

All human made reservoirs are included in the wetlands category. CSC in biomass due to conversions from croplands and grasslands has been reported in this category.

Croplands converted to Wetlands

All perennial and annual croplands converted to wetlands have been reported. Gain-loss method of IPCC (2006) (Eq 2.7) was used. The same C stock values were used as Croplands section. The following equations were used;

Perennial Cropland converted to Wetland (EFs used are from Tables 7.23 and 7.25)

- Aboveground CSC = AREA for Perennial CL-WL* 0 Mg C/ha – AREA * 10 Mg C/ha
- Belowground CSC = AREA for Perennial CL-WL* 0 Mg C/ha – AREA * 5 Mg C/ha
- Litter = AREA for Perennial CL-WL* 0 Mg C/ha – AREA * 0 Mg C/ha
- Soil = AREA for Perennial CL-WL* 0 Mg C/ha – AREA * 33.6 Mg C/ha

Annual Cropland converted to Wetland (EFs used are from Tables 7.23 and 7.25)

- Aboveground CSC =AREA for Annual CL-WL* 0 Mg C/ha – AREA * 0.75 Mg C/ha
- Belowground CSC=AREA for Annual CL-WL* 0 Mg C/ha – AREA * 0Mg C/ha
- Litter = AREA for Annual CL-WL* 0 Mg C/ha – AREA * 0.27 Mg C/ha
- Soil = AREA for Annual CL-WL* 0 Mg C/ha – AREA * (27.3 Mg C/ha for Warm-Dry, 23.9 Mg C/ha for Cool Dry)

As seen from the calculations above all conversions to wetlands (artificial wetlands) have been reported as emission.

Grasslands converted to Wetlands

Emissions from above and below ground biomass have been reported in this category. Gain-loss method of GPG 2003 (Equation 3.1.1) was used. The same C stock values were used as Grasslands section. The computations were as follows;

Grassland converted to Wetland (EFs used are from Tables 7.23 and 7.25)

- Aboveground CSC = AREA for GL-WL* 0 Mg C/ha – AREA * 0.49 Mg C/ha
- Belowground CSC= AREA for GL-WL * 0 Mg C/ha – AREA * 1.37Mg C/ha
- Litter = AREA for GL-WL * 0 Mg C/ha – AREA * 0.06 Mg C/ha
- Soil = AREA for GL-WL * 0 Mg C/ha – AREA * 29.3 Mg C/ha

6.6. Settlements (Category 4.E)

Source Category Description:

We gave special emphasis on this category because urbanization rate of Turkey is high and this causes emissions. This is the first time the Settlements category has been reported in T3 level. We used the results of a national research project funded by the TUBITAK with the Project Number 112Y096. The methods we developed for reporting Settlements category has been given in the Methodology section above.

The method we used to develop EFs for Settlements category is a T3 level modeling study while representativeness is weak because the study is conducted in Istanbul. At least 2-3 similar studies are needed to have a higher representativeness. The methodological level is T3 in this estimation because we performed a gridded spatial analysis modeling approach. The spatial resolution we used was 1.5x1.5 with SPOT 6 satellite images. More than 2000 grids were analyzed in an area of 740 km^2. The accuracy check was done with 1000 points with over 90% accuracy. The EFs were developed based on 59 sample plots. The total C stock (AG, BG, L, S) in the 1st level settlements (>20% imperviousness) was 85.27 Mg C/ha (Table 7.24) while it was far below this level in 4th level settlements (17.26 Mg C/ha).

The average CS in Settlements identified by CORINE maps has been 25.17 Mg C/ha in total being 20.14 Mg C/ha in biomass, 5.03 Mg C/ha soil pools.

We assumed that CSC in SL-SL is zero and L-SL is calculated as below.

Croplands converted to Settlements

Perennial Cropland converted to Settlements (EFs used are from Tables 7.23 and 7.25)

- Biomass CSC = AREA for Perennial CL-SL* 5.03 Mg C/ha – AREA * 15 Mg C/ha
- Litter (L) = AREA for Perennial CL-SL* 0 Mg C/ha – AREA * 0 Mg C/ha
- Soil (S) = AREA for Perennial CL-SL*20.14 Mg C/ha – AREA * 33.6 Mg C/ha
- Annual Cropland converted to Settlements (EFs used are from Tables 7.23 and 7.25)
- Biomass CSC = AREA for Annual CL-SL* 5.03 Mg C/ha – AREA * 0.75 Mg C/ha
- Litter = AREA for Annual CL-SL* 0 Mg C/ha – AREA * 0.27 Mg C/ha
- Soil = AREA for Annual CL-SL* 20.14 Mg C/ha – AREA * (27.3 Mg C/ha for Warm-Dry, 23.9 Mg C/ha for Cool Dry)

Grassland converted to Settlements

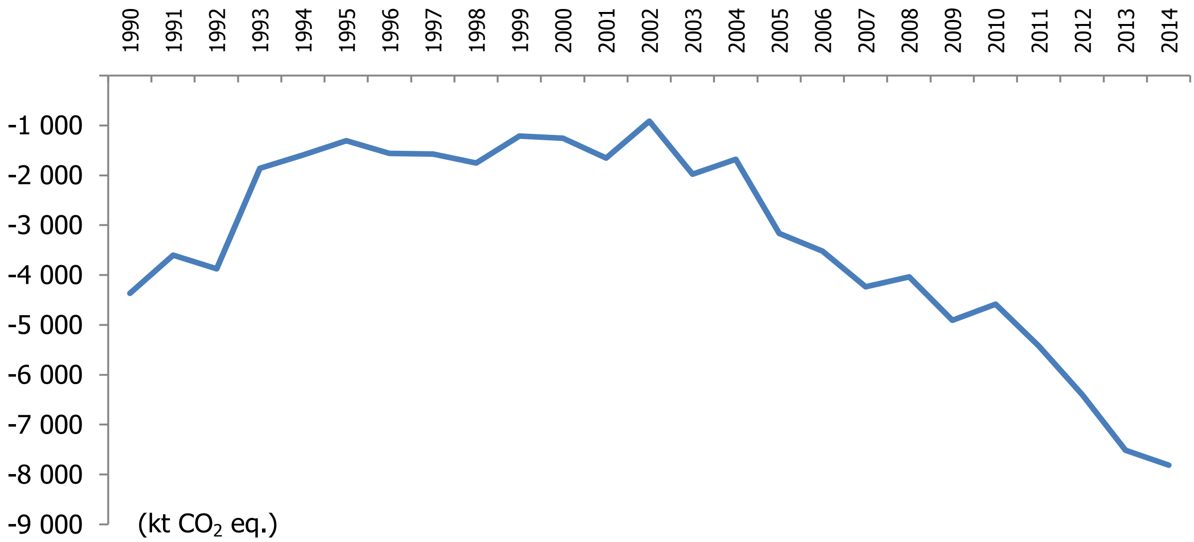
Grassland converted to Settlements (EFs used are from Tables 7.23 and 7.25)

Biomass CSC = AREA for GL-WL* 5.03 Mg C/ha – AREA * 1.86 Mg C/ha

6.7. Harvested Wood Products (Category 4.G)

The CSC of the harvested wood product category calculations have been done in the context of a study by Bouyer and Serengil (2014) and GDF (2016) (see Figure 6.7).

Figure 6.7 The CSC in HWP, 1990-2014



The following methodology has been applied in calculations;

- Corrected 1900-2014 data series: the United Nations Economic Commission for Europe (UNECE) Timber database gives disaggregated figures for HWP produced in Turkey from 1964 to 2014. We focused on the two main HWP categories, which are sawnwood (UNECE code: 5) and wood-based panels (UNECE code: 6).
- Comparing UNECE data series and GDF data series for industrial roundwood over 1976-2014 (starting date for GDF data series), we noticed some anomalies (with UNECE data series as a basis: max: +47%, min = -23%; mean = +16%). These anomalies could be due to two things: (i) use of volume over bark for UNECE and volume under bark for GDF (+15% for volume over bark), (ii) integration of industrial roundwood coming from the private sector for UNECE.

- In order to ensure coherence, we then corrected the 1976-2011 UNECE data series for sawnwood and wood-based panels taking into account for each year the % of anomaly. Luckily, from 1976 to 1982, the anomalies are very reduced (-1% in average), which allow using the UNECE data series from 1964 to 1975.
- After that, we used the corrected 1964-2014 data series and we extrapolated the 1900-1963 data series (starting in 1964) using the default value for rate of increase of HWP in Europe, based on Table 12.3 from AFOLU 2006. We estimated complete 1900-2013 data series for all the categories;
- Share of HWP categories over 2012-2020: We estimated the average share of each HWP over the last ten years: 48% for sawnwood and 38% for wood-based panels (the 14% of others HWP were not considered in the analysis, either because they were short-lived products or marginal or difficult to estimate). Then we used strategy documents of the GDF to analyze the harvest scenarios until 2020. We found out that there are 2 possible scenarios to close the gap between wood demand and supply; extensive and intensive. For each scenarios, we disaggregated the 2013-2020 volume of industrial roundwood into the two HWPs, using the calculated %;
- Inflow of HWP over 1900-2020: We multiplied the four data series (two scenarios x two HWPs) expressed in '000 m^3/yr by the "weighted" Basic Wood Density factor (D, tdm/m^3) calculated for mixed forest in Turkey. The default CF value was used to convert dm into C and 44/12 into CO_2 eq.
- Carbon stock and carbon stock changes in HWP: For each data series, we applied the Equation 12.1 (IPCC, 2006), using the ad hoc default values presented.

The CSC have been calculated by using an excel spreadsheet (Table 6.26) using the calculated (country specific) D values and a default CF value of 0.5 given in IPCC (2006).

Table 6.26 The calculation procedure for HWP.

	Production (in 1000 m^3, otherwise precised)	1978	2020	Explanations
IR-UN	Industrial round wood (UNECE, overbark)	7 863		
SW-UN	Sawn wood (UNECE)	4 650		
	% Sawn wood (UNECE)	59%	48%	SW/IR*100
WP-UN	Wood-based panels (UNECE)	541		
	% Wood-based panels (UNECE)	7%	38%	WP/IR*100
IR- GDF	Industrial round wood (GDF only, underbark)	7 694		
	Diff UNECE vs GDF (1977-2011)	2%	32%	(IR-UN)-(IR-GDF)/(IR-GDF)*100
SW-C	Sawn wood (UNECE, corrected)	4 548		
WP-C	Wood-based panels (UNECE, corrected)	529		
IR-GDFint	Industrial round wood(GDF only, Int. Scen)	7 694	26 359	
IR-GDFext	Industrial round wood(GDF only, Ext. Scen)	7 694	22 378	
=SW-C	P° Sawn wood (IntScen)	4 548	12 627	
=WP-C	P° Wood-based panels (IntScen)	529	9 908	
=SW-C	P° Sawn wood (ExtScen)	4 548	10 720	
=WP-C	P° Wood-based panels (ExtScen)	529	8 412	
I-SWint	Infloxsawn wood (IntScen) in '000 tC/yr	1 075	3 087	=(SW-C)*D*CF
I-WPint	Inflow wood-based panels (IntScen) in '000 tC/yr	125	2 422	=(WP-C)*D*CF
I-SWext	Inflow sawn wood (ExtScen) in '000 tC/yr	1 075	2 621	=(SW-C)*D*CF
I-WPext	Inflowwood-based panels (ExtScen) in '000 tC/yr	125	2 056	=(WP-C)*D*CF
CS-SWint	Carbon stock sawnwood (IntScen) in '000 tC/yr	12 698	44 232	Eq.12.1.(IPCC, 2006)
CS-WPint	Carbon stock wood-based panels (IntScen) in '000 tC/yr	786	21 382	Eq.12.1.(IPCC, 2006)
CSC-Int	Changes in HWP C stocks in '000 tC/yr (IntScen)	590	3 734	((CS-SWint (i)+ CS-Wpint) (i)) / ((CS-SWint (i-1)+ CS-Wpint) (i-1))
CSC-Int	Net removals in Mt CO_2 eq./yr (IntScen)	-2.16	-13.69	CSC-Int*-44/12/1000

The harvest rate was high in the 90's. From there, it decreased to its lowest level at the beginning of the 2000's (12.5 Million m^3/yr in 2001), before to rise again till now. It is worth noting that the harvest of firewood constantly decreased while the harvest of industrial roundwood, that stayed stable from the 90's to the 2000's (around 7 Mm^3/yr), started to increase strongly after (see Table 6.26).

Table 6.27 Annual harvest, 1990-2014

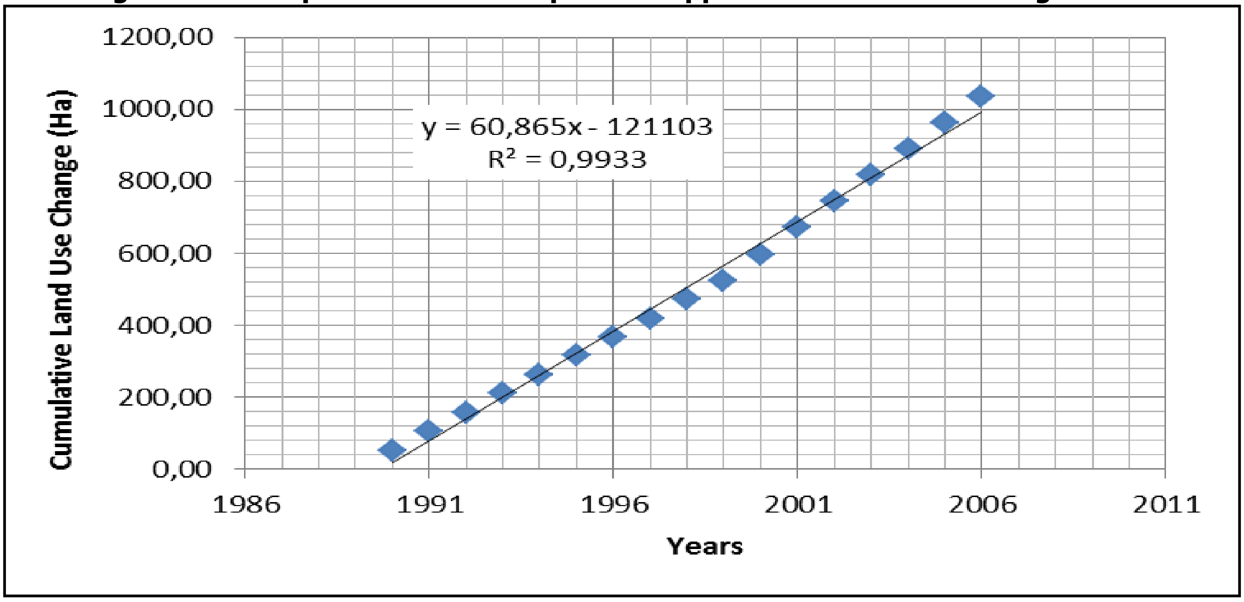
(thousand m^3)

Year	Industrialwood	Total fire wood	Grand total roundwood
1990	6 581	9 109	15 690
1991	6 513	8 627	15 140
1992	6 897	8 360	15 257
1993	7 010	8 135	15 145
1994	6 712	6 284	12 996
1995	8 460	7 155	15 614
1996	7 529	7 802	15 331
1997	7 471	6 988	14 460
1998	7 948	6 279	14 227
1999	8 034	6 126	14 160
2000	8 305	5 896	14 202
2001	7 942	5 683	13 624
2002	9 166	5 690	14 856
2003	8 397	5 862	14 259
2004	9 160	6 090	15 249
2005	9 325	5 750	15 075
2006	9 299	5 303	14 602
2007	10 053	5 127	15 180
2008	11 541	5 479	17 020
2009	11 464	5 571	17 035
2010	12 569	5 396	17 964
2011	13 532	5 083	18 616
2012	14 424	4 825	19 249
2013	13 668	4 486	18 154
2014	14 923	3 943	18 867

Uncertainty and time series consistency:

Data for some years or periods had to be interpolated or extrapolated to have a complete inventory that covers the whole reporting period. To extrapolate the data we used linear equations derived from cumulative values (Figure 6.8).

Figure 6.8 Interpolation and extrapolation approach for land use change data



Cumulative values are plotted and the trend line was extrapolated based on the linear equation.

Uncertainty estimates have been assessed based on IPCC (2006) as explained below.

The IPCC GPG was used to estimate biomass growth. The error range has been accepted as ±75% for default values.

The uncertainty of the AD is around 50% according to expert judgment considering that 3 different Land Use Maps have been used.

The overall uncertainty is calculated as;

$$Utotal = \sqrt{U1^2 + U1^2}$$

$$Utotal = \sqrt{75^2 + 50^2} = 90\%$$

Category-specific QA/QC and verification:

The QA/QC mechanism has been established in the LULUCF working unit established under MFAL. The unit is responsible of complying, reporting, quality control, improving and quality assurance of the inventory. The responsibility of the unit is limited to 5 land use categories other than Forestland.

The QA/QC mechanism of Forestlands is handled by GDF. All the calculations of sector were controlled by both a personnel from Eskişehir Forest Research Institute of GDF for QC and Prof.Dr.Yusuf Serengil from Forest Faculty of Istanbul University for QA.

Recalculations:

The improvement of this LULUCF sector goes on with new added categories and we also anticipate making recalculations at least for the next 2-3 submissions. Only after that a more stable inventory can be achieved.

Forest Land:

The carbon stock changes of the Forest Land category have been calculated at sub-regional level in this submission. Therefore calculation for this submission has been recalculated for the period 1990-2013 (See Table 6.28).

Table 6.28 Recalculation table, 1990-2013

Year	Without recalculation (kt CO_2 eq.)	With recalculation (kt CO_2 eq.)	Change (%)
1990	28 065	28 118	-0.19
1991	29 721	29 737	-0.05
1992	29 760	29 796	-0.12
1993	30 019	30 069	-0.17
1994	32 576	32 752	-0.54
1995	29 750	29 747	0.01
1996	30 234	30 267	-0.11
1997	32 846	32 816	0.09
1998	33 970	33 929	0.12
1999	34 924	34 864	0.17
2000	35 229	35 266	-0.10
2001	38 716	38 636	0.21
2002	38 626	38 543	0.22
2003	40 870	40 761	0.27
2004	40 291	40 146	0.36
2005	41 275	41 112	0.39
2006	42 553	42 413	0.33
2007	41 890	41 752	0.33
2008	38 078	37 990	0.23
2009	40 827	40 566	0.64
2010	42 833	42 567	0.62
2011	44 086	43 824	0.59
2012	44 350	44 070	0.63
2013	51 095	50 817	0.54

Grassland:

Forest Land converted grassland (deforestation) has been calculated for a first time this submission for the period 1990-2014.

Planned improvements:

There is a need to improve the forest resources inventory studies, the quality assurance of relevant data and increase the researches to obtain the country specific data. Planned activities are:

- Integrated Approach to Management of Forests in Turkey, With Demonstration in High Conservation Value Forests in the Mediterranean Region Project was initiated in 2013. With this project sustainable forest management, establishment of policy and institutional framework GHG inventory estimation and carbon sequestration of forests issues will be studied more in detail. This project also has been started to activities for establishing MRV system for GHG inventory of Forest Land category.
- Digitalization of the forest managing maps of Turkey was initiated in 2008. It will be finished in 2018.

Turkey is a partner of The International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (known as an ICP Forests) program. The ICP Forests project's soil analysis in Turkish forest was initiated in 2015 January. It will be finished until 2019. The results of this project will contribute to our soil, and litter C database.

There have been implemented three EU project about the LULUCF calculations. First project name is Environment and Climate Regional Accession Network (ECRAN). This project organize regional workshops about LULUCF calculations. Second project name is "Technical Assistance for Support to Mechanism for Monitoring Turkey's Greenhouse Gas Emissions" which has been start at February 2015. One of the expected result of this project: Improvement of the quality of the national inventory reports, with a focus on improved estimations and reporting following UNFCCC and IPCC guidelines. Third project name is 'Capacity Building in the Field of Climate Change in Turkey' which is in Terms of Reference (TOR) stage. One of the expected result of this project: To develop an analytical basis for the LULUCF sector. These projects are expected to increase the GHG reporting capacity.

In this submission, the emphasis has been given to the QA/QC of the AD and emission/factors.

In 2012 submission we started to report categories croplands, grasslands, and wetlands with explanations in the NIR. But completeness of the Inventory was weak. In the 2013 submission we expanded the number of categories reported and incorporated management activities in categories (perennial-annual conversions, emissions from organic soils etc.). In this submission we gave the emphasis on completeness again by adding Lands Converted to Settlement category, and litter pool. Therefore we focused on AD generation process and calculations. We also worked on the transparency issue by added explanations on especially methodology. The TUBITAK project explained above added new emission/removal factors. We expect to benefit from scientific studies more in the next submission.

We plan to give the emphasis on compatibility of AD between land use categories and will try to increase the completeness and accuracy of the estimations in the next submission.

The new Corine map for 2012 has not been finalized yet. So we had to use the existing maps.

The scientific study we mentioned in the last submission to determine C stocks in settlements has not been resulted but some results have been used in this submission. The research project is supported by the TUBITAK with a project number of 112Y096. We expect to benefit more from this project findings in the next submission.

The inconsistency issue between land uses still goes on. This is caused by the use of different land use databases between responsible agencies (GDF and TRGM). As a result of this a full land use matrix cannot be generated.

The study on Mapping Soil Organic Carbon (SOC) Stocks in Turkey (Aydın.G. et al. 2016) has been completed in 2015. In this study, exacted legacy soil maps (1:25000 scale) have been used to estimate SOC stock and the map covers whole the country territory. Since it's under the press for per-review publication, it was not used in this reporting period but it is planed to use for next periods.

7. WASTE (CRF SECTOR 5)

7.1. Sector Overview

The waste sector includes CH_4 emissions from solid waste disposal, CH_4 and N_2O emissions from biological treatment of solid waste, CO_2, CH_4 and N_2O emissions from open burning of waste and, CH_4 and N_2O emissions from wastewater treatment and discharge. Emissions from waste incineration are included in the inventory but reported in the energy sector since the purpose of waste incineration is energy recovery.

Total waste emissions for the year 2014 were 16.1 Mt CO_2 eq., or 3.4% of total GHG emissions (without LULUCF). Within the sector, 73.80% of the emissions were from solid waste disposal, followed by 26.08% from wastewater treatment and discharge, 0.11% from biological treatment of solid waste and 0.01% from open burning of waste.

The major GHG emissions from the waste sector are CH_4 emissions, which represent 88.5% of total emissions from this sector in 2014, followed by N_2O emissions with 11.5% and a very small per cent of CO_2 as 0.001%.

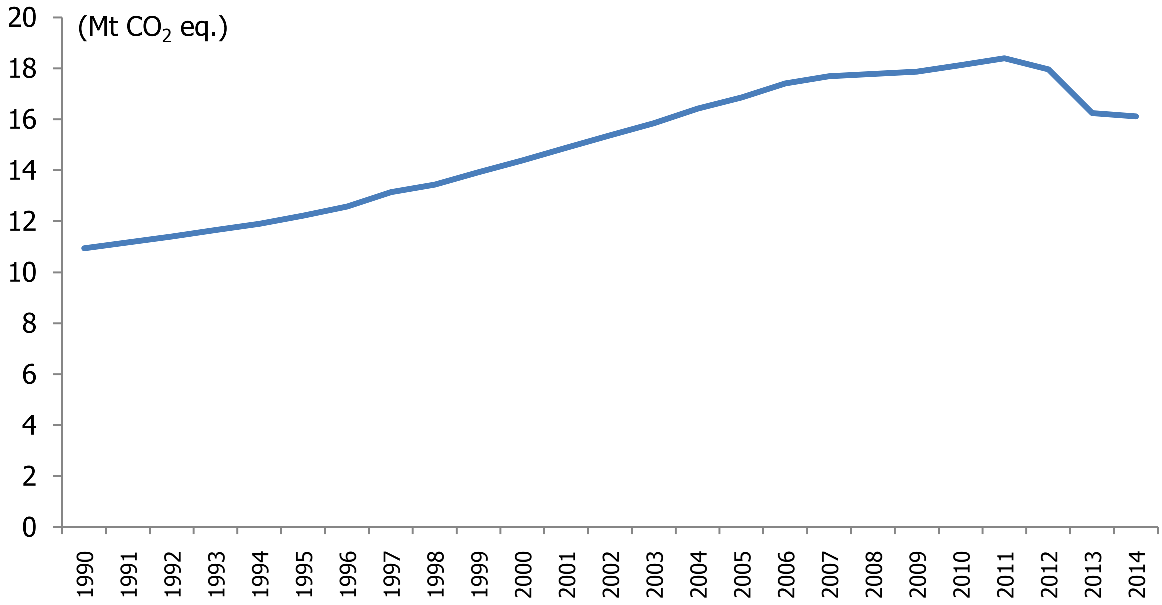
Table 7.1 CO_2 equivalent emissions for the waste sector, 2014

(kt CO_2 eq.)

GHG sources and sink categories	CO_2	CH_4	N_2O	Total
5. Waste	0.1	14 257.7	1 856.6	16 114.4
A. Solid waste disposal	NA	11 892.7	NA	11 892.7
B. Biological treatment of solid waste	NA	9.4	8.4	17.8
C. Incineration and open burning of waste	0.1	0.7	0.1	0.9
D. Wastewater treatment and discharge	NA	2 354.9	1 848.0	4 203.0

Waste emissions were 47.2% (5.2 Mt CO_2 eq.) higher in 2014 than they were in 1990 and 0.8% (0.1 Mt CO_2 eq.) lower than in 2013 as seen in Figure 7.1.

Figure 7.1 Total GHG emissions of waste sector, 1990-2014



Total emissions in the waste sector gradually increased between 1990 (10 945 kt CO_2 eq.) and 2014 (16 114 kt CO_2 eq.) driven largely by the steady rise in emissions from solid waste disposal between 1990 and 2011 followed by a decrease in emissions since from solid waste disposal between 2011 and 2013. Emissions from solid waste disposal increased by 102.7% (6 915 kt CO_2 eq.) between 1990 and 2011, before decreasing by 13.4 percent between 2011 and 2013 (1 823 kt CO_2 eq.), and increasing by 0.6% (71 kt CO_2 eq.) from 2013 to 2014. Methane recovery is reported as of 2002 (37 kt CO_2 eq.) and increasing to 4 767 kt CO_2 eq. in 2014. The decline in recent emissions is mainly due to the increase in methane recovery between 2011 (1 418 kt CO_2 eq.) and 2013 (4 320 kt CO_2 eq.), an increase of 204.7 percent. For the full discussion of trends for individual categories, see the category-specific discussions below.

Methodological tiers and EFs used to estimate emissions from waste sector are summarized by categories in Table 7.2.

Table 7.2 Summary of methods and emission factors used

GHG sources and sink categories	CO_2 Method applied	CO_2 Emission factor	CH_4 Method applied	CH_4 Emission factor	N_2O Method applied	N_2O Emission factor
5. Waste	T2	CS,D	T1,T2	CS,D	T1	D
A. Solid waste disposal	NA	NA	T2	CS,D	NA	NA
B. Biological treatment of solid waste	NA	NA	T1	D	T1	D
C. Incineration and open burning of waste	T2	CS,D	T1	D	T1	D
D. Wastewater treatment and discharge	NA	NA	T2	CS	T1	D

D: IPCC Default, CS: Country-Specific, NA: Not Applicable

7.2. Solid Waste Disposal (Category 5.A)

Source Category Description:

This category includes emissions from solid waste disposal sites (SWDS). The category consists of two waste disposal practices in Turkey:

- Managed waste disposal sites,
- Unmanaged waste disposal sites.

There are no semi-aerobic managed waste disposal sites (5.A.1.b) in Turkey and all managed waste disposal sites are categorized under anaerobic managed waste disposal sites (5.A.1.a). Unmanaged waste disposal sites (5.A.2) cannot be classified into deep and shallow due to lack of knowledge. The category covers CH_4 emissions from two types of waste in municipal SWDS in Turkey:

- Municipal solid waste (MSW), and
- Industrial waste.

In Turkey, clinical waste after being sterilized is included in the MSW and disposed in SWDS. Both clinical waste which is not being sterilized and hazardous waste are disposed in separated lots in SWDS. These wastes are not taken into account in this source category because these types of wastes are not producing methane. Industrial waste including hazardous and clinical waste is usually incinerated and considered inthe category of Public Electricity and Heat Production.

The total amount of waste disposed in the SWDS has increased through the years mainly due to population growth (Table 7.7). The number of managed SWDS has also increased over the years

(Table 7.4) and the share of managed SWDS as a fraction of total SWDS surpassed unmanaged SWDS as of from 2012 onwards, particularly due to improved landfill management practices, including landfill gas recovery.

Since 2004, Turkey has carried out many actions related to waste management and regulatory policies. The first legal regulation in this field in Turkey was the Solid Waste Control Regulation (14.03.1991) which provided for and guided practices in the collection and removal of domestic and industrial waste. Revisions of the regulation to harmonize it with the EU Landfill policy were carried out in 2010 (26.03.2010). Solid Waste Management Action Plan covering 2008-2012 was prepared by the former Ministry of Environment and Forestry (MoEF), using the outcomes of the EU funded Environmental Heavy Cost Investment Planning (EHCIP) Project, solid waste master plan projects and the EU Integrated Environmental Adaptation Strategy (NES) (2007-2023). All these waste management policies and actions in Turkey are expected to reduce the share of GHG emissions from the waste sector.

Methodological Issues:

Methane Emissions from Solid Waste Disposal

CH_4 emissions from solid waste disposal is a key category according to both a level and a trend assessment. CH_4 emissions of MSW and industrial waste are estimated from municipal SWDS in Turkey. The IPCC T2 First Order Decay (FOD) method recommended in the 2006 IPCC Guidelines for National GHG Inventories is used with default parameters and country-specific AD on current and historical waste disposal at SWDS to estimate CH_4 emissions.The CH_4 emissions from solid waste disposal for a single year can be estimated based on *Equation 3.1 in 2006 IPCC, Volume 5, Chapter 3* as given in Equation 7.1 below.

Equation 7.1

$$CH_4\ Emissions = \left[\sum_x CH_4\ generated_{x,T} - R_T\right] \bullet (1 - OX_T)$$

Where:

CH_4 Emissions	= CH_4 emitted in year *T*, Kt
T	= inventory year
x	= waste category or type/material
R_T	= recovered CH_4 in year *T*, Kt
OX_T	= oxidation factor in year *T*, (fraction)

The CH_4 generated by each category of waste disposed is added to get total CH_4 generated in each year. Finally, emissions of CH_4 are calculated by subtracting the CH_4 gas recovered from the disposal site.

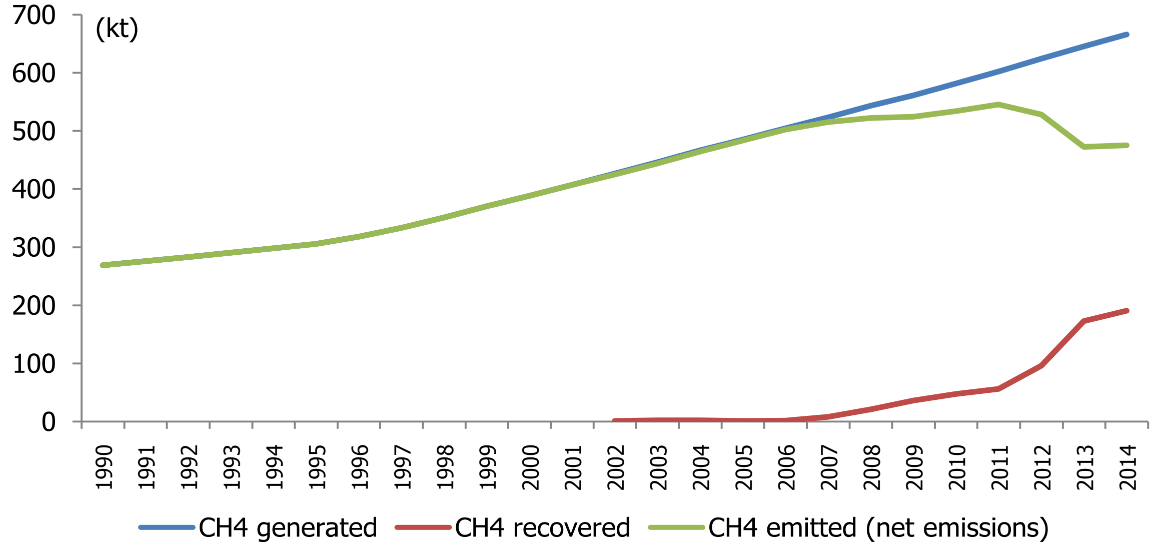
The total amount of CH_4 generated, CH_4 recovered and net CH_4 emissions from solid waste disposal sites are estimated as given in Table 7.3 and Figure 7.2.

Table 7.3 CH_4 generated, recovered and emitted from SWDS, 1990-2014

(kt)

Year	CH_4 Generated	CH_4 Recovered	CH_4 Emitted
1990	269.2	NO	269.2
1991	276.1	NO	276.1
1992	283.1	NO	283.1
1993	290.9	NO	290.9
1994	298.5	NO	298.5
1995	306.1	NO	306.1
1996	318.5	NO	318.5
1997	333.7	NO	333.7
1998	351.5	NO	351.5
1999	370.5	NO	370.5
2000	388.5	NO	388.5
2001	407.3	NO	407.3
2002	426.8	1.5	425.3
2003	446.7	2.5	444.2
2004	467.2	2.3	464.9
2005	485.1	1.7	483.4
2006	504.6	2.2	502.4
2007	523.7	8.3	515.4
2008	543.8	21.4	522.4
2009	561.4	36.5	524.9
2010	582.3	47.9	534.3
2011	602.5	56.7	545.8
2012	624.7	96.2	528.6
2013	645.7	172.8	472.9
2014	666.4	190.7	475.7

Figure 7.2 CH_4 emissions from solid waste disposal, 1990-2014



Choice of Activity Data

To calculate CH_4 generated, municipal solid waste AD and industrial waste AD are needed. As is described in more detail below individually for MSW and industrial waste, national data are used where possible, depending on availability of both AD. If national data are not available for a specific inventory year, population data and waste per capita data are used to estimate national data on MSW generation. Accordingly, GDP data and waste generation rate data are used as drivers for estimating industrial waste generation.

The percentage of waste generated which goes to SWDS (% to SWDS) and composition of waste going to SWDS are also used for the calculations.

The distribution of site types is used for calculating a weighted average methane correction factor (MCF). The other parameters needed for the FOD model are; degradable organic carbon (DOC), fraction of DOC which decomposes (DOC_F), methane generation rate constant (k), fraction of methane (F) and oxidation factor (OX).

The justification for the selection of parameters by Turkey is further described below.

Municipal Solid Waste Activity Data

The annual data of MSW disposed in the municipal SWDS (the amount of MSW both in managed and unmanaged landfills) are collected by TurkStat from *Municipal Waste Statistics Survey* which is applied to all municipalities. However, the survey could not be conducted on a regular basis before 2006, and since 2006 has started to be held biennially. The data for years 1994-1998, 2001-2004, 2006, 2008, 2010, 2012 and 2014 are available. The specific data collected by TurkStat are the amount of MSW is weighed, generally based on waste delivery vehicle capacity. 2005 data of MSW disposed in managed SWDS is gathered via *Waste Disposal and Recovery Facilities Statistics Survey* by TurkStat. In Turkey, managed SWDS are in operation since 1992 (See Table 7.4). In 1992 and 1993, there was only one managed SWDS according to the results of *Municipal Waste Statistics Survey*. Therefore, the waste disposal amounts of that site for those years are used for emission estimations (See Table 7.6). Missing data for the years not surveyed for total MSW delivered to SWDS are estimated by regression model. For distribution of MSW to managed and unmanaged landfills between 1990 and 2014, the missing data for the remaining years are estimated by linear interpolation. 2013 data of MSW disposed in managed SWDS has been recalculated by linear interpolation in the 2016 inventory submission due to the availability of 2014 survey data.

Data are generally available from the statistical surveys described above (noting the need to interpolate data for intervening years when survey data were not available). Data on MSW generation were not available prior to 1994. Recognizing that, in accordance with the 2006 IPCC Guidelines, data on MSW generation are needed for at least the last 50 years, Turkey has made assumptions to collect the full time series of data. As described further below, between 1950 and 1993, the amount of waste generated is estimated based on the waste per capita ratio in 1994 and mid-year population data for each year.

The total number of managed SWDS has increased by years as shown in Table 7.4 below.

Table 7.4 Number of municipal managed SWDS, 1992-2014

1992	1993	1994	1995	1996	1997	1998	2000	2001
1	1	2	6	6	8	8	10	12
2002	**2003**	**2004**	**2005**	**2006**	**2008**	**2010**	**2012**	**2014**
12	15	16	18	22	37	52	80	113

Source: (1992-2010) TurkStat, Municipal Waste Statistics

(2012-2014) TurkStat, Waste Disposal and Recovery Facilities Statistics

Amount of municipal waste by disposal methods are given in Table 7.5.

Table 7.5 Amount of municipal waste by disposal methods, 1994-2014

(kt)

Year	Municipality's dumping site	Controlled landfill site	Composting plant	Burning in an open area	Lake and river disposal	Burial	Other (1)
1994	14 479.2	809.0	192.1	442.1	557.6	523.4	753.3
1995	17 174.9	1 444.0	158.9	405.0	370.4	828.9	527.3
1996	17 519.5	2 847.0	178.8	437.9	370.3	823.6	303.3
1997	16 805.1	4 363.8	180.4	625.1	384.4	1 446.9	365.8
1998	16 852.8	5 257.9	166.3	386.1	374.9	852.4	1 039.1
2001	14 569.8	8 304.2	218.1	343.6	100.9	481.7	1 115.4
2002	16 310.0	7 047.0	383.1	220.5	196.8	499.9	715.8
2003	16 566.5	7 431.8	325.9	258.5	228.5	597.0	709.3
2004	16 415.8	7 001.5	350.7	101.6	154.7	426.5	562.7
2006	14 941.2	9 428.3	254.9	246.5	69.8	144.5	194.7
2008	12 677.1	10 947.4	275.7	239.3	47.7	100.5	73.1
2010	11 001.2	13 746.9	194.5	133.9	44.0	34.3	122.1
2012	9 771.0	15 484.2	154.7	104.8	33.4	94.3	202.3
2014	9 935.6	17 807.4	126.5	4.3	15.8	7.3	113.8

Source: TurkStat, Municipal Waste Statistics Survey

(1) Includes disposals by filling of land with waste, dumping onto land, etc.

The amount of waste disposed in unmanaged SWDS consists of the amount of waste disposed to municipality's dumping sites, burial and other.

Annual municipal solid waste at the SWDS and distribution of waste by waste management type are given in Table 7.6.

Table 7.6 Annual MSW and distribution of waste by management type, 1990-2014

	Annual MSW at the SWDS (kt)			Distribution of waste (%)	
Year	**Total**	**Managed**	**Unmanaged**	**Managed**	**Unmanaged**
1990	15 518.4	NO	15 518.4	0.0	100.0
1991	15 781.6	NO	15 781.6	0.0	100.0
1992	16 043.7	986.1	15 057.6	6.1	93.9
1993	16 304.7	827.2	15 477.5	5.1	94.9
1994	16 564.8	809.0	15 755.8	4.9	95.1
1995	19 975.1	1 444.0	18 531.1	7.2	92.8
1996	21 493.5	2 847.0	18 646.4	13.2	86.8
1997	22 981.5	4 363.8	18 617.7	19.0	81.0
1998	24 002.3	5 257.9	18 744.3	21.9	78.1
1999	23 256.9	6 273.3	16 983.5	27.0	73.0
2000	23 894.1	7 288.8	16 605.3	30.5	69.5
2001	24 471.1	8 304.2	16 166.9	33.9	66.1
2002	24 572.6	7 047.0	17 525.7	28.7	71.3
2003	25 304.6	7 431.8	17 872.8	29.4	70.6
2004	24 406.4	7 001.5	17 404.9	28.7	71.3
2005	25 947.4	7 078.2	18 869.2	27.3	72.7
2006	24 708.7	9 428.3	15 280.3	38.2	61.8
2007	25 484.4	10 187.9	15 296.5	40.0	60.0
2008	23 798.2	10 947.4	12 850.7	46.0	54.0
2009	25 700.0	12 347.2	13 352.8	48.0	52.0
2010	24 904.4	13 746.9	11 157.5	55.2	44.8
2011	26 319.0	14 615.5	11 703.5	55.5	44.5
2012	25 551.8	15 484.2	10 067.6	60.6	39.4
2013	25 267.0	16 645.8	8 621.2	65.9	34.1
2014	27 864.2	17 807.4	10 056.8	63.9	36.1

Population Data: Historical data are obtained from TurkStat's *Mid-year Population Estimations and Projections* from 1950 onwards as given in Table 7.7.

Table 7.7 Mid-year population, 1950-2014

Year	Population	Year	Population
1950	20 807 000	1983	47 864 000
1951	21 351 000	1984	49 070 000
1952	21 952 000	1985	50 307 000
1953	22 569 000	1986	51 480 000
1954	23 204 000	1987	52 370 000
1955	23 857 000	1988	53 268 000
1956	24 540 000	1989	54 192 000
1957	25 250 000	1990	55 120 000
1958	25 981 000	1991	56 055 000
1959	26 733 000	1992	56 986 000
1960	27 506 000	1993	57 913 000
1961	28 227 000	1994	58 837 000
1962	28 931 000	1995	59 756 000
1963	29 652 000	1996	60 671 000
1964	30 391 000	1997	61 582 000
1965	31 149 000	1998	62 464 000
1966	31 936 000	1999	63 364 000
1967	32 750 000	2000	64 269 000
1968	33 586 000	2001	65 166 000
1969	34 443 000	2002	66 003 000
1970	35 321 000	2003	66 795 000
1971	36 215 000	2004	67 599 000
1972	37 133 000	2005	68 435 000
1973	38 073 000	2006	69 295 000
1974	39 037 000	2007	70 158 000
1975	40 026 000	2008	71 052 000
1976	40 916 000	2009	72 039 000
1977	41 769 000	2010	73 142 000
1978	42 641 000	2011	74 224 000
1979	43 531 000	2012	75 176 000
1980	44 439 000	2013	76 055 000
1981	45 540 000	2014	76 903 000
1982	46 688 000		

Source: TurkStat, Mid-year Population Estimations and Projections

Waste Per Capita: To calculate waste per capita (kg/cap/yr), the amount of MSW generated and mid-year population data are used. The amount of MSW generated for the surveyed years (1994-1998, 2001-2004, 2006, 2008, 2010, 2012 and 2014) are obtained from TurkStat's *Municipal Waste Statistics.* The estimations of TurkStat's *Water and Waste Statistics Group* are used for the years 1999, 2000, 2005, 2007, 2009, 2011 and 2013. Due to lack of historical MSW generated data, the waste per capita of 1994 (398.5 kg/cap/yr) is used for 1950-1993.

Table 7.8 Waste per capita, 1990-2014

Year	MSW Generated (kt)	Population (millions)	Waste per capita (kg/cap/yr)
1990	21 966.7	55.1	398.5
1991	22 339.3	56.1	398.5
1992	22 710.3	57.0	398.5
1993	23 079.8	57.9	398.5
1994	23 448.0	58.8	398.5
1995	27 234.1	59.8	455.8
1996	29 348.0	60.7	483.7
1997	31 943.8	61.6	518.7
1998	32 972.9	62.5	527.9
1999	30 470.0	63.4	480.9
2000	30 617.0	64.3	476.4
2001	31 030.9	65.2	476.2
2002	30 999.3	66.0	469.7
2003	31 081.4	66.8	465.3
2004	29 736.2	67.6	439.9
2005	31 351.9	68.4	458.1
2006	30 081.8	69.3	434.1
2007	30 365.6	70.2	432.8
2008	28 454.0	71.1	400.5
2009	30 196.0	72.0	419.2
2010	29 733.0	73.1	406.5
2011	30 862.0	74.2	415.8
2012	30 786.0	75.2	409.5
2013	30 920.0	76.1	406.5
2014	31 230.0	76.9	406.1

% to SWDS: To calculate percentage of MSW generated which goes to SWDS, the amount of MSW generated and MSW landfilled data are used. The amount of MSW landfilled for the surveyed years (1994-1998, 2001-2004, 2006, 2008, 2010, 2012 and 2014) are obtained from TurkStat's *Municipal Waste Statistics Survey.* The estimations of TurkStat's *Water and Waste Statistics Group* are used for the years 1999, 2000, 2005, 2007, 2009, 2011 and 2013. Due to lack of MSW generated data, % to SWDS of 1994 (70.6%) is used for 1950-1993.

% to SWDS obtained by dividing the amount of MSW landfilled by MSW generated are given for 1990-2014 in Table 7.9.

Table 7.9 Percentage of MSW disposed in the SWDS, 1990-2014

Year	MSW Generated (kt)	MSW Landfilled (kt)	% to SWDS (%)
1990	21 966.7	15 518.4	70.6
1991	22 339.3	15 781.6	70.6
1992	22 710.3	16 043.7	70.6
1993	23 079.8	16 304.7	70.6
1994	23 448.0	16 564.8	70.6
1995	27 234.1	19 975.1	73.3
1996	29 348.0	21 493.5	73.2
1997	31 943.8	22 981.5	71.9
1998	32 972.9	24 002.3	72.8
1999	30 470.0	23 256.9	76.3
2000	30 617.0	23 894.1	78.0
2001	31 030.9	24 471.1	78.9
2002	30 999.3	24 572.6	79.3
2003	31 081.4	25 304.6	81.4
2004	29 736.2	24 406.4	82.1
2005	31 351.9	25 947.4	82.8
2006	30 081.8	24 708.7	82.1
2007	30 365.6	25 484.4	83.9
2008	28 454.0	23 798.2	83.6
2009	30 196.0	25 700.0	85.1
2010	29 733.0	24 904.4	83.8
2011	30 862.0	26 319.0	85.3
2012	30 786.0	25 551.8	83.0
2013	30 920.0	25 267.0	81.7
2014	31 230.0	27 864.2	89.2

Waste Composition Data: Waste composition data are available for the years 1993 and 2006 only. For 1993, the source of the data are *TurkStat, Environmental Statistics, Household Solid Waste Composition and Tendency Survey Results, 1993*. The results of this survey on a national scale are also published in *OECD Environmental Data, Compendium 2006-2008*. The second data source was developed under the Solid Waste Master Plan Project of MoEF for 2006 and published in *Waste Management Action Plan, 2008-2012; MoEF*. Due to lack of historical waste composition data, the data of 1993 are used for the years 1950 to 1992. Due to lack of knowledge and taking into account the economical crisis of 1994, 1998-1999 and 2001, the data of 1993 are also used from 1994 to 2001. Composition data from 2006, as contained in the *Waste Management Action Plan*, was used for 2006-2014.

Table 7.10 Waste composition data

(%)

Year	Food	Garden	Paper	Wood	Textile	Nappies	Plastics, other inert
1990 - 2001	64.0	0.0	6.0	0.0	4.0	0.0	26.0
2002 - 2014	34.0	19.0	16.0	0.0	0.0	0.0	31.0

Industrial Waste Activity Data

The annual data of industrial waste disposed in the municipal SWDS are collected by TurkStat's *Manufacturing Industry Establishments Water, Wastewater and Waste Statistics Survey* which is applied to manufacturing industry establishments having 50 or more employees. However, the survey could not be conducted on a regular basis before 2008, and since 2008 has started to be held biennially. The data are available for the years 1994-1997, 2000, 2004, 2008, 2010, 2012 and 2014. The missing data for the remaining years between 1994 and 2014are estimated by linear interpolation.

Data are available from the statistical surveys described above (noting the need to interpolate data for intervening years when survey data were not available). Data on industrial waste generation were not available prior to 1994. Recognizing that, in accordance with the 2006 IPCC Guidelines, data on industrial waste generation are needed for at least the last 50 years, Turkey has made assumptions to collect the full time series of data. As described further below, between 1950 and 1993, the amount of waste generated is estimated based on the waste generation rate in 1994 and GDP data for each year.

It is noticed that the industrial waste data of the previous inventory submission were included in the data for managed and unmanaged MSW disposed of in the municipal SWDS. Therefore, the industrial waste AD have been revised to avoid double counting duplicates within the waste amount in the SWDS. This year the amount of industrial waste sent to municipalities was subtracted from the estimated amount of industrial waste data for the whole time series. Besides, only the amount of degradable organic material from industrial waste disposed at SWDS is taken into account since only those industrial wastes which are expected to contain DOC and fossil carbon should be considered for the purpose of emission estimations from SWDS. Excluding the industrial waste that is already included in the Municipal Waste Statistics (to avoid double counting), Turkey concluded that there are no separately managed industrial waste disposal practices in the SWDS. For this reason, the distribution of industrial waste by waste management type is 100% unmanaged for the whole time series.

The amount of industrial waste disposed of in unmanaged SWDS consists of dumping onto land, burial and disposals to the Organized Industrial Zones.

Annual industrial waste at the SWDS and distribution of waste by waste management type are given in Table 7.11.

Table 7.11 Annual IW and distribution of waste by management type, 1990-2014

	Annual IW at the SWDS (kt)			Distribution of waste (%)	
Year	**Total**	**Managed**	**Unmanaged**	**Managed**	**Unmanaged**
1990	12.9	NO	12.9	0.0	100.0
1991	12.9	NO	12.9	0.0	100.0
1992	13.6	NO	13.6	0.0	100.0
1993	15.4	NO	15.4	0.0	100.0
1994	11.4	NO	11.4	0.0	100.0
1995	6.7	NO	6.7	0.0	100.0
1996	8.8	NO	8.8	0.0	100.0
1997	0.8	NO	0.8	0.0	100.0
1998	4.7	NO	4.7	0.0	100.0
1999	7.2	NO	7.2	0.0	100.0
2000	10.4	NO	10.4	0.0	100.0
2001	5.6	NO	5.6	0.0	100.0
2002	4.4	NO	4.4	0.0	100.0
2003	3.3	NO	3.3	0.0	100.0
2004	1.6	NO	1.6	0.0	100.0
2005	2.7	NO	2.7	0.0	100.0
2006	3.3	NO	3.3	0.0	100.0
2007	4.0	NO	4.0	0.0	100.0
2008	3.9	NO	3.9	0.0	100.0
2009	3.4	NO	3.4	0.0	100.0
2010	4.2	NO	4.2	0.0	100.0
2011	4.5	NO	4.5	0.0	100.0
2012	4.7	NO	4.7	0.0	100.0
2013	5.6	NO	5.6	0.0	100.0
2014	6.1	NO	6.1	0.0	100.0

GDP Data: Historical data for GDP by production approach are obtained from TurkStat's *National Accounts* from 1923 onwards. GDP data (in purchasers' value) in current prices are given in Table 7.12.

Table 7.12 GDP by production approach, 1950-2014

(million USD)

Year	GDP	Year	GDP
1950	3 469	1983	60 373
1951	4 167	1984	58 643
1952	4 793	1985	66 408
1953	5 585	1986	75 018
1954	5 700	1987	85 638
1955	6 854	1988	90 495
1956	7 909	1989	106 123
1957	10 518	1990	149 195
1958	12 552	1991	149 156
1959	15 687	1992	156 656
1960	9 932	1993	177 332
1961	5 512	1994	131 639
1962	6 402	1995	168 080
1963	7 402	1996	181 077
1964	7 872	1997	188 735
1965	8 419	1998	270 947
1966	9 997	1999	247 544
1967	11 144	2000	265 384
1968	18 008	2001	196 736
1969	20 128	2002	230 494
1970	18 825	2003	304 901
1971	16 847	2004	390 387
1972	21 319	2005	481 497
1973	26 854	2006	526 429
1974	36 985	2007	648 754
1975	46 300	2008	742 094
1976	52 996	2009	616 703
1977	60 613	2010	731 608
1978	66 277	2011	773 980
1979	80 960	2012	786 283
1980	67 457	2013	823 044
1981	70 419	2014	799 370
1982	63 485		

Source: TurkStat, National Accounts

Waste Generation Rate: To calculate waste generation rate (kt/million USD GDP/yr), between 1950 and 1994,the amount of industrial waste (IW) generated and GDP data are used. As noted above, the amount of IW generated for the surveyed years (1994-1997, 2000, 2004, 2008, 2010, 2012 and 2014) are obtained from TurkStat's *Manufacturing Industry Establishments Water, Wastewater and Waste Statistics Survey.* Missing data for the years not surveyed (1998, 1999, 2001-2003, 2005-2007, 2009, 2011 and 2013) are estimated by linear interpolation. Due to lack of historical IW generated data, the waste generation rate of 1994 (0.09 kt/million USD GDP/yr) is used for 1950-1993 (see Table 7.13).

% to SWDS: To calculate the percentage of industrial waste generated which goes to SWDS, the amount of industrial waste generated and industrial waste landfilled data are used. The amount of industrial waste landfilled for the surveyed years (1994-1997, 2000, 2004, 2008, 2010, 2012 and 2014) are obtained from TurkStat's *Manufacturing Industry Establishments Water, Wastewater and Waste Statistics Survey.* Due to lack of industrial waste generated data, the percentage of industrial waste sent to SWDS in 1994 (0.1%) is used for 1950-1993.

The percentage of industrial waste to SWDS is obtained by dividing the amount of industrial waste landfilled by industrial waste generated data.

Industrial waste AD are given in detail in Table 7.13.

Table 7.13 Industrial waste activity data, 1990-2014

Year	GDP (million USD)	Waste generation rate (kt/million USD/yr)	Total IW (kt)	% to SWDS (%)	Total to SWDS (kt)
1990	149 195.0	0.09	13 615.4	0.10	12.9
1991	149 156.0	0.09	13 611.8	0.10	12.9
1992	156 656.0	0.09	14 296.3	0.10	13.6
1993	177 332.0	0.09	16 183.1	0.10	15.4
1994	131 639.0	0.09	12 013.2	0.10	11.4
1995	168 080.0	0.07	12 492.8	0.05	6.7
1996	181 077.0	0.08	13 921.1	0.06	8.8
1997	188 735.0	0.08	14 659.5	0.01	0.8
1998	270 946.9	0.07	19 835.6	0.02	4.7
1999	247 543.7	0.07	17 017.2	0.04	7.2
2000	265 384.4	0.06	17 058.9	0.06	10.4
2001	196 736.2	0.06	11 689.1	0.05	5.6
2002	230 494.2	0.05	12 573.5	0.03	4.4
2003	304 901.3	0.05	15 149.2	0.02	3.3
2004	390 386.8	0.04	17 497.5	0.01	1.6
2005	481 496.9	0.04	18 210.4	0.01	2.7
2006	526 429.4	0.03	16 224.6	0.02	3.3
2007	648 753.6	0.02	15 453.2	0.03	4.0
2008	742 094.4	0.02	12 481.6	0.03	3.9
2009	616 703.3	0.02	10 819.9	0.03	3.4
2010	731 608.4	0.02	13 366.5	0.03	4.2
2011	773 979.7	0.02	14 167.7	0.03	4.5
2012	786 282.5	0.02	14 420.3	0.03	4.7
2013	823 044.4	0.02	15 647.0	0.04	5.6
2014	799 369.8	0.02	15 733.5	0.04	6.1

Amount Deposited Data

The resulting estimates of total waste amount deposited in SWDS are summarized in Table 7.14.

Table 7.14 Amount deposited in SWDS, 1990-2014

(kt)

Year	Food	Garden	Paper	Textile	Deposited MSW	Inert	Industrial
1990	9 931.8	-	931.1	620.7	15 518.4	4 034.8	12.9
1991	10 100.2	-	946.9	631.3	15 781.6	4 103.2	12.9
1992	10 268.0	-	962.6	641.7	16 043.7	4 171.4	13.6
1993	10 435.0	-	978.3	652.2	16 304.7	4 239.2	15.4
1994	10 601.5	-	993.9	662.6	16 564.8	4 306.9	11.4
1995	12 784.0	-	1 198.5	799.0	19 975.1	5 193.5	6.7
1996	13 755.8	-	1 289.6	859.7	21 493.5	5 588.3	8.8
1997	14 708.2	-	1 378.9	919.3	22 981.5	5 975.2	0.8
1998	15 361.4	-	1 440.1	960.1	24 002.3	6 240.6	4.7
1999	14 884.4	-	1 395.4	930.3	23 256.9	6 046.8	7.2
2000	15 292.2	-	1 433.6	955.8	23 894.1	6 212.5	10.4
2001	15 661.5	-	1 468.3	978.8	24 471.1	6 362.5	5.6
2002	8 354.7	4 668.8	3 931.6	-	24 572.6	7 617.5	4.4
2003	8 603.6	4 807.9	4 048.7	-	25 304.6	7 844.4	3.3
2004	8 298.2	4 637.2	3 905.0	-	24 406.4	7 566.0	1.6
2005	8 822.1	4 930.0	4 151.6	-	25 947.4	8 043.7	2.7
2006	8 400.9	4 694.6	3 953.4	-	24 708.7	7 659.7	3.3
2007	8 664.7	4 842.0	4 077.5	-	25 484.4	7 900.1	4.0
2008	8 091.4	4 521.6	3 807.7	-	23 798.2	7 377.4	3.9
2009	8 738.0	4 883.0	4 112.0	-	25 700.0	7 967.0	3.4
2010	8 467.5	4 731.8	3 984.7	-	24 904.4	7 720.4	4.2
2011	8 948.5	5 000.6	4 211.0	-	26 319.0	8 158.9	4.5
2012	8 687.6	4 854.8	4 088.3	-	25 551.8	7 921.0	4.7
2013	8 590.8	4 800.7	4 042.7	-	25 267.0	7 832.8	5.6
2014	9 473.8	5 294.2	4 458.3	-	27 864.2	8 637.9	6.1

Methane Correction Factor (MCF)

Due to the assumption that all managed SWDS are categorized under anaerobic managed SWDS, the default MCF from the 2006 IPCC Guidelines for anaerobic managed SWDS (1.0) is taken for managed SWDS. Since, there is no information about classification of deep (>=5 meters waste and/or high water table) or shallow (<5 meters waste) for unmanaged waste disposal sites, the MCF for uncategorized SWDS (0.6) is used for unmanaged waste disposal practices.

A weighted average of MCF from the estimated distribution of site types is needed for the calculation CH_4 emissions from solid waste disposal sites. Calculated values for the MCF are given in Table 7.15.

Table 7.15 Weighted averages of MCF, 1990-2014

(weight fraction)

Year	Weighted average MCF for MSW	Weighted average MCF for IW
1990	0.60	0.60
1991	0.60	0.60
1992	0.62	0.60
1993	0.62	0.60
1994	0.62	0.60
1995	0.63	0.60
1996	0.65	0.60
1997	0.68	0.60
1998	0.69	0.60
1999	0.71	0.60
2000	0.72	0.60
2001	0.74	0.60
2002	0.71	0.60
2003	0.72	0.60
2004	0.71	0.60
2005	0.71	0.60
2006	0.75	0.60
2007	0.76	0.60
2008	0.78	0.60
2009	0.79	0.60
2010	0.82	0.60
2011	0.82	0.60
2012	0.84	0.60
2013	0.86	0.60
2014	0.86	0.60

Choice of Emission Factor and Other Parameters

2006 IPCC default values are selected for utilization in the IPCC Waste Model using the FOD method with the starting year 1950.

Degradable Organic Carbon (DOC): IPCC default values for the degradable organic carbon content of various components (waste types/material) used in the model are listed in Table 7.16.

Table 7.16 2006 IPCC default DOC values by individual waste type (weight fraction, wet basis)

Waste Type	DOC
Food waste	0.15
Garden	0.20
Paper	0.40
Wood and straw	0.43
Textiles	0.24
Nappies	0.24
Sewage sludge	0.05
Industrial waste	0.15

DOC by weight is calculated from the degradable portion of the MSW based on *Equation 3.7 in the 2006 IPCC, Volume 5, Chapter 3* and the IPCC defaults are taken from section 2.3.3.

Equation 7.2

$$\% \text{ DOC (by net weight)} = (0.15 \times A) + (0.20 \times B) + (0.40 \times C) + (0.24 \times D)$$

Where:

A = fraction of food waste in MSW

B = fraction of garden waste in MSW

C = fraction of paper in MSW

D = fraction of textiles in MSW

0.13 and 0.15 are the calculated values of DOC by weight for the inventory years of 1990-2001 and 2002-2014, respectively.

Fraction of Degradable Organic Carbon Which Decomposes (DOC_f): In the absence of country-specific information, the recommended IPCC default value for DOC_f (0.5) is used for the entire time series.

Methane Generation Rate Constant (k): IPCC default methane generation rate constants are selected according to the IPCC climate zone definitions in the model. Default k values for dry temperate are listed below and applied for the entire time series.

Table 7.17 2006 IPCC default dry temperate k values by waste type (years^{-1})

Waste Type	k
Food waste	0.06
Garden	0.05
Paper	0.04
Wood and straw	0.02
Textiles	0.04
Nappies	0.05
Sewage sludge	0.06
Industrial waste	0.05

Fraction of Methane in Generated Landfill Gas (F): Most waste in SWDS generates a gas with approximately 50% CH_4. The IPCC default value for the fraction of CH_4 in landfill gas (0.5) is used for the entire time series.

Oxidation Factor (OX): The oxidation factor reflects the amount of CH_4 from SWDS that is oxidized in the soil or other material covering the waste. The default value for OX is zero for managed, unmanaged and uncategorized SWDS and this is the value applied by Turkey for the entire time series.

Methane Recovery

The recovery of methane and its subsequent utilization is also considered in the inventory. Methane recovery from landfill gas started to be implemented in Turkey in 2002. Therefore, the quantity of recovered methane is subtracted from the methane produced beginning in the year 2002. In 2013, *Waste Disposal and Recovery Facilities Survey, 2012* was applied to all waste disposal and recovery facilities having a license or a temporary license, and regardless of license, to controlled landfill sites, incineration plants and composting plants operated by or on behalf of municipalities. Based on the information obtained from the survey, TurkStat sent official letters to each facility recovering methane for requesting the quantity of methane gas and electricity production for the entire operating period of the facility. The facilities estimate the quantity of methane recovered by measuring of gas recovered. The obtained information on the quantity of produced electricity is used for cross-check of the quantity of methane recovered.

The coverage of the facilities are followed and updated depending on availability of new information; including information obtained from the facility, the information from the latest survey *(Waste*

Disposal and Recovery Facilities Survey, 2014) etc. The emissions from energy production from the recovered CH_4 gas in SWDS were included in the category of Public Electricity and Heat Production.

The number of managed SWDS with landfill gas recovery and the amount of recovered methane, by year, are given in Table 7.18.

Table 7.18 Methane recovery, 1990-2014

Year	Number of SWDS with landfill gas recovery	Recovered methane (kt)
1990	NA	NO
1991	NA	NO
1992	NA	NO
1993	NA	NO
1994	NA	NO
1995	NA	NO
1996	NA	NO
1997	NA	NO
1998	NA	NO
1999	NA	NO
2000	NA	NO
2001	NA	NO
2002	1	1.5
2003	1	2.5
2004	1	2.3
2005	1	1.7
2006	1	2.2
2007	2	8.3
2008	3	21.4
2009	4	36.5
2010	5	47.9
2011	8	56.7
2012	13	96.2
2013	17	172.8
2014	20	190.7

There is no official data on landfill gas flaring although an additional question of landfill gas flaring has been added to the *Waste Disposal and Recovery Facilities Survey, 2014*. It will be also considered in the upcoming inventory in the case that new information is obtained.

Uncertainties and Time-Series Consistency:

Uncertainty values for AD are estimated as 10.0% and 30.0% for managed and unmanaged SWDS, respectively. The uncertainty values reflect the uncertainty associated with some of the assumptions made by Turkey in estimating underlying activity data for MSW and industrial waste. Although waste statistics on the amount of MSW generated are not available for all years after 1990, the periodic availability of survey data reduces the uncertainty of these data. The assumption that waste generation per capita prior to 1994 is constant likely overestimates the MSW generation for this time period. Further, estimating MSW generation based on population does not account for the fact that not all of the population may be serviced with waste collection. Data on waste composition are available only for two years (1993 and 2006), and these compositions were assumed to apply for the period 1990-2001 and 2002-2014, respectively, adding to the uncertainty of the activity data.

Combined uncertainty values of EFs are estimated as 32.0% and 41.5% for managed and unmanaged SWDS based on *Table 3.5 in 2006 IPCC, Volume 5, Chapter3.*

The estimates are calculated in a consistent manner over time series.

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under Turkey's QA/QC plan.

As part of the QA/QC procedures for the 2016 inventory submission it was identified that there was a double counting of industrial waste data delivered to solid waste disposal sites; some industrial waste data were also included in the MSW statistics. This double counting was removed and the time series recalculated.

The data used in Solid Waste Disposal (CRF Category 5.A) are derived from waste statistics database of TurkStat. TurkStat is producing all its statistics according to the European Code of Practice Principles. Therefore high quality data are used in the emission estimates of this category.

Recalculation:

2013 data for the amount of MSW disposed in managed SWDS is recalculated by linear interpolation due to the availability of 2014 survey data.

Emission estimates from solid waste disposal (CRF Category 5.A) are recalculated over the 1990-2013 time series due to thoroughly research on country-specific values of industrial waste disposed in the SWDS from related surveys. This research identified that a significant amount of industrial waste was included in the Municipal Waste Statistics. The impact of this recalculation resulted in a decline in emissions of 6% for 1990 and 158% in 2013.

In summary, CH_4 emissions from solid waste disposal sites have been recalculated for the years 1990-2013. Compared to the previous inventory submission, CH4 emissions in 2013 decreased by 45.1 per cent (9 707.34 kt), and decreased in 1990 by 30.6 per cent (2 962.18 kt).

Planned Improvement:

Depending on availability of good quality country-specific data, waste composition data and other parameters for some major managed SWDS in Turkey will be studied within the *Technical Assistance for Support to Mechanism for Monitoring Turkey's Greenhouse Gas Emissions (TASK-GHG) Project* a future inventory submission, pending completion of the study and necessary QA/QC on the results.

As noted above, Turkey has added an additional question on flaring of landfill gas to its *Waste Disposal and Recovery Facilities Survey, 2014*, but there is no information available yet. The results of the next survey *(Waste Disposal and Recovery Facilities Survey, 2016)* will be assessed, and if appropriate, the results incorporated into the next inventory submission(s).

7.3. Biological Treatment of Solid Waste (Category 5.B)

Source Category Description:

This category includes emissions from composting and anaerobic digestion of organic waste. Turkey reports CH_4 and N_2O emissions from composting of municipal solid waste (5.B.1). Turkey has no information available on the existence of anaerobic digestion of organic waste. Therefore, consistent with the 2006 IPCC Guidelines, Turkey assumes that there is no anaerobic digestion in the country. However, this treatment process will be also considered and reported in coming years depending on availability of any information.

Biological treatment of solid waste emissions decreased by 14.2% (2.94 kt CO_2 eq.) between 1990 (20.75 kt CO_2 eq.) and 2014 (17.81 kt CO_2 eq.).

Methodological Issues:

To estimate both CH_4 and N_2O emissions for composting, Turkey multiples the mass of organic waste composted by a default emission factor (the IPCC T1 method), as recommended in the 2006 IPCC Guidelines for National GHG Inventories.

Collection of Activity Data

The amount of waste delivered to composting plants (1994-1998, 2001-2004, 2006, 2008, 2010, 2012 and 2014) are available in TurkStat's *Municipal Waste Statistics* as provided in Table 7.5. The estimations of TurkStat's *Water and Waste Statistics Group* are also available for the years not surveyed (1999, 2000, 2005, 2007, 2009, 2011 and 2013). However, after the sorting processes in composting plants, some amount of waste which cannot be composted is transferred to controlled landfill sites or sold. Therefore, Turkey uses the "total amount of waste treated by composting plants" as the AD in the emissions estimations instead of the "total amount of waste delivered to composting plants", where such data are available. The composted waste data are available in TurkStat's *Municipal Waste Statistics* for the years 2006, 2008 and 2010, and TurkStat's *Waste Disposal and Recovery Facilities Statistics* for the years 2005, 2012 and 2014. The amount of waste for composting is estimated by weighed onsite.

For the years not surveyed (1994-2004, 2007, 2009, 2011 and 2013), the average "fraction of waste composted" is used to estimate the amount of waste treated by composting plants for providing a complete time series from 1994-2014. The fractions of waste composted are calculated as the "total amount of waste treated by composting plants" divided by the "total amount of waste delivered to composting plants" for the years of 2005, 2006, 2008, 2010, 2012 and 2014. The fraction of the year 2012 is determined as an outlier and is not taken into account while calculating the average value as 57.0%. Due to lack of historical waste data treated by composting plants, the AD of 1994 (109.5 kt) is used for 1990-1993.

Number of composting plants in Turkey is listed below as a supplementary information.

Table 7.19 Number of composting plants, 1995-2014

1995	2000	2005	2006	2008	2010	2012	2014
1	2	4	4	4	5	6	4

Source: (1995-2010) TurkStat, Municipal Waste Statistics

(2012-2014) TurkStat, Waste Disposal and Recovery Facilities Statistics

Choice of Emission Factor

EFs of 4.0 g CH_4/kg waste treated (on a wet weight basis) and 0.3 g N_2O/kg waste treated (on a wet weight basis) are selected for the estimates of CH_4 and N_2O emissions respectively, based on *Table 4.1 in the 2006 IPCC Guidelines, Volume 5, Chapter 4.*

The total annual amount of waste treated (as wet weight) by composting plants and emissions from composting are provided in Table 7.20.

Table 7.20 Activity data, CH_4 and N_2O emissions from composting, 1990-2014

(kt)

Year	Amount of waste treated by composting plants	CH_4 Emissions	N_2O Emissions
1990	109.5	0.44	0.033
1991	109.5	0.44	0.033
1992	109.5	0.44	0.033
1993	109.5	0.44	0.033
1994	109.5	0.44	0.033
1995	90.6	0.36	0.027
1996	102.0	0.41	0.031
1997	102.9	0.41	0.031
1998	94.8	0.38	0.028
1999	128.6	0.51	0.039
2000	136.3	0.55	0.041
2001	124.4	0.50	0.037
2002	218.5	0.87	0.066
2003	185.9	0.74	0.056
2004	200.0	0.80	0.060
2005	165.4	0.66	0.050
2006	104.8	0.42	0.031
2007	190.3	0.76	0.057
2008	143.0	0.57	0.043
2009	179.6	0.72	0.054
2010	134.2	0.54	0.040
2011	166.0	0.66	0.050
2012	158.9	0.64	0.048
2013	91.3	0.37	0.027
2014	94.0	0.38	0.028

As seen in Figure 7.3, Figure 7.4 and Figure 7.5, the fluctuations of CH_4 and N_2O emissions from composting depend mainly on the fluctuations of AD. Emissions were relatively stable between 1990 and 1999, before demonstrating larger interannual fluctuations in recent years. CH_4 emissions have a maximum value of 0.87 kt in 2002 while having a minimum value of 0.36 kt in 1995. Likewise, N_2O emissions have a maximum value of 0.066 kt in 2002 while having a minimum value of 0.027 kt in 1995.

Figure 7.3 Amount of waste treated by composting plants, 1990-2014

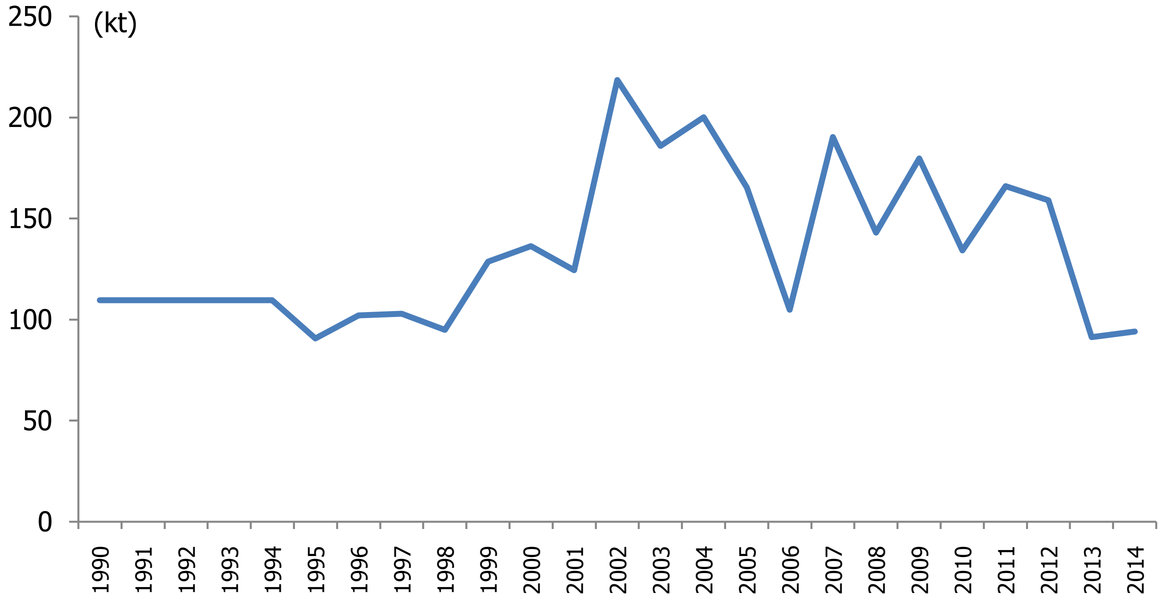


Figure 7.4 CH_4 emissions from composting, 1990-2014

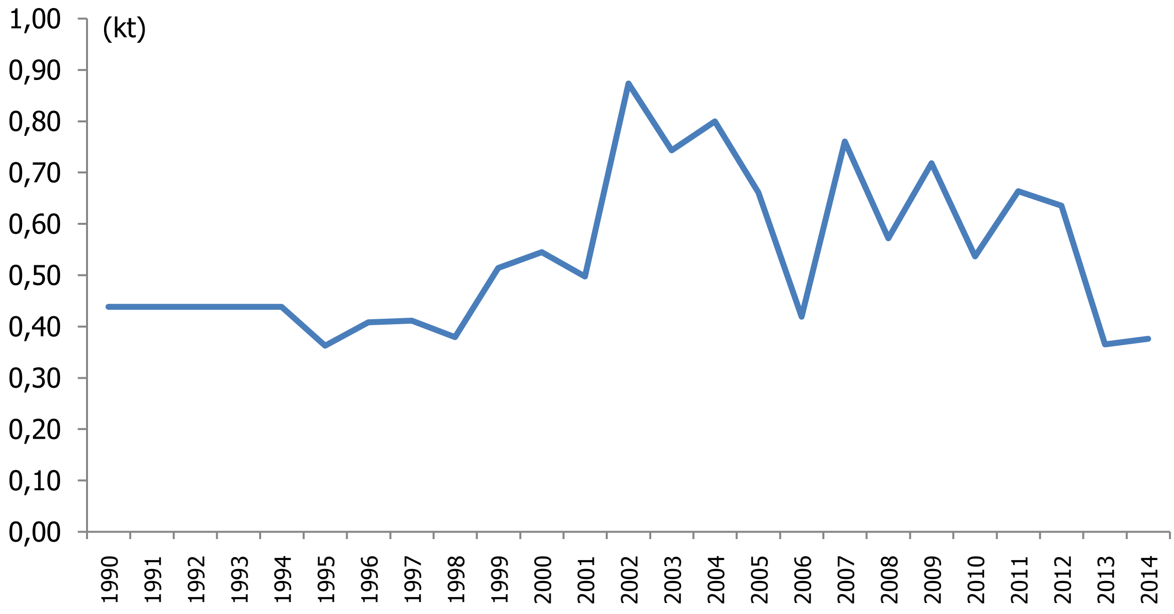
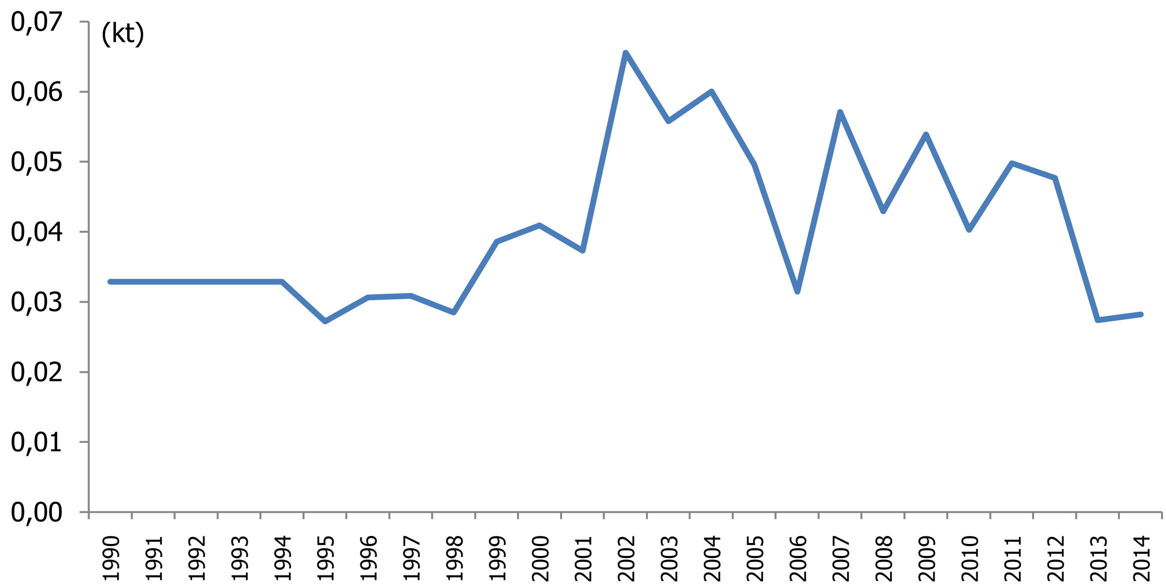


Figure 7.5 N_2O emissions from composting, 1990-2014



Uncertainties and Time-Series Consistency:

The uncertainty value for AD is estimated as 10.0% based on *Table 3.5 in the 2006 IPCC Guidelines, Volume 5, Chapter 3*.The uncertainty value of the EF is considered as 20.0% for both CH_4 and N_2O EFs since there is no sufficient information in 2006 IPCC.

The estimates are calculated in a consistent manner over time series.

Source-Specific QA/QC and Verification:

QA/QC procedures implemented for each category in order to verify and improve the inventory under the Turkey's QA/QC plan.

The data used in Biological Treatment of Solid Waste (CRF Category 5.B) are derived from waste statistics database of TurkStat. TurkStat is producing all its statistics according to the European Code of Practice Principles. Therefore high quality data are used in the emission estimates of this category.

Recalculation:

Emission estimates from biological treatment of solid waste (CRF Category 5.B) were recalculated over the 1990-2013 time series due to using "total amount of waste treated by composting plants" as AD in emission estimations instead of "total amount of waste delivered to composting plants" which is used as AD in the previous submission. This error was identified during QC checks.

Overall, recalculations resulted in a decrease in emissions of 13.0 kt CO_2 eq. (43.0%) in 2013 and a decrease in emissions of 15.6 kt CO_2 eq. (43.0%) in 1990.

Planned Improvement:

Emissions and amount of CH_4 for energy recovery from anaerobic digestion at biogas facilities (5.B.2) will be included in next inventory submissions depending on the availability of such treatment processes. Turkey continues to monitor the available waste statistics and any other information to determine the existence of biogas facilities with anaerobic digestion. At this time, no such information exists, but when it becomes available, Turkey intends to estimate these emissions.

7.4. Incineration and Open Burning of Waste (Category 5.C)

Source Category Description:

This category includes emissions from open burning of waste. The category covers CO_2, CH_4 and N_2O emissions from open burning of waste (5.C.2) which is divided into waste of biogenic origin (5.C.2.1) and waste of non-biogenic origin (5.C.2.2). Only municipal solid waste is open burned in Turkey (5.C.2.2.a). CO_2 emissions from waste of biogenic origin are reported but not counted as part of the national total GHG emissions. Unlike CO_2, emissions of CH_4 and N_2O from biogenic derived wastes are estimated and accounted for under the waste sector.

Emissions from waste incineration (5.C.1) are included in the inventory but reported in the energy sector since the purpose of waste incineration is for energy recovery. Emissions from MSW of biogenic origin (5.C.1.1.a) and MSW of non-biogenic origin (5.C.1.2.a) are not occurring since MSW is not incinerated in the incineration plants in Turkey.

Emissions from incineration of industrial solid waste of biogenic origin (5.C.1.1.b.i) and industrial solid waste of non-biogenic origin (5.C.1.2.b.i) are included in public electricity and heat production (1.A.1.a), chemicals (1.A.2.c) and other (1.A.2.g) sub-categories in the energy sector.

Emissions from incineration of clinical waste of biogenic origin (5.C.1.1.b.ii) and clinical waste of non-biogenic origin (5.C.1.2.b.ii) are included in public electricity and heat production (1.A.1.a).

Emissions from open burning of waste declined 98.9% (79.9 kt CO_2 eq.) between 1990 to 2014, including a decrease of 92.2% (10.7 kt CO_2 eq.) between 2013 and 2014. The main reason of this trend is the decreasing amount of waste open-burned by years, especially with a sharp decline in 2014.

CO_2 Emissions

The CO_2 emissions from open burning of waste are estimated on the basis of waste types/material (such as paper, wood, plastics) in the waste open-burned as given in *Equation 5.2 in the 2006 IPCC Guidelines, Volume 5, Chapter 5.* Total CO_2 emissions from open burning fluctuate between 1990-2014 as shown in Figure 7.6. The biogenic CO_2 emissions from open burning should not be included in national total emission estimates according to the information given in *2006 IPCC, Volume 5, Chapter 5, Section 5.1* as in Table 7.21.

Figure 7.6 CO_2 emissions from open burning of waste, 1990-2014

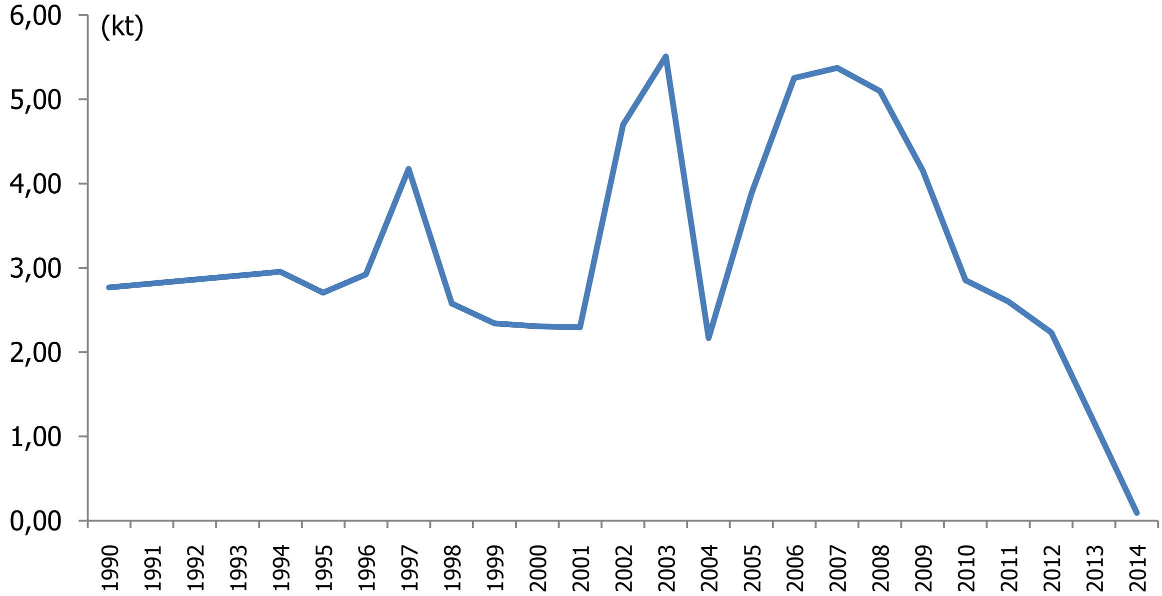


Table 7.21 CO_2 emissions from open burning of waste, 1990-2014

(kt)

Year	Total	Biogenic	Non-biogenic
1990	2.766	0.044	2.766
1991	2.813	0.045	2.813
1992	2.859	0.046	2.859
1993	2.906	0.047	2.906
1994	2.952	0.047	2.952
1995	2.704	0.043	2.704
1996	2.924	0.047	2.924
1997	4.174	0.067	4.174
1998	2.578	0.041	2.578
1999	2.339	0.038	2.339
2000	2.307	0.037	2.307
2001	2.294	0.037	2.294
2002	4.700	0.043	4.700
2003	5.509	0.050	5.509
2004	2.166	0.020	2.166
2005	3.879	0.035	3.879
2006	5.254	0.048	5.254
2007	5.373	0.049	5.373
2008	5.099	0.046	5.099
2009	4.154	0.038	4.154
2010	2.853	0.026	2.853
2011	2.599	0.024	2.599
2012	2.232	0.020	2.232
2013	1.166	0.011	1.166
2014	0.091	0.001	0.091

CH_4 Emissions

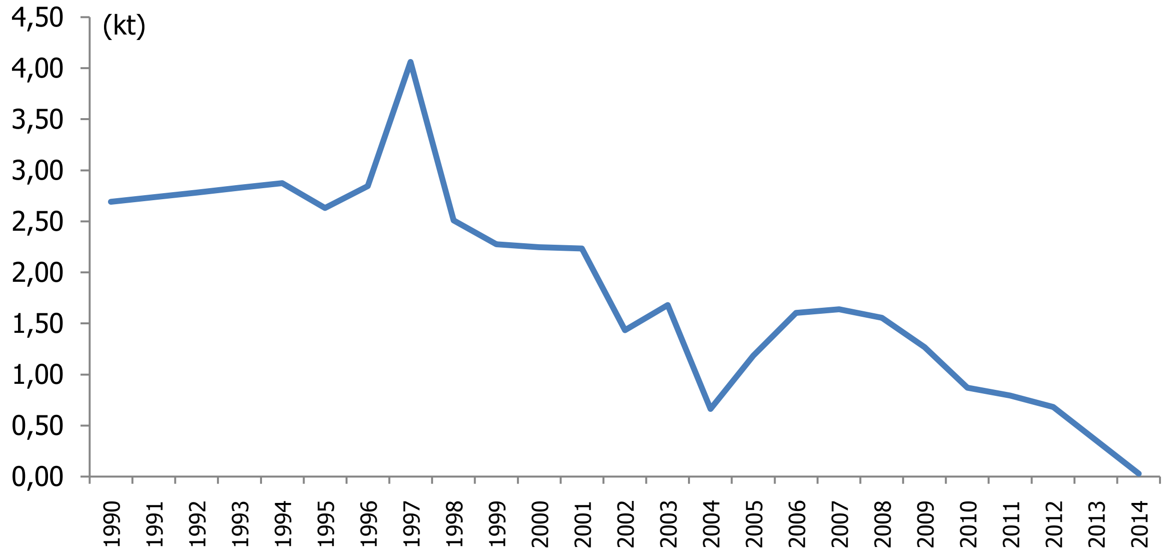
Estimated results of CH_4 emissions are given in Table 7.22 and Figure 7.7. The CH_4 emissions show a decreasing trend with the same fluctuations as with AD between 1990 and 2014 as can be seen in Figure 7.9 below.

Table 7.22 CH_4 emissions from open burning of waste, 1990-2014

(kt)

Year	Total	Biogenic	Non-biogenic
1990	2.692	1.885	0.808
1991	2.738	1.917	0.821
1992	2.784	1.948	0.835
1993	2.829	1.980	0.849
1994	2.874	2.012	0.862
1995	2.633	1.843	0.790
1996	2.846	1.992	0.854
1997	4.063	2.844	1.219
1998	2.510	1.757	0.753
1999	2.277	1.594	0.683
2000	2.246	1.572	0.674
2001	2.233	1.563	0.670
2002	1.434	0.717	0.717
2003	1.680	0.840	0.840
2004	0.661	0.330	0.330
2005	1.183	0.592	0.592
2006	1.603	0.801	0.801
2007	1.639	0.819	0.819
2008	1.555	0.778	0.778
2009	1.267	0.634	0.634
2010	0.870	0.435	0.435
2011	0.793	0.396	0.396
2012	0.681	0.340	0.340
2013	0.356	0.178	0.178
2014	0.028	0.014	0.014

Figure 7.7 CH_4 emissions from open burning of waste, 1990-2014



N_2O Emissions

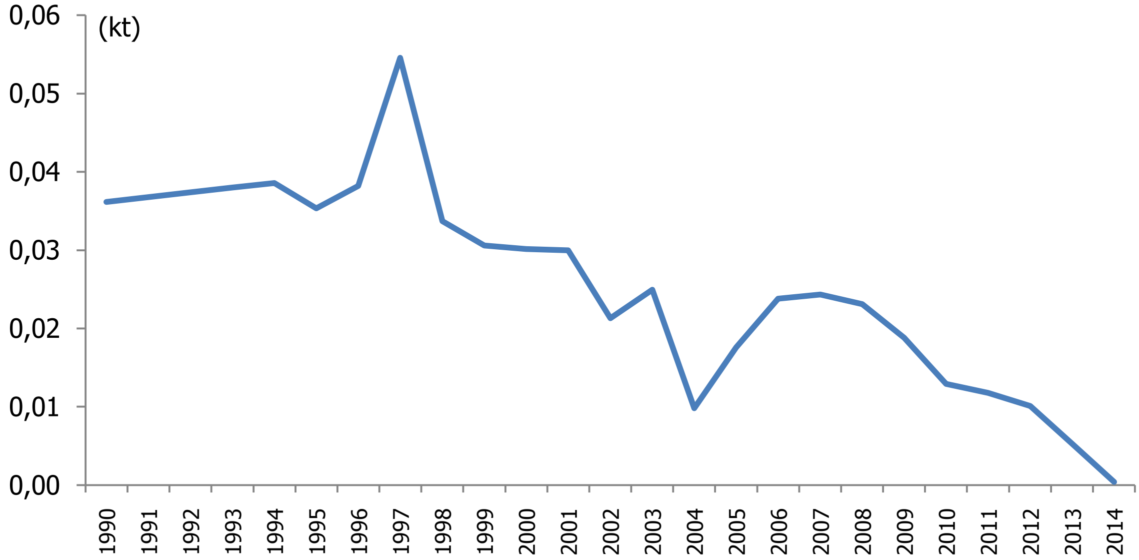
Estimated results of N_2O emissions from open burning of waste are given in Table 7.23 and Figure 7.8. As with CH_4 emissions, N_2O emissions have a decreasing trend with the same fluctuations as of AD between 1990 and 2014 as can be seen in Figure 7.9 below.

Table 7.23 N_2O emissions from open burning of waste, 1990-2014

(kt)

Year	Total	Biogenic	Non-biogenic
1990	0.0362	0.0193	0.0169
1991	0.0368	0.0196	0.0172
1992	0.0374	0.0199	0.0175
1993	0.0380	0.0202	0.0178
1994	0.0386	0.0206	0.0180
1995	0.0354	0.0188	0.0165
1996	0.0382	0.0204	0.0179
1997	0.0546	0.0291	0.0255
1998	0.0337	0.0180	0.0158
1999	0.0306	0.0163	0.0143
2000	0.0302	0.0161	0.0141
2001	0.0300	0.0160	0.0140
2002	0.0213	0.0093	0.0120
2003	0.0250	0.0109	0.0141
2004	0.0098	0.0043	0.0055
2005	0.0176	0.0076	0.0099
2006	0.0238	0.0104	0.0135
2007	0.0244	0.0106	0.0138
2008	0.0231	0.0101	0.0131
2009	0.0188	0.0082	0.0106
2010	0.0129	0.0056	0.0073
2011	0.0118	0.0051	0.0067
2012	0.0101	0.0044	0.0057
2013	0.0053	0.0023	0.0030
2014	0.0004	0.0002	0.0002

Figure 7.8 N_2O emissions from open burning of waste, 1990-2014



Methodological Issues:

The IPCC Tier 2a method recommended in the 2006 IPCC Guidelines for National GHG Inventories is applied to estimate CO_2 emissions. As elaborated below, Turkey multiplies the amount of waste types open-burned (wet weight) by the dry matter content, the fossil carbon fraction and an oxidation factor. To estimate CH_4 and N_2O emissions, IPCC default emission factors are multiplied by the amount of waste open-burned (the IPCC T1 method in the 2006 IPCC Guidelines).

Collection of Activity Data

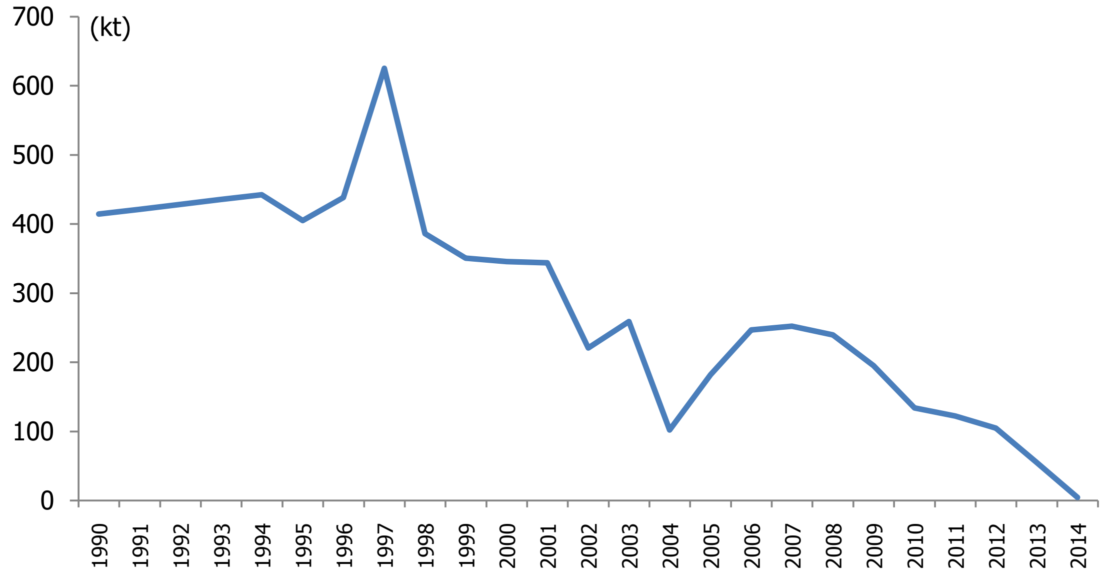
Activity data for open burning of MSW are estimated by using the total amount of MSW open-burned (1994-1998, 2001-2004, 2006, 2008, 2010, 2012 and 2014) as obtained from TurkStat's *Municipal Waste Statistics Survey* as given in Table 7.5 and applying an estimate of the composition of MSW.

To calculate the total amount of MSW open-burned for the years not surveyed (1999, 2000, 2005, 2007, 2009, 2011 and 2013) the total amount of MSW open-burned as a fraction of the MSW generated data is calculated for the available years (MSW generated data are given in Table 7.8). Open-burned % in generated MSW for the years 1999, 2000, 2005, 2007, 2009 and 2011 are estimated by linear interpolation. Due to lack of historical data for MSW open-burned, the open-burned % of 1994 (1.89%) is used for 1990-1993. The open-burned % of 2013 (0.18%) is recalculated by linear interpolation due to the availability of 2014 survey data. As a result, the total amount of MSW open-burned is calculated for the entire time-series and provided in Table 7.24 and Figure 7.9.

Table 7.24 The fraction and amount of MSW open-burned, 1990-2014

Year	Fraction of MSW open-burned (%)	Amount of MSW open-burned (kt)
1990	1.89	414.22
1991	1.89	421.24
1992	1.89	428.24
1993	1.89	435.21
1994	1.89	442.15
1995	1.49	405.03
1996	1.49	437.90
1997	1.96	625.14
1998	1.17	386.13
1999	1.15	350.34
2000	1.13	345.52
2001	1.11	343.59
2002	0.71	220.55
2003	0.83	258.53
2004	0.34	101.62
2005	0.58	182.05
2006	0.82	246.55
2007	0.83	252.12
2008	0.84	239.29
2009	0.65	194.95
2010	0.45	133.88
2011	0.40	121.98
2012	0.34	104.75
2013	0.18	54.72
2014	0.01	4.28

Figure 7.9 Total amount of MSW open-burned



Country-specific values on the total waste amount (Table 7.24) and the waste fraction for each component for MSW are needed to apply Tier 2a. To calculate the country-specific waste fraction, MSW composition data are used as given in Table 7.25. Default dry matter content, total carbon content and fossil carbon fraction of different MSW components are given in Table 7.26 which is based on *Table 2.4 in the 2006 IPCC Guidelines, Volume 5, Chapter 2.*

Table 7.25 MSW composition data by type of origin

(%)

MSW Component	Origin	1990-2001 (1)	2002-2014 (2)
Paper/cardboard	Biogenic	6.0	16.0
Textiles	Non-biogenic	4.0	0.0
Food waste	Biogenic	64.0	34.0
Wood	Biogenic	0.0	0.0
Garden and Park waste	Non-biogenic	0.0	19.0
Nappies	Non-biogenic	0.0	0.0
Plastics	Non-biogenic	3.0	2.0
Metal	Non-biogenic	1.0	1.0
Glass	Non-biogenic	2.0	6.0
Other, inert waste	Non-biogenic	20.0	22.0

(1) TurkStat, Environmental Statistics, Household Solid Waste Composition and Tendency Survey Results, 1993

(2) MoEF, Waste Management Action Plan, 2008-2012

Table 7.26 Default dry matter content, total carbon content and fossil carbon fraction

(%)

MSW Component	Origin	Dry matter content in % of wet weight	Total carbon content in % of dry weight	Fossil carbon fraction in % of total carbon
Paper/cardboard	Biogenic	90.0	46.0	1.0
Textiles	Non-biogenic	80.0	50.0	20.0
Food waste	Biogenic	40.0	38.0	-
Wood	Biogenic	85.0	50.0	-
Garden and Park waste	Non-biogenic	40.0	49.0	0.0
Nappies	Non-biogenic	40.0	70.0	10.0
Rubber and Leather	Non-biogenic	84.0	67.0	20.0
Plastics	Non-biogenic	100.0	75.0	100.0
Metal	Non-biogenic	100.0	NA	NA
Glass	Non-biogenic	100.0	NA	NA
Other, inert waste	Non-biogenic	90.0	3.0	100.0

Choice of Emission Factor

Dry matter content (dm), total carbon content (CF) and fossil carbon fraction (FCF) in MSW are calculated by using *Equations 5.8, 5.9 and 5.10* respectively as given in the *2006 IPCC Guidelines, Volume 5, Chapter 5.* Two different waste fractions (WF) of 1990-2001 and 2002-2014 are used as given in Table 7.27 which is based on *Table 5.2 in 2006 IPCC, Volume 5, Chapter 5* and the fractions in Table 7.25 and 7.26 above*.* A default oxidation factor in % of carbon input (OX) is selected for MSW as 58.0%.

Table 7.27 Parameters related to CO_2 emission factors

(%)

Year	Origin	dm	CF	FCF	OX
1990-2001	Biogenic	31.0	27.1	0.06	58.0
	Non-biogenic	27.2	4.85	23.8	58.0
2002-2014	Biogenic	28.0	20.3	0.16	58.0
	Non-biogenic	36.4	11.5	24.0	58.0

The CH_4 emissions from open burning of waste are estimated by using the IPCC default EF of 6500 g CH_4 / t wet weight for both biogenic and non-biogenic origin of MSW as reported in the *2006 IPCC Guidelines, Volume 5, Chapter 5, Section 5.4.2*.

The N_2O emissions from open burning of waste are estimated by using the IPCC default EF of 150 g N_2O / t dry weight for MSW according to the *2006 IPCC Guidelines, Volume 5, Chapter 5, Table 5.6.* Since the related EF refers to dry weight, the weight of waste open-burned is converted from wet weight to dry weight as reported in the *2006 IPCC Guidelines, Volume 5, Chapter 5, Section 5.3.3*for MSW of both biogenic and non-biogenic origin.

Uncertainties and Time-Series Consistency:

The uncertainty value for AD is estimated as 30.4%. The uncertainty value of the CO_2EF is considered as 20.0%. Since default values for CH_4 and N_2O EFs are used, the uncertainty values of ± 100% are estimated for both EFs as recommended in the *2006 IPCC Guidelines, Volume 5, Chapter 5, Section 5.7.1.*

The estimates are calculated in a consistent manner over time series.

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under Turkey's QA/QC plan.

The data used in Incineration and Open Burning of Waste (CRF Category 5.C) are derived from the waste statistics database of TurkStat. TurkStat is producing all its statistics according to the European Code of Practice Principles. Therefore high quality data are used in the emission estimates of this category.

Recalculation:

2013 data for the fraction of MSW open-burned is recalculated by linear interpolation due to the availability of 2014 survey data from TurkStat's *Municipal Waste Statistics Survey*. For 2013, emissions declined by 2.3 kt CO_2 eq. (0.2%).

Planned Improvement:

There are no planned improvements for next inventory submissions regarding this category.

7.5. Wastewater Treatment and Discharge (Category 5.D)

Source Category Description:

This category includes CH_4 and N_2O emissions from wastewater treatment and discharge systems. Wastewater originates from domestic, commercial and industrial sources by treatment and disposal systems. Because of the IPCC methodology, emissions from commercial wastewater are estimated as part of domestic wastewater. Treatment and disposal types for domestic and industrial wastewater are separated into collected and uncollected systems. Each system is divided into untreated and treated systems. For collected systems; sea, river and lake discharge, and stagnant sewer are the untreated systems. Aerobic and anaerobic treatments are the main treated systems of sewered to plants. For uncollected systems; septic system is considered as treated and sea, river and lake discharge as untreated practices in Turkey.

CH_4 emissions are estimated for both domestic wastewater (5.D.1) and industrial wastewater (5.D.2). N_2O emissions from 5.D.2 are also reported in 5.D.1.

Wastewater treatment and discharge emissions increased by 2.2% (89 kt CO_2 eq.) for the period 1990-2014, but decreased by 4.5% (196 kt CO_2 eq.) between 2013 and 2014. Main drivers for the decrease are the increased methane recovery from domestic wastewater treatment plants starting in 1998 and administrative division changes in the proportion of urban and rural population after 2013. Methane recovery in domestic wastewater treatment increased by 576.7 per cent (791 kt CO_2 eq.) between 1998 (137 kt CO_2 eq.) and 2014 (929 kt CO_2 eq.).

Methodological Issues:

Methane Emissions from Wastewater

Methane Emissions from Domestic Wastewater

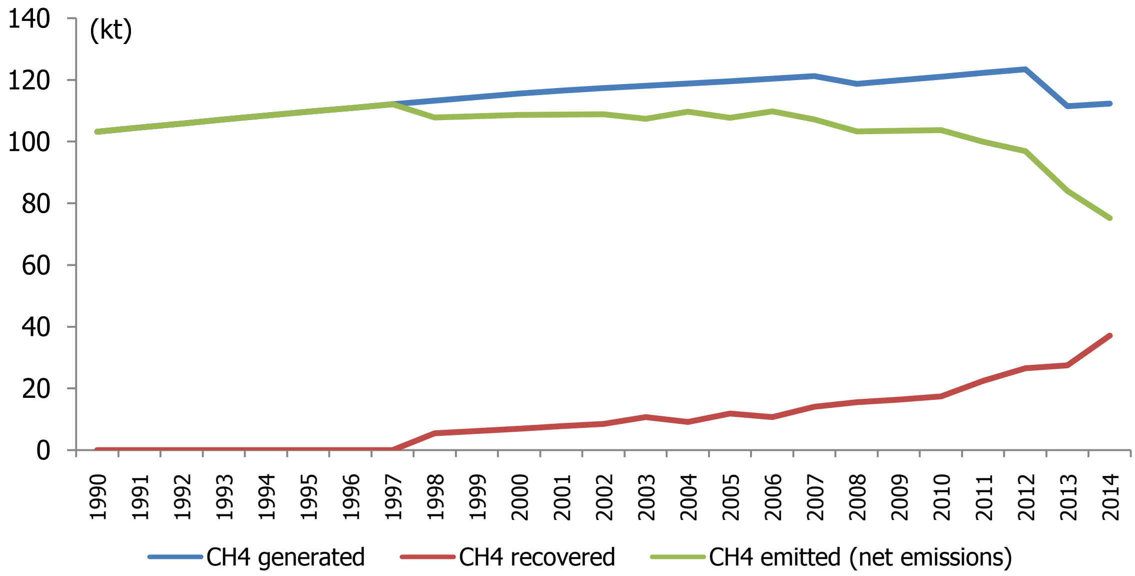
The IPCC T2 method of the 2006 IPCC Guidelines is applied to estimate CH_4 emissions from domestic wastewater. CH_4 emissions are estimated by using *Equation 6.1 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.* Total CH_4 emissions are estimated based on country-specific information on the total organics in wastewater minus the total amount of sludge and multiplying by the IPCC default emission factor, corrected for country-specific fractions of urban/rural populations and the fraction of the wastewater utilizing the various discharge pathways. The amount of methane generated, methane recovered and net methane emissions are estimated as given in Table 7.28 and Figure 7.10.

Table 7.28 CH_4 generated, recovered and emitted from domestic wastewater, 1990-2014

(kt)

Year	CH_4 Generated	CH_4 Recovered	CH_4 Emitted
1990	103.2	NO	103.2
1991	104.5	NO	104.5
1992	105.8	NO	105.8
1993	107.1	NO	107.1
1994	108.4	NO	108.4
1995	109.7	NO	109.7
1996	110.9	NO	110.9
1997	112.1	NO	112.1
1998	113.2	5.5	107.8
1999	114.4	6.2	108.2
2000	115.6	6.9	108.6
2001	116.5	7.8	108.7
2002	117.4	8.5	108.8
2003	118.1	10.7	107.4
2004	118.8	9.2	109.7
2005	119.6	11.9	107.7
2006	120.4	10.7	109.8
2007	121.2	14.1	107.2
2008	118.8	15.5	103.3
2009	119.9	16.4	103.5
2010	121.1	17.4	103.7
2011	122.4	22.5	99.9
2012	123.5	26.6	96.9
2013	111.5	27.5	84.0
2014	112.3	37.1	75.2

Figure 7.10 CH_4 emissions from domestic wastewater, 1990-2014



The key drivers for the decreasing trend in net emissions are the increasing of methane recovery after the beginning year of 1998. Despite having an increasing trend normally, the main reasons for the sharp decreases in generated methane in the years of 2008 and 2013 are the administrative division changes in the proportion of urban and rural population in 2008 and 2013.

Collection of Activity Data

To calculate CH_4 emissions from domestic wastewater, total organics in wastewater (TOW) and organic component removed as sludge (S) are needed. The TOW is calculated by using *Equation 6.3 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.* The total population is used to calculate TOW and S values. For the entire time series, the total population is taken from Turkstat's *Population and Migration Statistics*. The total population is then divided into the rural and urban fractions to better characterize the discharge pathways for the domestic wastewater. For the years 1990 and 2000, rural and urban population are available from *General Population Censuses*. The results of *Address Based Population Registration System* are used from 2007 to 2014 to split the rural and urban population. Rural and urban population fractions are used to interpolate fractions of rural and urban population for the missing years. The figures are given in Table 7.29.

Table 7.29 Fraction of population and total, rural, urban population, 1990-2014

Year	Fraction of rural	Fraction of urban	Total population	Rural population	Urban population
1990	41.0	59.0	55 120 000	22 592 114	32 527 886
1991	40.4	59.6	56 055 000	22 645 221	33 409 779
1992	39.8	60.2	56 986 000	22 685 723	34 300 277
1993	39.2	60.8	57 913 000	22 713 690	35 199 310
1994	38.6	61.4	58 837 000	22 729 580	36 107 420
1995	38.0	62.0	59 756 000	22 732 684	37 023 316
1996	37.5	62.5	60 671 000	22 723 466	37 947 534
1997	36.9	63.1	61 582 000	22 701 996	38 880 004
1998	36.3	63.7	62 464 000	22 659 275	39 804 725
1999	35.7	64.3	63 364 000	22 612 590	40 751 410
2000	35.1	64.9	64 269 000	22 557 058	41 711 942
2001	34.3	65.7	65 166 000	22 352 793	42 813 207
2002	33.5	66.5	66 003 000	22 114 135	43 888 865
2003	32.7	67.3	66 795 000	21 847 423	44 947 577
2004	31.9	68.1	67 599 000	21 571 923	46 027 077
2005	31.1	68.9	68 435 000	21 293 571	47 141 429
2006	30.3	69.7	69 295 000	21 009 177	48 285 823
2007	29.5	70.5	70 158 000	20 711 968	49 446 032
2008	25.0	75.0	71 052 000	17 788 932	53 263 068
2009	24.5	75.5	72 039 000	17 626 295	54 412 705
2010	23.7	76.3	73 142 000	17 362 715	55 779 285
2011	23.2	76.8	74 224 000	17 222 484	57 001 516
2012	22.7	77.3	75 176 000	17 076 420	58 099 580
2013	8.7	91.3	76 055 000	6 580 425	69 474 575
2014	8.2	91.8	76 903 000	6 344 309	70 558 691

The urban population consists of the total population of province and district centers and, rural population consists of the total population of towns and villages. The proportions of the population living in the province and district centers were 91.3% in 2013 and 91.8% in 2014, while this figure was 77.3% in 2012. The main reason for this sharp rise was the establishment of 14 new metropolitan municipalities and enlarging the municipal borders by abolition of towns and villages in all of the 30 metropolitan provinces in 2013.

TOW is calculated by using a country-specific per capita BOD as 53 g/person/day for wastewater collected by sewers. The source of this BOD is *Derivation of Factors for Pollution Loads Discharged to Receiving Bodies by Municipalities, İpek Turtin Uzer, Turkish Statistical Institute Expertness Thesis, Ankara, 2010*. This study includes a country-specific per capita BOD for receiving bodies as 25 g/person/day. Country-specific per capita BOD for sludge removed is calculated as 28 g/person/day by using these data to be able to calculate organic component removed as sludge (S). Correction factor (I) is taken as the default value of 1.0. TOW and S values for domestic wastewater are calculated as given in Table 7.30.

Table 7.30 TOW and S for domestic wastewater, 1990-2014

(kt BOD/yr)

Year	TOW	S
1990	1 066.3	563.3
1991	1 084.4	572.9
1992	1 102.4	582.4
1993	1 120.3	591.9
1994	1 138.2	601.3
1995	1 156.0	610.7
1996	1 173.7	620.1
1997	1 191.3	629.4
1998	1 208.4	638.4
1999	1 225.8	647.6
2000	1 243.3	656.8
2001	1 260.6	666.0
2002	1 276.8	674.6
2003	1 292.1	682.6
2004	1 307.7	690.9
2005	1 323.9	699.4
2006	1 340.5	708.2
2007	1 357.2	717.0
2008	1 374.5	726.2
2009	1 393.6	736.2
2010	1 414.9	747.5
2011	1 435.9	758.6
2012	1 454.3	768.3
2013	1 471.3	777.3
2014	1 487.7	785.9

Choice of Emission Factor

As given in *Equation 6.2 in the 2006 IPCC Guidelines, Volume 5, Chapter 6*, CH_4 EFs for each domestic wastewater treatment/discharge pathway or system are calculated by multiplying the default maximum CH_4 producing capacity (B_o) for domestic wastewater (0.6 kg CH_4/kg BOD) by the methane correction factor (MCF) for each type of treatment and discharge pathway or system, which is given in the *2006 IPCC Guidelines, Volume 5, Chapter 6, Table 6.3*.

To calculate country-specific values for the degrees of treatment utilization (T), by population class, the results of TurkStat's *Municipal Wastewater Statistics Survey, 2012* and *Sectoral Water and Wastewater Statistics Survey, 2012* are used. The degrees of utilizations are given in Table 7.31.

Table 7.31 Degrees of treatment utilization (T) by population class

Treatment or discharge system or pathway		T (%)
Rural	To sea, river and lake	0.43
	To aerobic plant, not well managed	0.44
	To septic systems	10.72
Urban	To sea, river and lake	15.43
	To aerobic plant, well managed	44.01
	To aerobic plant, not well managed	1.82
	To anaerobic digester for sludge	20.83
	To septic systems	6.31
Total		100.00

Weighted CH_4 EFs are calculated by using CH_4 EFs by each type of treatment and discharge pathway or system and the fractional usage of different treatment systems by population class. Weighted CH_4 EFs for domestic wastewater with background data are given in Table 7.32.

Table 7.32 MCF, EFs, utilization degrees and weighted EFs by population class

Type of treatment and discharge pathway or system	MCF	CH_4 EF	T (Rural)	T (Urban)
Untreated system				
Sea, river, lake discharge	0.10	0.06	0.0043	0.1543
Treated system				
Centralized, aerobic, well managed	0.00	0.00		0.4401
Centralized, aerobic, not well managed	0.30	0.18	0.0044	0.0182
Anaerobic digester for sludge	0.80	0.48		0.2083
Septic system	0.50	0.30	0.1072	0.0631
Total			**0.12**	**0.88**
Weighted CH_4 EFs (kg CH_4/kg BOD)			**0.29**	**0.15**

Methane Recovery

The recovery of methane and its subsequent utilization is also considered in the inventory. Methane recovery from biogas started to be implemented in Turkey in 1998. Therefore, the quantity of recovered methane is subtracted from the methane produced beginning in the year 1998. In 2013, *Municipal Wastewater Statistics Survey, 2012* was applied to all municipalities. Based on the information obtained from the survey, TurkStat sent official letters to each facility recovering methane for requesting the quantity of methane gas and electricity production for the entire operating period of the facility. The facilities estimate the quantity of methane recovered by measuring of gas recovered.

The obtained information on the quantity of produced electricity is used for cross-check of the quantity of methane recovered.

The coverage of the facilities are followed and updated depending on availability of new information; the information obtained from the facility, the information from the latest survey *(Municipal Wastewater Statistics Survey, 2014)* etc. The emissions of energy production from the recovered CH_4 gas in biogas facilities were included in the category of Public Electricity and Heat Production.

The number of biogas facilities and the amount of recovered methane by year are given in Table 7.33.

Table 7.33 Methane recovery, 1990-2014

Year	Number of biogas facilities	Recovered methane (kt)
1990	NA	NO
1991	NA	NO
1992	NA	NO
1993	NA	NO
1994	NA	NO
1995	NA	NO
1996	NA	NO
1997	NA	NO
1998	1	5.5
1999	1	6.2
2000	1	6.9
2001	2	7.8
2002	2	8.5
2003	2	10.7
2004	3	9.2
2005	4	11.9
2006	4	10.7
2007	7	14.1
2008	7	15.5
2009	7	16.4
2010	8	17.4
2011	12	22.5
2012	13	26.6
2013	17	27.5
2014	18	37.1

Methane Emissions from Industrial Wastewater

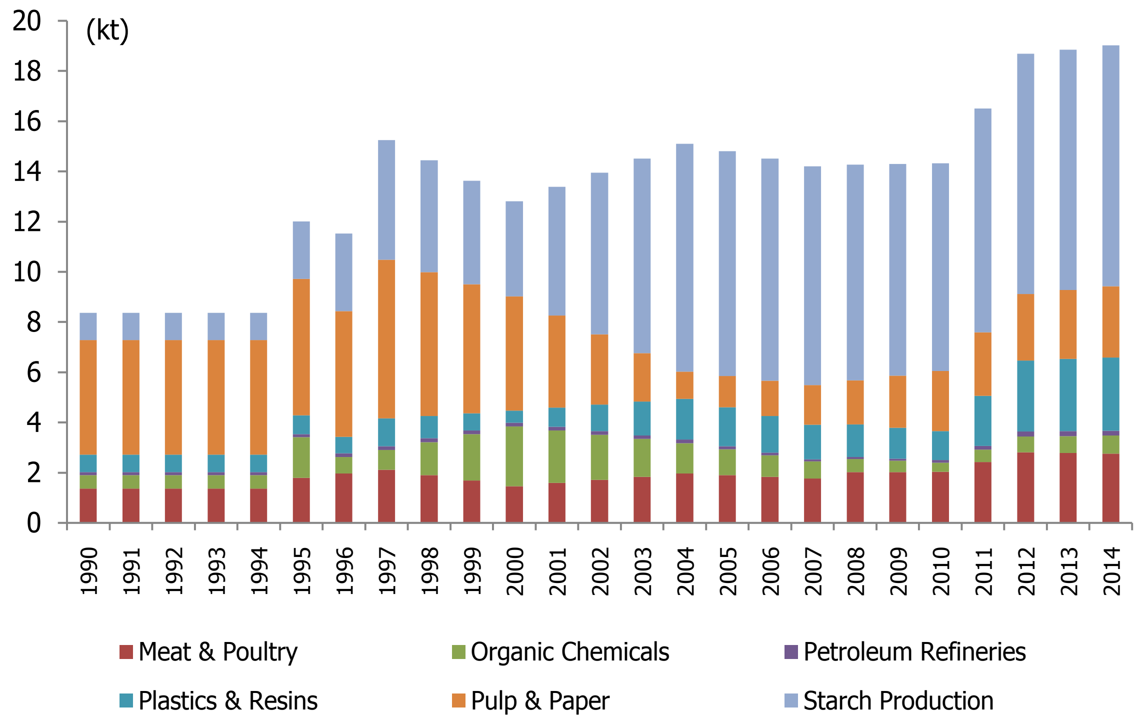
This section deals with estimating CH_4 emissions from on-site industrial wastewater treatment. The IPCC T2 method of the 2006 IPCC Guidelines is applied to estimate CH_4 emissions from industrial wastewater. CH_4 emissions are estimated by using *Equation 6.4 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.*Specifically, the country-specific information on the total organically degradable material in wastewater, by industry, is multiplied by a specific emission factor that takes into account the relative use of various treatment/discharge pathways. There is no recovery of methane from industrial wastewater and sludge removal is assumed to be zero. Amount of methane emissions, by industry, are estimated as given in Table 7.34 and Figure 7.11.

Table 7.34 CH_4 emissions from industrial wastewater by industry, 1990-2014

(kt)

Year	Total	Meat & Poultry	Organic Chemicals	Petroleum Refineries	Plastics & Resins	Pulp & Paper	Starch Production
1990	8.37	1.37	0.54	0.12	0.70	4.56	1.09
1991	8.37	1.37	0.54	0.12	0.70	4.56	1.09
1992	8.37	1.37	0.54	0.12	0.70	4.56	1.09
1993	8.37	1.37	0.54	0.12	0.70	4.56	1.09
1994	8.37	1.37	0.54	0.12	0.70	4.56	1.09
1995	12.01	1.79	1.62	0.12	0.75	5.43	2.29
1996	11.53	1.97	0.66	0.15	0.65	5.01	3.09
1997	15.25	2.12	0.78	0.15	1.10	6.32	4.78
1998	14.44	1.90	1.31	0.15	0.90	5.73	4.45
1999	13.63	1.68	1.85	0.15	0.69	5.14	4.12
2000	12.82	1.47	2.38	0.15	0.48	4.55	3.80
2001	13.38	1.59	2.08	0.15	0.77	3.68	5.12
2002	13.95	1.71	1.79	0.15	1.05	2.80	6.44
2003	14.52	1.84	1.50	0.15	1.34	1.93	7.76
2004	15.10	1.96	1.21	0.14	1.63	1.08	9.08
2005	14.80	1.90	1.03	0.13	1.54	1.25	8.96
2006	14.51	1.84	0.85	0.11	1.46	1.42	8.84
2007	14.21	1.77	0.67	0.09	1.37	1.59	8.72
2008	14.27	2.02	0.53	0.07	1.30	1.75	8.60
2009	14.29	2.03	0.44	0.09	1.22	2.08	8.43
2010	14.32	2.03	0.36	0.11	1.14	2.41	8.26
2011	16.50	2.42	0.50	0.15	1.99	2.52	8.91
2012	18.68	2.81	0.63	0.19	2.84	2.64	9.57
2013	18.85	2.79	0.67	0.19	2.88	2.74	9.58
2014	19.02	2.76	0.71	0.19	2.92	2.85	9.60

Figure 7.11 CH_4 emissions from industrial wastewater, 1990-2014



Collection of Activity Data

To calculate CH_4 emissions from industrial wastewater, total organically degradable material in wastewater for each industry (TOW_i) is used as AD and calculated by applying *Equation 6.6 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.* Organic component removed as sludge (S) is zero in the inventory years. The amount of industrial wastewater treated for the following major industrial sectors are obtained from TurkStat's *Manufacturing Industry Establishments Water Wastewater and Waste Statistics* for the years 1994-1997, 2000, 2004, 2008, 2010, 2012 and 2014. Missing data for the years not surveyed (1998, 1999, 2001-2003, 2005-2007, 2009 and 2011) are estimated by linear interpolation. In the previous inventory submission, TOW_i and emissions for 2013 were assumed the same as in 2012 due to the lack of data. In the current inventory, 2013 data are recalculated by linear interpolation due to the availability of 2014 survey data. The amount of industrial wastewater treated by industrial sectors are given in Table 7.35.

Table 7.35 Amount of industrial wastewater treated by sector, 1990-2014

(thousand m^3/yr)

Year	Total	Meat& poultry	Organic chemicals	Petroleum refineries	Plastics& resins	Pulp& paper (combined)	Starch production
1990	110 753	25 749	13 771	9 155	14 574	39 072	8 432
1991	110 753	25 749	13 771	9 155	14 574	39 072	8 432
1992	110 753	25 749	13 771	9 155	14 574	39 072	8 432
1993	110 753	25 749	13 771	9 155	14 574	39 072	8 432
1994	110 753	25 749	13 771	9 155	14 574	39 072	8 432
1995	164 593	33 752	41 583	9 239	15 739	46 583	17 697
1996	145 711	37 124	16 875	11 393	13 479	42 956	23 884
1997	185 827	39 935	20 148	11 704	23 001	54 176	36 863
1998	183 379	35 820	33 812	11 610	18 672	49 121	34 344
1999	180 932	31 706	47 475	11 517	14 343	44 066	31 825
2000	178 484	27 591	61 139	11 423	10 014	39 011	29 306
2001	181 945	29 936	53 629	11 355	16 004	31 527	39 494
2002	185 406	32 281	46 118	11 288	21 995	24 044	49 682
2003	188 867	34 625	38 608	11 220	27 985	16 560	59 870
2004	192 492	36 970	31 097	11 152	33 975	9 240	70 058
2005	184 002	35 758	26 501	9 728	32 198	10 691	69 127
2006	175 512	34 545	21 904	8 305	30 421	12 143	68 196
2007	167 022	33 333	17 308	6 881	28 643	13 594	67 264
2008	165 487	38 049	13 515	5 457	27 088	15 045	66 333
2009	164 901	38 165	11 443	6 939	25 475	17 837	65 042
2010	164 314	38 282	9 372	8 421	23 862	20 628	63 750
2011	201 980	45 624	12 791	11 620	41 503	21 649	68 792
2012	239 646	52 967	16 211	14 819	59 145	22 670	73 834
2013	241 879	52 494	17 277	14 636	59 995	23 535	73 944
2014	244 112	52 020	18 342	14 452	60 844	24 399	74 054

TOW_i is calculated by applying COD values for each industrial sector as given in Table 7.36, that are based on *Table 6.9 in the 2006 IPCC Guidelines, Volume 5, Chapter 6* and the results are given in Table 7.37.

Table 7.36 COD values by industry type

Industry Type	COD (kg/m^3)
Meat & Poultry	4.1
Organic Chemicals	3.0
Petroleum Refineries	1.0
Plastics & Resins	3.7
Pulp & Paper (combined)	9.0
Starch Production	10.0

Table 7.37 TOW_i in wastewater by industry sector, 1990-2014

(kt COD/yr)

Year	Total	Meat& poultry	Organic chemicals	Petroleum refineries	Plastics& resins	Pulp& paper	Starch production
1990	645.9	105.6	41.3	9.2	53.9	351.6	84.3
1991	645.9	105.6	41.3	9.2	53.9	351.6	84.3
1992	645.9	105.6	41.3	9.2	53.9	351.6	84.3
1993	645.9	105.6	41.3	9.2	53.9	351.6	84.3
1994	645.9	105.6	41.3	9.2	53.9	351.6	84.3
1995	926.8	138.4	124.7	9.2	58.2	419.2	177.0
1996	889.5	152.2	50.6	11.4	49.9	386.6	238.8
1997	1177.2	163.7	60.4	11.7	85.1	487.6	368.6
1998	1114.5	146.9	101.4	11.6	69.1	442.1	343.4
1999	1051.8	130.0	142.4	11.5	53.1	396.6	318.3
2000	989.2	113.1	183.4	11.4	37.1	351.1	293.1
2001	1032.9	122.7	160.9	11.4	59.2	283.7	394.9
2002	1076.6	132.4	138.4	11.3	81.4	216.4	496.8
2003	1120.3	142.0	115.8	11.2	103.5	149.0	598.7
2004	1165.5	151.6	93.3	11.2	125.7	83.2	700.6
2005	1142.5	146.6	79.5	9.7	119.1	96.2	691.3
2006	1119.4	141.6	65.7	8.3	112.6	109.3	682.0
2007	1096.4	136.7	51.9	6.9	106.0	122.3	672.6
2008	1101.0	156.0	40.5	5.5	100.2	135.4	663.3
2009	1102.9	156.5	34.3	6.9	94.3	160.5	650.4
2010	1104.9	157.0	28.1	8.4	88.3	185.7	637.5
2011	1273.4	187.1	38.4	11.6	153.6	194.8	687.9
2012	1441.8	217.2	48.6	14.8	218.8	204.0	738.3
2013	1454.9	215.2	51.8	14.6	222.0	211.8	739.4
2014	1468.0	213.3	55.0	14.5	225.1	219.6	740.5

Choice of Emission Factor

As given in *Equation 6.5 in the 2006 IPCC Guidelines, Volume 5, Chapter 6*, CH_4EFs for each industrial wastewater treatment/discharge pathway or system are calculated by multiplying the default maximum CH_4 producing capacity (B_o) for industrial wastewater (0.25 kg CH_4/kg COD) by the methane correction factor (MCF) for each type of treatment and discharge pathway or system which is given in the *2006 IPCC Guidelines, Volume 5, Chapter 6, Table 6.8*.

Weighted CH_4 EFs are calculated by multiplying CH_4 EFs for each type of treatment and discharge pathway or system and fractional usage of the different treatment systems. Weighted CH_4 EF for industrial wastewater with background data are given in Table 7.38.

Table 7.38 MCF, EFs, fractional usages and weighted EF for industrial wastewater

Type of treatment and discharge pathway or system	MCF	CH_4 EF	Fractional usage
Untreated system			
Sea, river, lake discharge	0.10	0.03	0.173
Treated system			
Aerobic treatment plant, well managed	0.00	0.00	0.668
Aerobic treatment plant, not well managed	0.30	0.08	0.088
Anaerobic digester for sludge	0.80	0.20	0.025
Anaerobic reactor	0.80	0.20	0.030
Septic system	0.50	0.13	0.016
Total			**1.00**
Weighted CH_4 EF (kg CH_4/kg COD)			**0.01**

Nitrous Oxide Emissions from Wastewater

Turkey applies the default method from the 2006 IPCC Guidelines to estimate N_2O emissions from domestic wastewater. N_2O emissions from domestic wastewater effluent are estimated by using *Equation 6.7 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.* Specifically, N_2O emissions are assumed to equal the amount of nitrogen discharged to aquatic environments, multiplied by an emission factor.

N_2O emissions from centralized wastewater treatment plants with nitrification and denitrification steps are also taken into account by subtracting the amount of nitrogen associated with N_2O emissions from these plants from the total nitrogen discharged in the wastewater effluent. N_2O emissions from such plants are estimated by using *Equation 6.9 in 2006 IPCC, Volume 5, Chapter 6.* The estimation results are given in Table 7.39 and Figure 7.12.

There has been a steady increase in N_2O emissions from wastewater during the period 1990-2014, as shown in Figure 7.12. N_2O emissions increase of 39.5% since 1990.

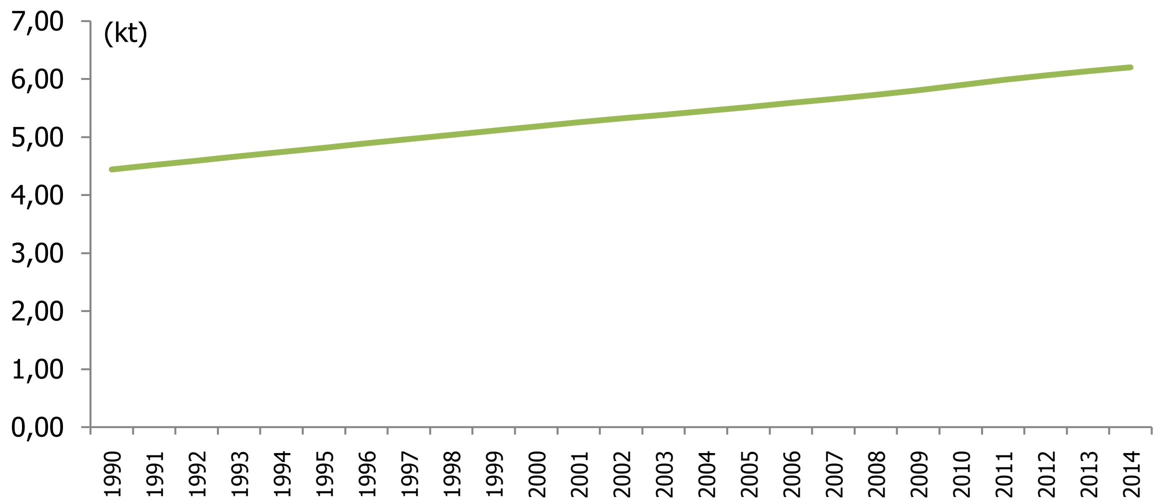
Turkey reports N_2O emissions from industrial wastewater as "IE" in CRF table 5.D. As discussed further below, N_2O emissions from industrial wastewater (category 5.D.2) discharged into sewers is included in the N_2O emissions from domestic wastewater (category 5.D.1).

Table 7.39 N_2O emissions from wastewater, 1990-2014

(kt)

Year	N_2O emissions from wastewater effluent	N_2O emissions from centralized WWT plants	N_2O emissions
1990	4.47	0.02	4.44
1991	4.54	0.02	4.52
1992	4.62	0.02	4.60
1993	4.69	0.02	4.67
1994	4.77	0.02	4.74
1995	4.84	0.02	4.82
1996	4.92	0.02	4.89
1997	4.99	0.02	4.97
1998	5.06	0.02	5.04
1999	5.13	0.02	5.11
2000	5.21	0.02	5.18
2001	5.28	0.02	5.26
2002	5.35	0.03	5.32
2003	5.41	0.03	5.39
2004	5.48	0.03	5.45
2005	5.54	0.03	5.52
2006	5.61	0.03	5.59
2007	5.68	0.03	5.66
2008	5.76	0.03	5.73
2009	5.84	0.03	5.81
2010	5.93	0.03	5.90
2011	6.01	0.03	5.99
2012	6.09	0.03	6.06
2013	6.16	0.03	6.13
2014	6.23	0.03	6.20

Figure 7.12 N_2O emissions from wastewater, 1990-2014



Collection of Activity Data

For the estimation of N_2O emissions from wastewater effluent, the total annual amount of nitrogen in the wastewater effluent ($N_{EFFLUENT}$) is estimated by using the average of the available years of annual protein consumption data of the FAO as 36.8 kg/person/year. 104.9,100.9, 98.8, 99.0 g/person/day are the total protein consumptions for the periods 1990-1992, 1995-1997, 2000-2002 and 2005-2007, respectively. Data are available from:

(http://www.fao.org/fileadmin/templates/ess/documents/food_security_statistics/country_profiles/eng/Turkey_E.pdf)

Additional relevant parameters to calculate total nitrogen in the effluent are given in Table 7.40. Default values from the *2006 IPCC Guidelines, Volume 5, Chapter 6, Table 6.11* are used for the fraction of nitrogen in protein (0.16 kg N/kg protein), the fraction of non-consumed protein (1.4), and the fraction of industrial and commercial co-discharged protein (1.25). As discussed above for domestic wastewater, Turkey assumes that there is zero sludge removed. Regarding the fraction of non-consumed protein, Turkey has applied the value for developed countries using garbage disposals.

Table 7.40 Parameters for estimation of nitrogen in effluent

Per capita protein consumption (Protein) (kg/person/year)	Fraction of nitrogen in protein (F_{NPR}) (kg N/kg protein)	Fraction of non-consumed protein ($F_{NON-CON}$)	Fraction of industrial and commercial co-discharged protein ($F_{IND-COM}$)	Nitrogen removed with sludge (N_{SLUDGE}) (kg)
36.83	0.16	1.40	1.25	0.00

Choice of Emission Factor

To estimate N_2O emissions from wastewater effluent, the IPCC default N_2O EF ($EF_{EFFLUENT}$) is selected as 0.005 kg N_2O-N/kg-N from the *2006 IPCC Guidelines, Volume 5, Chapter 6, Table 6.11*.

The IPCC default EF (EF_{PLANTS}) to estimate N_2O emissions from centralized wastewater treatment plants of 3.2 g N_2O/person/year as given in the 2006 IPCC Guidelines, *Volume 5, Chapter 6, Table 6.11* is applied. To estimate N_2O emissions from such plants, a country-specific value of the degree of utilization of modern, centralized WWT plants (T_{PLANT}) is calculated as 9.6%.

Uncertainties and Time-Series Consistency:

Domestic Wastewater Treatment and Discharge: For CH_4 emissions, the uncertainty for AD is estimated as 5.0% and for CH_4 EF it is calculated as 37.7% by using default uncertainty ranges provided in the *2006 IPCC Guidelines, Volume 5, Chapter 6, Table 6.7.*

For N_2O emissions, the uncertainty for AD is estimated as 30.0%. The uncertainty value of the N_2O EF is calculated as 42.4% by using uncertainty values of 30.0% for both $EF_{EFFLUENT}$ and EF_{PLANTS} based on expert judgment since there is no sufficient information in the related section of the 2006 IPCC.

Industrial Wastewater Treatment and Discharge: For CH_4 emissions, the uncertainty for AD is estimated as 11.2% and for CH_4 EF it is calculated as 39.1% by using default uncertainty ranges provided in the *2006 IPCC Guidelines, Volume 5, Chapter 6, Table 6.10.*

The estimates are calculated in a consistent manner over time series.

Source-Specific QA/QC and Verification:

QA/QC procedures implemented for each category in order to verify and improve the inventory under the Turkey's QA/QC plan.

The data used in Wastewater Treatment and Discharge (CRF Category 5.D) are derived from waste statistics database of TurkStat. TurkStat is producing all its statistics according to the European Code of Practice Principles. Therefore high quality data are used in the emission estimates of this category.

Recalculation:

2013 data for the amount of industrial wastewater treated by industrial sectors are recalculated by linear interpolation due to the availability of 2014 survey data.

Planned Improvement:

There are no planned improvements for next inventory submissions regarding this category.

7.6. Other (Category 5.E)

There are no other activities to be considered under this category.

8. OTHER

Turkey does not report any emissions under the category 'Other'.

9. INDIRECT CARBON DIOXIDE AND NITROUS OXIDE EMISSIONS

Turkey does not reporton indirect carbon dioxide and nitrous oxide emissions.

10. RECALCULATIONS AND IMPROVEMENTS

Recalculations;

In-country review held in 2014 in Turkey. Most of the findings and recommendations of ERT considered and necessary improvements made in 2013 inventory. However, 2013 inventory was the first year of the use 2006 IPCC guidelines and the new CRF Reporter GHG inventory software (CRF) Web Application. Implementing software and new guidelines for the first time inevitably caused some problems. Therefore before starting the 2014 inventory preparation, the inventory team re-examine the 2013 inventory and try to determine the conditions that were not meet the TACCC criteria. Based on the outcomes of the examination some AD revisions, reallocation of emissions or error corrections were made in 2014 inventory.

The recalculations made since the 2015 inventory submission are described in the sector Chapters 3-7 in detail and the reasons for recalculations were also summarized below;

In energy sector;

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2013 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from all subcategories of 1A2 and 1A4 were re calculated for 1990-2013 period.

CO_2 and CH_4 emissions from iron and steel category were included under 2.C.1 iron and steel production category and also under 1.A.2.a category only N_2O emissions were included and CO_2 and CH_4 emissions were included under 2.C.1 in 2013 submission. Moreover, emissions from autoproducers within the integrated iron & steel facilities were allocated under 1A2g category. In 2014 inventory all emission sources within the integrated iron & steel facilities examined in detail with the collaboration of experts from the companies and in technical assistance of Italian inventory experts. Based on the output of that sector analysis, CO_2 and CH_4 were reallocated under IPPU and Energy sector in appropriate manner. CO_2, CH_4 and N_2O emissions from all fuels, except hard coal and coke were reallocated under Energy sectors. The emission from hard coal and coke used in blast furnaces were considered under IPPU. Moreover Emissions from autoproduces in 1A2a category were separated from 1A2g emissions and included under 1A2a category. Therefore all GHG emissions for 1990-2013 periods were recalculated for 1A2a and 1A2g.

Waste incineration was observed in chemical industry (1A2c) and non metallic mineral industry (1A2f). 2006 IPCC default EFs were used in the emission estimation. So waste data were need to be classified into waste oil, industrial waste and sewage sludge (waste as biomass). In 2013 inventory, the classification of waste into those 3 were waste categories made based on expert judgement. However, in 2014 inventory, waste oil and sewage sludge waste were re-classified based on the waste categorization of "EU Waste Statistics Regulation" and waste other than waste oil and sewage sludge was considered as industrial waste.

AD used for the estimation of fugitive emissions were chosen based on the guidance provided in the 2006 IPCC guideline Vol.2 chapter 4. Table 4.2.7. In that table, for natural gas transmission and storage, the use of marketable gas amount is recommended as AD. The national gas transmission data were available for 1990-2013 and same amount were used for the emission estimation from natural gas storage. However, in the framework of the improvement activities to find more appropriate and qualified data, it was found out that there was no natural gas storage facilities until 2007 in Turkey and quite small capacity storage (3-5%) of natural gas transmission amount) were available since 2007. BOTAŞ provided real natural gas storage values for 2007-2014 and emissions were recalculated for 1990-2013 period.

In IPPU sector;

Carbon content of natural gas used for ammonia production was revised. In the previous submission, the latest year country specific carbon content was used for whole inventory period. However, for 2014 inventory, natural gas the carbon content was revised backwards to 1990. CO_2 emission recalculated accordingly.

One of the nitric acid plants was not covered in 2013 inventory. Based on the completion of missing data, the emissions for 2006 to 2013 were recalculated.

There was a transaction error in soda ash production emission estimation so 2009 -2013 emissions were recalculated.

It was found that there was no methanol production in Turkey but it was obtained either by recycling the solvents or as a byproduct from a distillation process during the manufacture of poppy plant resulting in no CO_2 emission. So, CO_2 emissions for 1990-2013 were recalculated. Also 2005-2009 production data for carbon black was revised and CO_2 emissions were recalculated accordingly.

There was a double counting problem since the blast furnace gas produced in blast furnace and sent to offsite and used for coke production and electricity production facilities within the integrated iron & steel production complex was also considered in IPPU sector. CO_2 emissions for 1990-2013 were recalculated. Also the CO_2 emissions resulting from sinter production were recalculated due to revision of the coke breeze consumption data.

The 2013 ferromanganese production data was revised and therefore the emission was recalculated accordingly in ferroalloys production sectors.

There was a transaction error in aluminum production CO_2 emission estimation so 1990-2012.

The 2013 lead production data was revised and therefore the emission from lead production was recalculated accordingly.

The 2013 zinc production data was revised and therefore the emission from zinc production was recalculated accordingly.

Emission estimations for Product Use as Substitutes for ODS category was not in line with 2006 IPCC guidelines. HFC emissions were recalculated in line with 2006 IPCC guidelines for 2000-2013 period.

In agriculture sector;

CH_4 and N_2O emissions from manure management for 1990-2013 were recalculated. There was a major transaction error in mules and asses and poultry. Additional recalculations were done also for other animal categories including cattle.

Recalculation was also exercised for two subcategories of agricultural soils category. Emissions for urine and dung deposited by grazing animals was recalculated because of a transaction error leading to a mismatch between hybrid dairy cattle and domestic dairy cattle for the years 1990-2012.

Furthermore, the subcategory nitrogen leaching and runoff was recalculated due to transaction errors for the same period.

In LULUCF sector;

The carbon stock changes of the Forest Land category have been calculated at sub-regional level in this submission. Therefore calculation for this submission has been recalculated for the period 1990-2014.

Forest Land converted Grassland (deforestation) has been calculated for a first time this submission for the period 1990-2014.

In waste sector;

2013 data for MSW disposed in managed SWDS is recalculated by linear interpolation due to the availability of 2014 survey data.

Also Emission estimates from Solid Waste Disposal (CRF Category 5.A) are recalculated over the 1990-2013 time series due to revision of AD on industrial waste disposed in the SWDS. Biological Treatment of Solid Waste (5.B)

Emission estimates from Biological Treatment of Solid Waste (CRF Category 5.B) are recalculated for 1990-2013 period due to the revision of AD on composting plants.

2013 data for the fraction of MSW open-burned is recalculated by linear interpolation due to the availability of 2014 survey data.

2013 data for the amount of industrial wastewater treated by industrial sectors are recalculated by linear interpolation due to the availability of 2014 survey data.

The overall effect of the recalculations for the waste sector in 1990 was a decrease in emissions in 1990 of 2 977.8 kt CO_2 eq (-21.4 per cent) and a decrease in emissions of 9 772.6 kt CO_2 eq in 2013 (-37.6 per cent). On average, between 1990 and 2014, emissions declined 30.0 per cent per year.

All those recalculations/error corrections resulted in decrease in the total CO_2 eq. emissions without LULUCF for whole 1990-2013 period. The decrease was 10.4 Mt in 1990 and 20.3 Mt in 2013 emissions. The implications of those amounts to the total CO_2 eq. emissions without LULUCF was 4.76% and 4.42% respectively.

The reasons and the implications of recalculations by CRF category is given in the below table for 1990 and 2013.

Table 10.1 Recalculations made in 2014 inventory and implications to the emission level, 1990 and 2013

CRF category	Reasons for recalculation	Implication to the CRF category level (kt CO_2 eq.)		Implication to the total emission w/o LULUCF (%)	
		1990	2013	1990	2013
1. Energy		912	-1 210	0.42	-0.26
A. Fuel combustion (sectoral approach)		**913**	**-1 189**	**0.42**	**-0.26**
2. Manufacturing industries and construction	Revision of country specific carbon contens for lignite hard coal and natural gas for all inventory years. seperation of autoproducers emissions in 1A2a iron and steelindustry from 1A2g categories and reallocation them in 1A2a category. Reclassification of waste incinerated in 1A1c and 1A1f category and recalculation of emissions accordingly.	1 243	-512	0.57	-0.11
3. Transport	Revision of country specific carbon contents for residual fueloil and diesel oil, Completion of missing AD for pipeline transport Completion of missing AD for biofuels	163	-44	0.07	-0.01
4. Other sectors	Revision of country specific carbon contens for lignite hard coal and natural gas	-493	-634	-0.23	-0.14
B. Fugitive emissions from fuels	Revision of AD for the natural gas storage	-1	-21	-0.001	-0.005
2. Industrial Processes		**-7 954**	**-8 813**	**-3.65**	**-1.92**
B. Chemical industry	Revision of country specific carbon content of natural gas for ammonia production. Correction of AD for nitric acid production. Correction of a formulation mistake on soda ash production. Correction of AD for carbon black and methanol	6	915	0.00	0.20
C. Metal industry	Correction of a double counting on iron and steel production. Correction of AD on ferra alloy production. Correction of a formulation mistake on aluminum production. Correction of AD for lead production. Correction of AD for zinc production.	-7 960	-7 529	-3.65	-1.64
F. Product uses as ODS substitutes	HFC emission estimation methodology was harmonized with the 2006 IPCC methodology.	-	-1 236	-	-0.27
3. Agriculture		**-372**	**-487**	**-0.17**	**-0.11**
B. Manure management	Correction of major transaction errors in mules and asses, and poultry. Additional transaction corrections for other animal types including cattle.	-368	-487	-0.17	-0.11

Table 10.1 Recalculations made in 2014 inventory and implications to the emission level in 1990 and 2013 (cont'd)

CRF category	Reasons for recalculation	Implication to the CRF category level (kt CO_2 eq.)		Implication to the total emission w/o LULUCF (%)	
		1990	2013	1990	2013
D. Agricultural soils	Correction of transaction errors regarding hybrid dairy cattle and domestic dairy cattle for the category urine and dung deposited by grazing animals. Additional corrections in "Nitrogen leaching and run-off".	-3	-	-0.002	-
4. Land use, land-use change and forestry(2)		**-54**	**278**	**-0.02**	**0.06**
A. Forest land	The carbon stock changes of the Forest Land category have been calculated at sub-regional level in this submission. Therefore calculation for this submission has been recalculated between period 1990 and 2013. We have clarified deforestation by this way.	-258	-2 166	-0.12	-0.47
C. Grassland	Inclusion of forestland converted to grassland in the inventory for the first time.	205	2 444	0.09	0.53
5. Waste		**-2 978**	**-9 773**	**-1.36**	**-2.13**
A. Solid waste disposal	Revision of 2013 AD for MSW disposed in managed SWDS. Correction of AD for industrial waste disposed in SWDS for 1990-2013 time series.	-2 962	-9 707	-1.36	-2.11
B. Biological treatment of solid waste	Correction of AD for composting plants for 1990-2013 time series.	-16	-13	-0.007	-0.003
C. Incineration and open burning of waste	Revision of 2013 AD for open-burning.	-	-2	-	-0.001
D. Waste water treatment and discharge	Revision 2013 AD for the amount of industrial wastewater treated by industrial sectors.	-	-50	-	-0.011
Total CO_2 eq. emissions without land use, land-use change and forestry		**-10 392**	**-20 283**	**-4.76**	**-4.42**

Considerable improvements have been made in the 2014 inventory (2016 submission)_. However there are still areas to be improved mainly related to using higher tiers,especially for key categories. Planned improvements are summarized as follows:

In energy sectors;

Uncertainty level is planned to be determined in cooperation with refineries authorities.

Work on the carbon balance in integrated iron and steel production plants in cooperation with sector experts will be continued. Meanwhile, the reasons of Carbon content of coke oven gas and blast furnace gas out of 2006 IPCC default values will be investigated in cooperation with expert from integrated iron&steel facilities.

Regarding civil aviation, work on data quality regarding fuel consumption and air traffic will be continued in cooperation with experts from related institutions will be continued

Regarding road transportation, since the category is key category, Tiers used in emission estimation needs to be increased. The data availability required for T2 have been searched. Vehicle-km travelled is registered by the vehicle inspection stations during the periodical inspection of vehicles. However dealing with such a big data scattered across the country is huge work. It is planned to gather vehicle km travelled data in collaboration with inspection stations.

Regarding railways, work on the improvement of data on fuel consumption and distance travelled of diesel motor locomotives in railways sector will be continued.

Regarding domestic navigation based on the results of the projects named "Control of Ship-Sourced Emissions in Turkey" will be available in the next years. So, direct emission measurement from domestic navigation sectors will be used in the inventory.

In IPPU sector;

The national level data on the types of lime produced are already available. It is planned to determine the country specific EF for the high-calcium lime and make T2 calculation in next submissions.

Data series is not complete for 1990-2004 period magnesite production. It is planned to search all kind of alternative data sources such as mining sector reports, or scientific studies to complete data set.

Turkey has been working on the establishment of national Monitoring, Reporting and Verification system. Regulation on Monitoring of Greenhouse Gas Emissions (MRV Regulation which is adapted from 600/2012/EC ve 601/2012/EC excluding CCS and aviation) is issued by MoEU on 22 July 2014.

The objective of this Regulation is to regulate the principles and procedures regarding the monitoring, verification and reporting of the greenhouse gas emissions originating from the activities listed in Annex-1 of the Regulation.

Activities covered included in Annex-I are listed below:

- Combustion of fuels in installations with a total rated thermal input exceeding 20 MW (except in installations for the incineration of hazardous or municipal waste)
- Refining of mineral oil
- Production of coke
- Metal ore (including sulphide ore) roasting or sintering, including pelletisation
- Production of pig iron or steel (primary or secondary fusion) including continuous casting, with a capacity exceeding 2.5 tonnes per hour
- Production or processing of ferrous metals (including ferro-alloys) where combustion units with a total rated thermal input exceeding 20 MW are operated. Processing includes, inter alia, rolling mills, re-heaters, annealing furnaces, smitheries, foundries, coating and pickling
- Production of primary aluminum
- Production of secondary aluminum where combustion units with a total rated thermal input exceeding 20 MW are operated
- Production or processing of non-ferrous metals, including production of alloys, refining, foundry casting, etc., where combustion units with a total rated thermal input (including fuels used as reducing agents) exceeding 20 MW are operated
- Production of cement clinker in rotary kilns with a production capacity exceeding 500 tonnes per day or in other furnaces with a production capacity exceeding 50 tonnes per day
- Production of lime or calcination of dolomite or magnesite in rotary kilns or in other furnaces with a production capacity exceeding 50 tonnes per day
- Manufacture of glass including glass fibre with a melting capacity exceeding 20 tonnes per day
- Manufacture of ceramic products by firing, in particular roofing tiles, bricks, refractory bricks, tiles, stoneware or porcelain, with a production capacity exceeding 75 tonnes per day
- Manufacture of mineral wool insulation material using glass, rock or slag with a melting capacity exceeding 20 tonnes per day
- Drying or calcination of gypsum or production of plaster boards and other gypsum products, where combustion units with a total rated thermal input exceeding 20 MW are operated
- Production of pulp from timber or other fibrous materials
- Production of paper or cardboard with a production capacity exceeding 20 tonnes per day

- Production of carbon black involving the carbonisation of organic substances such as oils, tars, cracker and distillation residues, where combustion units with a total rated thermal input exceeding 20 MW are operated
- Production of nitric acid
- Production of adipic acid
- Production of glyoxal and glyoxylic acid
- Production of ammonia
- Production of bulk organic chemicals by cracking, reforming, partial or full oxidation or by similar processes, with a production capacity exceeding 100 tonnes per day
- Production of hydrogen (H_2) and synthesis gas by reforming or partial oxidation with a production capacity exceeding 25 tonnes per day
- Production of soda ash (Na_2CO_3) and sodium bicarbonate ($NaHCO_3$)
- Greenhouse gas emissions will be monitored within the framework of the principles set by the MoEU. In this respect, detailed information from facilities will be obtained by 2019 and after this year accurate data can be provided for national GHG inventory.

In agriculture sector;

It is planned to use T2 for enteric fermentation and manure management category in the next submissions.

In LULUCF sector;

There is a need to improve the forest resources inventory studies, the quality assurance of relevant data and increase the researches to obtain the country specific data. Planned activities are:

- Integrated Approach to Management of Forests in Turkey, With Demonstration in High Conservation Value Forests in the Mediterranean Region Project was initiated in 2013. With this project sustainable forest management, establishment of policy and institutional framework GHG inventory estimation and carbon sequestration of forests issues will be studied more in detail. This project also has been started to activities for establishing MRV system for GHG inventory of Forest Land category.
- Digitalization of the forest managing maps of Turkey was initiated in 2008. It will be finished in 2018.

Turkey is a partner of ICP Forests program. The ICP forest project’s soil analysis in Turkish forest was initiated in 2015 January. It will be finished until 2019. The results of this project will contribute to our soil, and litter C database.

There have been implemented three EU project about the LULUCF calculations. First project name is ECRAN. This project organizes regional workshops about LULUCF calculations. Second project name is "Technical Assistance for Support to Mechanism for Monitoring Turkey's Greenhouse Gas Emissions" which has been start at February 2015. One of the expected result of this project: Improvement of the quality of the national inventory reports, with a focus on improved estimations and reporting following UNFCCC and IPCC guidelines. Third project name is 'Capacity Building in the Field of Climate Change in Turkey' which is TOR stage. One of the expected result of this project: To develop an analytical basis for the LULUCF sector. These projects are expected to increase the GHG reporting capacity.

In this submission, the emphasis has been given to the QA/QC of the AD and EFs.

In 2012 submission we started to report categories croplands, grasslands, and wetlands with explanations in the NIR. But completeness of the Inventory was weak. In the 2013 submission we expanded the number of categories reported and incorporated management activities in categories (perennial-annual conversions, emissions from organic soils etc.). In this submission we gave the emphasis on completeness again by adding Lands Converted to Settlement category, and litter pool. Therefore we focused on AD generation process and calculations. We also worked on the transparency issue by added explanations on especially methodology. The TUBITAK project explained above added new emission/removal factors. We expect to benefit from scientific studies more in the next submission.

We plan to give the emphasis on compatibility of AD between land use categories and will try to increase the completeness and accuracy of the estimations in the next submissions.

The new Corine map for 2012 has not been finalized yet. So we had to use the existing maps.

The scientific study we mentioned in the last submission to determine C stocks in settlements has not been resulted but some results have been used in this submission. The research project is supported by the TUBITAK with a project number of 112Y096. We expect to benefit more from these project findings in the next submission.

The inconsistency issue between land uses still goes on. This is caused by the use of different land use databases between responsible agencies (OGM and TRGM). As a result of this a full land use matrix cannot be generated.

The study on Mapping Soil Organic Carbon (SOC) Stocks in Turkey (Aydın.G. et al. 2016) has been completed in 2015. In this study, exacted legacy soil maps (1:25000 scale) have been used to estimate SOC stock and the map covers whole the country territory. Since it's under the press for per-review publication, it was not used in this reporting period but it is planed to use for next periods.

In waste sector;

Depending on availability of good quality country-specific data, waste composition data and other parameters for some major managed SWDS in Turkey will be studied within the *Technical Assistance for Support to Mechanism for Monitoring Turkey's Greenhouse Gas Emissions (TASK-GHG) Project* for next inventory submissions.

Emissions and amount of methane for energy recovery from anaerobic digestion at biogas facilities (5.B.2) will be included in next inventory submissions depending on the availability of such treatment processes.

Annex 1: Key Categories

This annex presents the use of an IPCC T1 key category analysis and results for Turkey's inventory submission. The 2006 IPCC Guidelines for National GHG Inventories (IPCC 2006) recommend as good practice the identification of key categories of emissions and removals. The intent is to help inventory agencies prioritize their efforts to improve overall estimates. A key category is defined as "one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions and removals" (IPCC 2006); this term is used in reference to both source and sink categories.

The IPCC T1 quantitative approach is used to identify key categories from two perspectives: their contribution to the overall emissions and their contribution to the emission trend. The level assessment analyzes the emission contribution that each category makes to the national total (with and without LULUCF). The trend assessment uses each category's relative contribution to the overall emissions, but assigns greater weight to the categories whose relative trend departs from the overall trend (with and without LULUCF). In this assessment, trends are calculated as the absolute changes between the base and most recent inventory years.

The percent contributions to both levels and trends in emissions are calculated and sorted from greatest to least. A cumulative total is calculated for both approaches. A cumulative contribution threshold of 95% for both level and trend assessments is a reasonable approximation of the 90% uncertainty for the T1 method of determining key categories (IPCC 2006). This threshold has therefore been used in this analysis to define an upper boundary for key category identification. Hence, when source and sink contributions are sorted in decreasing order of importance, those largest ones that together contribute to 95% of the cumulative total are considered quantitatively to be key categories.

The level contribution of each source or sink category is calculated according to Equation 4.1. in the 2006 IPCC Guidelines while the trend assessment is calculated according to Equations 4.2. and 4.3.

In the 2014 inventory key category analysis, there were 42 key categories shown in Table A1.1. below

Table A1 Key category analysis summary, 2014

Source Category		Fuel	Gas	Criteria used for key source identification: Level	Criteria used for key source identification: Trend	Key category excluding LULUCF	Key category including LULUCF
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CO_2	x	x	x	x
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CO_2	x	x	x	x
1.A.1.b.	Petroleum Refining	Liquid fuels	CO_2	x	x	x	x
1.A.1.b.	Petroleum Refining	Gaseous fuels	CO_2	x	x	x	x
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CO_2	x	x	x	x
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CO_2	x	x	x	x
1.A.2.a.	Iron and Steel Production	Solid fuels	CO_2	x	x	x	x
1.A.2.a.	Iron and Steel Production	Liquid fuels	CO_2		x	x	x
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CO_2		x	x	x
1.A.2.c.	Chemicals	Gaseous fuels	CO_2	x		x	x
1.A.2.c.	Chemicals	Liquid fuels	CO_2		x	x	x
1.A.2.c.	Chemicals	Solid fuels	CO_2		x		x
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	CO_2	x	x	x	x
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	CO_2	x	x	x	x
1.A.2.f.	Non metalic minerals	Liquid fuels	CO_2	x	x	x	x
1.A.2.f.	Non metalic minerals	Solid fuels	CO_2	x	x	x	x
1.A.2.f.	Non metalic minerals	Gaseous fuels	CO_2	x	x	x	x
1.A.2.f.	Non metalic minerals	Other fossil fuels	CO_2		x		x
1.A.2.g.	Other Industries	Gaseous Fuels	CO_2	x	x	x	x
1.A.2.g.	Other Industries	Solid Fuels	CO_2	x	x	x	x
1.A.2.g.	Other Industries	Liquid Fuels	CO_2	x	x	x	x
1.A.3.a.	Domestic Aviation	Jet kerosene	CO_2	x	x	x	x
1.A.3.b.	Road Transportation	Diesel oil	CO_2	x	x	x	x
1.A.3.b.	Road Transportation	LPG	CO_2	x	x	x	x
1.A.3.b.	Road Transportation	Gasoline	CO_2	x	x	x	x
1.A.4.b.	Residential	Gaseous fuels	CO_2	x	x	x	x
1.A.4.b.	Residential	Solid fuels	CO_2	x	x	x	x
1.A.4.b.	Residential	Liquid fuels	CO_2	x	x	x	x
1.A.4.b.	Residential	Biomass	CH_4		x	x	x
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CO_2	x	x	x	x
1.B.1.	Coal Mining	Solid fuels	CH_4	x		x	x

Table A1 Key category analysis summary, 2014 (cont'd)

Source Category		Fuel	Gas	Criteria used for key source identification		Key category excluding LULUCF	Key category including LULUCF
				Level	Trend		
1.B.2.b	Natural Gas		CH_4	x	x	x	x
2.A.1.	Cement Production (Mineral Products)		CO_2	x	x	x	x
2.A.2.	Lime Production (Mineral Products)		CO_2	x	x	x	x
2.A.4.	Other process uses of carbonates		CO_2	x	x	x	x
2.C.1.	Iron and Steel Production		CO_2	x		x	x
2.C.3.	Aluminium production		PFCs		x	x	x
2.F.	Product uses as substitutes for ODS		HFCs	x	x	x	x
3.A.	Enteric fermentation		CH_4	x	x	x	x
3.B.	Manure management		N_2O	x		x	x
3.B.	Manure management		CH_4	x	x	x	x
3.D.	Agricultural soils		N_2O	x	x	x	x
4.A.	Forest land		CO_2	x	x	x	
4.C.	Grassland		CO_2	x	x	x	
4.D.	Wetlands		CO_2		x	x	
4.G.	Harvested wood products		CO_2	x	x	x	
5.A.1.	Managed waste disposal sites		CH_4	x	x	x	x
5.A.2.	Unmanaged waste disposal sites		CH_4		x	x	x
5.D.1.	Domestic wastewater		CH_4	x	x	x	x
5.D.1.	Domestic wastewater		N_2O	x			x

Table A1.2 shows the 1990 key categories identified from the level assessment without LULUCF.

Table A2 Key category analysis level assessment with LULUCF, 2014

Source	Category	Fuel	Gas	Emissions 2014	Abs (2014)	Cont. (%)	Cum. Cont. (%)
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CO_2	75 964.6	75 964.6	14.3	14.3
4.A.	Forest land		CO_2	-54 458.4	54 458.4	10.2	24.5
1.A.3.b.	Road Transportation	Diesel oil	CO_2	51 305.5	51 305.5	9.6	34.1
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CO_2	46 944.6	46 944.6	8.8	42.9
2.A.1.	Cement Production (Mineral Products)		CO_2	34 070.3	34 070.3	6.4	49.3
3.A.	Enteric fermentation		CH_4	27 434.3	27 434.3	5.2	54.5
1.A.4.b.	Residential	Gaseous fuels	CO_2	24 453.2	24 453.2	4.6	59.1
1.A.4.b.	Residential	Solid fuels	CO_2	21 310.1	21 310.1	4.0	63.1
3.D.	Agricultural soils		N_2O	15 089.9	15 089.9	2.8	65.9
5.A.1.	Managed waste disposal sites		CH_4	11 892.7	11 892.7	2.2	68.2
2.C.1.	Iron and Steel Production		CO_2	11 819.1	11 819.1	2.2	70.4
1.A.2.f.	Non metalic minerals	Liquid fuels	CO_2	11 289.9	11 289.9	2.1	72.5
1.A.2.f.	Non metalic minerals	Solid fuels	CO_2	10 879.7	10 879.7	2.0	74.5
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CO_2	10 315.3	10 315.3	1.9	76.5
1.A.3.b.	Road Transportation	LPG	CO_2	8 469.1	8 469.1	1.6	78.1
4.G.	Harvested wood products		CO_2	-7 809.2	7 809.2	1.5	79.5
1.A.2.g.	Other Industries	Gaseous Fuels	CO_2	6 866.6	6 866.6	1.3	80.8
1.A.2.g.	Other Industries	Solid Fuels	CO_2	5 937.5	5 937.5	1.1	81.9
1.B.1.	Coal Mining	Solid fuels	CH_4	5 842.9	5 842.9	1.1	83.0
1.A.3.b.	Road Transportation	Gasoline	CO_2	5 774.6	5 774.6	1.1	84.1
2.A.2.	Lime Production (Mineral Products)		CO_2	4 966.5	4 966.5	0.9	85.1
2.F.	Product uses as substitutes for ODS		HFCs	4 916.6	4 916.6	0.9	86.0
1.A.3.a.	Domestic Aviation	Jet kerosene	CO_2	4 047.0	4 047.0	0.8	86.7
1.A.2.a.	Iron and Steel Production	Solid fuels	CO_2	3 689.9	3 689.9	0.7	87.4
1.A.2.f.	Non metalic minerals	Gaseous fuels	CO_2	3 449.1	3 449.1	0.6	88.1
1.A.2.g.	Other Industries	Liquid Fuels	CO_2	3 327.2	3 327.2	0.6	88.7
3.B.	Manure management		CH_4	3 178.4	3 178.4	0.6	89.3
1.A.2.c.	Chemicals	Gaseous fuels	CO_2	3 145.0	3 145.0	0.6	89.9
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CO_2	2 849.4	2 849.4	0.5	90.4
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CO_2	2 670.1	2 670.1	0.5	90.9

Table A2 Key category analysis level assessment with LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emissions 2014	Abs (2014)	Cont. (%)	Cum. Cont. (%)
1.A.1.b.	Petroleum Refining	Liquid fuels	CO_2	2 624.3	2 624.3	0.5	91.4
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	CO_2	2 561.2	2 561.2	0.5	91.9
1.A.4.b.	Residential	Liquid fuels	CO_2	2 517.9	2 517.9	0.5	92.4
3.B.	Manure management		N_2O	2 513.5	2 513.5	0.5	92.8
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	CO_2	2 262.6	2 262.6	0.4	93.3
2.A.4.	Other process uses of carbonates		CO_2	2 237.3	2 237.3	0.4	93.7
1.B.2.b	Natural Gas		CH_4	2 013.0	2 013.0	0.4	94.1
4.C.	Grassland		CO_2	1 948.2	1 948.2	0.4	94.4
1.A.1.b.	Petroleum Refining	Gaseous fuels	CO_2	1 881.8	1 881.8	0.4	94.8
5.D.1.	Domestic wastewater		CH_4	1 879.4	1 879.4	0.4	95.1
5.D.1.	Domestic wastewater		N_2O	1 848.0	1 848.0	0.3	95.5
2.B.2.	Nitric acid production		N_2O	1 808.1	1 808.1	0.3	95.8
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	CO_2	1 686.3	1 686.3	0.3	96.1
1.A.4.b.	Residential	Solid fuels	CH_4	1 595.4	1 595.4	0.3	96.4
1.A.2.c.	Chemicals	Solid fuels	CO_2	1 546.5	1 546.5	0.3	96.7
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO_2	1 240.1	1 240.1	0.2	97.0
1.A.2.f.	Non metalic minerals	Other fossil fuels	CO_2	1 204.1	1 204.1	0.2	97.2
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	CO_2	1 041.6	1 041.6	0.2	97.4
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	CO_2	995.0	995.0	0.2	97.6
1.A.4.b.	Residential	Biomass	CH_4	978.1	978.1	0.2	97.8
1.A.3.b.	Road Transportation	Diesel oil	N_2O	810.4	810.4	0.2	97.9
3.H.	Urea Application		CO_2	787.7	787.7	0.1	98.1
2.B.8.	Petrochemical and carbon black production		CO_2	748.8	748.8	0.1	98.2
2.B.1.	Ammonia Production		CO_2	736.2	736.2	0.1	98.3
1.A.2.d.	Pulp, Paper and Print	Solid fuels	CO_2	623.8	623.8	0.1	98.5
2.A.3.	Glass Production		CO_2	610.3	610.3	0.1	98.6
1.A.3.e.	Pipeline Transportation	Gaseous fuels	CO_2	601.8	601.8	0.1	98.7
4.E.	Settlements		CO_2	570.6	570.6	0.1	98.8
1.A.3.c.	Railways	Liquid fuels	CO_2	503.5	503.5	0.1	98.9
5.D.2.	Industrial wastewater		CH_4	475.6	475.6	0.1	99.0
1.B.2.c	Venting and Flaring		CH_4	466.8	466.8	0.1	99.1

Table A2 Key category analysis level assessment with LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emissions 2014	Abs (2014)	Cont. (%)	Cum. Cont. (%)
2.D.1.	Lubricant Use		CO_2	385.6	385.6	0.1	99.1
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	N_2O	329.5	329.5	0.1	99.2
1.A.2.b.	Non-Ferrous Metals	Solid fuels	CO_2	305.8	305.8	0.1	99.3
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	CO_2	251.3	251.3	0.0	99.3
1.B.2.a	Oil		CH_4	250.6	250.6	0.0	99.4
3.F.	Field burning of agricultural residues		CH_4	249.7	249.7	0.0	99.4
1.A.3.b.	Road Transportation	LPG	CH_4	208.1	208.1	0.0	99.4
1.A.3.b.	Road Transportation	Gasoline	N_2O	198.6	198.6	0.0	99.5
3.C.	Rice cultivation		CH_4	191.1	191.1	0.0	99.5
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	CO_2	188.5	188.5	0.0	99.5
1.A.3.b.	Road Transportation	Gaseous fuels	CO_2	162.0	162.0	0.0	99.6
1.A.4.b.	Residential	Biomass	N_2O	155.5	155.5	0.0	99.6
1.B.2.c	Venting and Flaring		CO_2	139.1	139.1	0.0	99.6
2.B.7.	Soda ash production		CO_2	135.4	135.4	0.0	99.7
2.C.2.	Ferroalloys Production		CO_2	131.8	131.8	0.0	99.7
4.B.	Cropland		CO_2	-131.5	131.5	0.0	99.7
1.A.2.a.	Iron and Steel Production	Liquid fuels	CO_2	115.0	115.0	0.0	99.7
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO_2	96.1	96.1	0.0	99.7
1.A.4.b.	Residential	Solid fuels	N_2O	95.1	95.1	0.0	99.8
3.F.	Field burning of agricultural residues		N_2O	77.2	77.2	0.0	99.8
2.C.2.	Ferroalloys Production		CH_4	74.7	74.7	0.0	99.8
1.A.2.c.	Chemicals	Liquid fuels	CO_2	73.8	73.8	0.0	99.8
1.A.3.b.	Road Transportation	Diesel oil	CH4	68.0	68.0	0.0	99.8
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	CO_2	66.2	66.2	0.0	99.8
1.A.3.c.	Railways	Liquid fuels	N_2O	58.3	58.3	0.0	99.8
2.C.3.	Aluminium Production		CO_2	54.9	54.9	0.0	99.9
1.A.4.b.	Residential	Gaseous fuels	CH_4	53.5	53.5	0.0	99.9
1.A.3.b.	Road Transportation	Gasoline	CH_4	52.1	52.1	0.0	99.9
1.A.4.c.	Agriculture/Forestry/Fisheries	Solid fuels	CO_2	51.2	51.2	0.0	99.9
1.A.2.f.	Non metalic minerals	Solid fuels	N_2O	48.3	48.3	0.0	99.9

Table A2 Key category analysis level assessment with LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emissions 2014	Abs (2014)	Cont. (%)	Cum. Cont. (%)
1.A.3.a.	Domestic Aviation	Jet kerosene	N_2O	41.7	41.7	0.0	99.9
2.C.5.	Zinc Production		CO_2	32.9	32.9	0.0	99.9
2.C.1.	Iron and Steel Production		CH_4	30.2	30.2	0.0	99.9
1.A.2.f.	Non metalic minerals	Solid fuels	CH_4	27.0	27.0	0.0	99.9
1.A.2.g.	Other Industries	Solid Fuels	N_2O	26.2	26.2	0.0	99.9
2.B.8.	Petrochemical and carbon black production		CH_4	25.1	25.1	0.0	99.9
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	N_2O	24.0	24.0	0.0	99.9
1.A.2.f.	Non metalic minerals	Liquid fuels	N_2O	20.8	20.8	0.0	99.9
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CH_4	20.1	20.1	0.0	99.9
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CH_4	18.4	18.4	0.0	99.9
2.B.5.	Carbide production		CO_2	15.5	15.5	0.0	99.9
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	CO_2	15.1	15.1	0.0	99.9
1.A.2.g.	Other Industries	Solid Fuels	CH_4	14.5	14.5	0.0	99.9
1.A.3.e.	Pipeline Transportation	Gaseous fuels	CH_4	13.5	13.5	0.0	100.0
1.A.2.c.	Chemicals	Other fossil fuels	CO_2	13.4	13.4	0.0	100.0
1.A.4.b.	Residential	Gaseous fuels	N_2O	12.8	12.8	0.0	100.0
1.A.3.e.	Pipeline Transportation	Gaseous fuels	N_2O	12.6	12.6	0.0	100.0
1.A.2.f.	Non metalic minerals	Other fossil fuels	N_2O	10.3	10.3	0.0	100.0
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N_2O	10.0	10.0	0.0	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CH_4	9.7	9.7	0.0	100.0
5.B.1	Composting		CH_4	9.4	9.4	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	N_2O	9.3	9.3	0.0	100.0
1.A.2.f.	Non metalic minerals	Liquid fuels	CH_4	8.7	8.7	0.0	100.0
5.B.1.	Composting		N_2O	8.4	8.4	0.0	100.0
1.A.3.b.	Road Transportation	LPG	N_2O	8.0	8.0	0.0	100.0
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CO_2	7.9	7.9	0.0	100.0
2.C.5.	Lead Production		CO_2	7.5	7.5	0.0	100.0
1.A.2.g.	Other Industries	Liquid Fuels	N_2O	7.1	7.1	0.0	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	N_2O	6.9	6.9	0.0	100.0
1.A.2.a.	Iron and Steel	Solid fuels	N_2O	6.6	6.6	0.0	100.0

Table A2 Key category analysis level assessment with LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emissions 2014	Abs (2014)	Cont. (%)	Cum. Cont. (%)
1.A.3.b.	Road Transportation	Gaseous fuels	CH_4	6.5	6.5	0.0	100.0
1.A.2.f.	Non metalic minerals	Other fossil fuels	CH_4	6.5	6.5	0.0	100.0
1.A.2.c.	Chemicals	Solid fuels	N_2O	6.4	6.4	0.0	100.0
1.A.4.b.	Residential	Liquid fuels	CH_4	5.2	5.2	0.0	100.0
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	N_2O	3.9	3.9	0.0	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Solid fuels	CH_4	3.9	3.9	0.0	100.0
1.A.3.b.	Road Transportation	Biomass	N_2O	3.7	3.7	0.0	100.0
1.B.2.a	Oil		CO_2	3.6	3.6	0.0	100.0
1.A.2.g.	Other Industries	Gaseous Fuels	N_2O	3.6	3.6	0.0	100.0
1.A.2.g.	Other Industries	Liquid Fuels	CH_4	3.1	3.1	0.0	100.0
1.A.1.a.	Public Electricity and Heat Production	Biomass	N_2O	3.0	3.0	0.0	100.0
1.A.2.g.	Other Industries	Gaseous Fuels	CH_4	3.0	3.0	0.0	100.0
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH_4	3.0	3.0	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	CH_4	2.9	2.9	0.0	100.0
1.A.1.b.	Petroleum Refining	Liquid fuels	N_2O	2.9	2.9	0.0	100.0
1.B.2.b	Natural Gas		CO_2	2.8	2.8	0.0	100.0
1.A.2.d.	Pulp, Paper and Print	Solid fuels	N_2O	2.7	2.7	0.0	100.0
2.D.2.	Paraffin Wax Use		CO_2	2.7	2.7	0.0	100.0
1.A.3.b.	Road Transportation	Gaseous fuels	N_2O	2.5	2.5	0.0	100.0
1.A.2.c.	Chemicals	Solid fuels	CH_4	2.5	2.5	0.0	100.0
1.A.1.a.	Public Electricity and Heat Production	Biomass	CH_4	2.0	2.0	0.0	100.0
1.A.2.a.	Iron and Steel	Gaseous fuels	N_2O	1.9	1.9	0.0	100.0
1.A.2.f.	Non metalic minerals	Gaseous fuels	N_2O	1.8	1.8	0.0	100.0
1.A.1.b.	Petroleum Refining	Liquid fuels	CH_4	1.7	1.7	0.0	100.0
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	CH_4	1.6	1.6	0.0	100.0
1.A.2.c.	Chemicals	Gaseous fuels	N_2O	1.6	1.6	0.0	100.0
1.A.2.a.	Iron and Steel Production	Solid fuels	CH_4	1.6	1.6	0.0	100.0
1.A.2.f.	Non metalic minerals	Gaseous fuels	CH_4	1.5	1.5	0.0	100.0
1.A.4.b.	Residential	Liquid fuels	N_2O	1.4	1.4	0.0	100.0
1.A.2.c.	Chemicals	Gaseous fuels	CH_4	1.4	1.4	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	N_2O	1.3	1.3	0.0	100.0

Table A2 Key category analysis level assessment with LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emissions 2014	Abs (2014)	Cont. (%)	Cum. Cont. (%)
1.A.3.a.	Domestic Aviation	Jet kerosene	CH_4	1.3	1.3	0.0	100.0
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CH_4	1.3	1.3	0.0	100.0
1.A.2.b.	Non-Ferrous Metals	Solid fuels	N_2O	1.2	1.2	0.0	100.0
1.A.2.d.	Pulp, Paper and Print	Biomass	N_2O	1.2	1.2	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	CH_4	1.1	1.1	0.0	100.0
1.A.2.d.	Pulp, Paper and Print	Solid fuels	CH_4	1.1	1.1	0.0	100.0
1.A.1.b.	Petroleum Refining	Gaseous fuels	N_2O	1.0	1.0	0.0	100.0
1.A.1.b.	Petroleum Refining	Gaseous fuels	CH_4	0.9	0.9	0.0	100.0
1.A.3.d.	Domestic Navigation	Residual fuel oil	N_2O	0.7	0.7	0.0	100.0
1.A.3.c.	Railways	Liquid fuels	CH_4	0.7	0.7	0.0	100.0
5.C.2.	Open burning of waste		CH_4	0.7	0.7	0.0	100.0
1.B.2.c.	Venting		N_2O	0.6	0.6	0.0	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	CH_4	0.6	0.6	0.0	100.0
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	N_2O	0.6	0.6	0.0	100.0
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	N_2O	0.5	0.5	0.0	100.0
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	N_2O	0.5	0.5	0.0	100.0
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	CH_4	0.5	0.5	0.0	100.0
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	CH_4	0.4	0.4	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	N_2O	0.4	0.4	0.0	100.0
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	CH_4	0.3	0.3	0.0	100.0
1.A.1.c.	Manufacture of solid fuels	Solid fuels	N_2O	0.3	0.3	0.0	100.0
1.A.3.b.	Road Transportation	Biomass	CH_4	0.3	0.3	0.0	100.0
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CH_4	0.3	0.3	0.0	100.0
1.A.2.a.	Iron and Steel	Liquid fuels	N_2O	0.3	0.3	0.0	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Solid fuels	N_2O	0.2	0.2	0.0	100.0
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH_4	0.2	0.2	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	CH_4	0.2	0.2	0.0	100.0
1.A.2.b.	Non-Ferrous Metals	Solid fuels	CH_4	0.2	0.2	0.0	100.0
1.A.2.c.	Chemicals	Liquid fuels	N_2O	0.2	0.2	0.0	100.0
1.A.2.d.	Pulp, Paper and Print	Biomass	CH_4	0.2	0.2	0.0	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	N_2O	0.1	0.1	0.0	100.0

Table A2 Key category analysis level assessment with LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emissions 2014	Abs (2014)	Cont. (%)	Cum. Cont. (%)
1.A.2.c.	Chemicals	Other fossil fuels	N_2O	0.1	0.1	0.0	100.0
1.C.	CO2 Transport and Storage		CO_2	0.1	0.1	0.0	100.0
5.C.2.	Open burning of waste		N_2O	0.1	0.1	0.0	100.0
1.A.2.a.	Iron and Steel Production	Liquid fuels	CH_4	0.1	0.1	0.0	100.0
5.C.2.	Open burning of waste		CO_2	0.1	0.1	0.0	100.0
1.A.2.c.	Chemicals	Other fossil fuels	CH_4	0.1	0.1	0.0	100.0
1.A.2.c.	Chemicals	Liquid fuels	CH_4	0.1	0.1	0.0	100.0
1.A.2.f.	Non metalic minerals	Biomass	N_2O	0.0	0.0	0.0	100.0
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	N_2O	0.0	0.0	0.0	100.0
1.A.2.f.	Non metalic minerals	Biomass	CH_4	0.0	0.0	0.0	100.0
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	N_2O	0.0	0.0	0.0	100.0
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	CH_4	0.0	0.0	0.0	100.0
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CH_4	0.0	0.0	0.0	100.0
5.A.	Forest land		CH_4	0.0	0.0	0.0	100.0
1.B.2.c.	Flaring		N_2O	0.0	0.0	0.0	100.0
4.A.	Forest land		N_2O	0.0	0.0	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Biomass	N_2O	0.0	0.0	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Biomass	CH_4	0.0	0.0	0.0	100.0
1.A.3.c.	Railways	Solid fuels	CO_2		0.0	0.0	100.0
4.D.	Wetlands		CO_2		0.0	0.0	100.0
1.A.2.c.	Chemicals	Biomass	CH_4	0.0	0.0	0.0	100.0
1.A.3.c.	Railways	Solid fuels	CH_4	0.0	0.0	0.0	100.0
5.A.2.	Unmanaged waste disposal sites		CH_4	0.0	0.0	0.0	100.0
1.A.2.c.	Chemicals	Biomass	N_2O	0.0	0.0	0.0	100.0
1.A.3.c.	Railways	Solid fuels	N_2O	0.0	0.0	0.0	100.0
2.C.3.	Aluminium production		PFCs		0.0	0.0	100.0
Total all gases				**407 670.1**	**532 468.3**		

Table A3 Key category analysis level assessment without LULUCF, 2014

Source	Category	Fuel	Gas	Emiss 2014	Abs (2014)	Cont. (%)	Cum. Cont. (%)
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CO_2	75 964.6	75 964.6	16.2	16.2
1.A.3.b.	Road Transportation	Diesel oil	CO_2	51 305.5	51 305.5	11.0	27.2
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CO_2	46 944.6	46 944.6	10.0	37.3
2.A.1.	Cement Production (Mineral Products)		CO_2	34 070.3	34 070.3	7.3	44.5
3.A.	Enteric fermentation		CH_4	27 434.3	27 434.3	5.9	50.4
1.A.4.b.	Residential	Gaseous fuels	CO_2	24 453.2	24 453.2	5.2	55.6
1.A.4.b.	Residential	Solid fuels	CO_2	21 310.1	21 310.1	4.6	60.2
3.D.	Agricultural soils		N_2O	15 089.9	15 089.9	3.2	63.4
5.A.1.	Managed waste disposal sites		CH_4	11 892.7	11 892.7	2.5	66.0
2.C.1.	Iron and Steel Production		CO_2	11 819.1	11 819.1	2.5	68.5
1.A.2.f.	Non metalic minerals	Liquid fuels	CO_2	11 289.9	11 289.9	2.4	70.9
1.A.2.f.	Non metalic minerals	Solid fuels	CO_2	10 879.7	10 879.7	2.3	73.2
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CO_2	10 315.3	10 315.3	2.2	75.5
1.A.3.b.	Road Transportation	LPG	CO_2	8 469.1	8 469.1	1.8	77.3
1.A.2.g.	Other Industries	Gaseous Fuels	CO_2	6 866.6	6 866.6	1.5	78.7
1.A.2.g.	Other Industries	Solid Fuels	CO_2	5 937.5	5 937.5	1.3	80.0
1.B.1.	Coal Mining	Solid fuels	CH_4	5 842.9	5 842.9	1.2	81.3
1.A.3.b.	Road Transportation	Gasoline	CO_2	5 774.6	5 774.6	1.2	82.5
2.A.2.	Lime Production (Mineral Products)		CO_2	4 966.5	4 966.5	1.1	83.5
2.F.	Product uses as substitutes for ODS		HFCs	4 916.6	4 916.6	1.1	84.6
1.A.3.a.	Domestic Aviation	Jet kerosene	CO_2	4 047.0	4 047.0	0.9	85.5
1.A.2.a.	Iron and Steel Production	Solid fuels	CO_2	3 689.9	3 689.9	0.8	86.3
1.A.2.f.	Non metalic minerals	Gaseous fuels	CO_2	3 449.1	3 449.1	0.7	87.0
1.A.2.g.	Other Industries	Liquid Fuels	CO_2	3 327.2	3 327.2	0.7	87.7
3.B.	Manure management		CH_4	3 178.4	3 178.4	0.7	88.4
1.A.2.c.	Chemicals	Gaseous fuels	CO_2	3 145.0	3 145.0	0.7	89.1

Table A3 Key category analysis level assessment without LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emiss 2014	Abs (2014)	Cont. (%)	Cum. Cont. (%)
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CO_2	2 849.4	2 849.4	0.6	89.7
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CO_2	2 670.1	2 670.1	0.6	90.2
1.A.1.b.	Petroleum Refining	Liquid fuels	CO_2	2 624.3	2 624.3	0.6	90.8
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	CO_2	2 561.2	2 561.2	0.5	91.3
1.A.4.b.	Residential	Liquid fuels	CO_2	2 517.9	2 517.9	0.5	91.9
3.B.	Manure management		N_2O	2 513.5	2 513.5	0.5	92.4
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	CO_2	2 262.6	2 262.6	0.5	92.9
2.A.4.	Other process uses of carbonates		CO_2	2 237.3	2 237.3	0.5	93.4
1.B.2.b	Natural Gas		CH_4	2 013.0	2 013.0	0.4	93.8
1.A.1.b.	Petroleum Refining	Gaseous fuels	CO_2	1 881.8	1 881.8	0.4	94.2
5.D.1.	Domestic wastewater		CH_4	1 879.4	1 879.4	0.4	94.6
5.D.1.	Domestic wastewater		N_2O	1 848.0	1 848.0	0.4	95.0
2.B.2.	Nitric acid production		N_2O	1 808.1	1 808.1	0.4	95.4
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	CO_2	1 686.3	1 686.3	0.4	95.8
1.A.4.b.	Residential	Solid fuels	CH_4	1 595.4	1 595.4	0.3	96.1
1.A.2.c.	Chemicals	Solid fuels	CO_2	1 546.5	1 546.5	0.3	96.4
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO_2	1 240.1	1 240.1	0.3	96.7
1.A.2.f.	Non metalic minerals	Other fossil fuels	CO_2	1 204.1	1 204.1	0.3	97.0
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	CO_2	1 041.6	1 041.6	0.2	97.2
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	CO_2	995.0	995.0	0.2	97.4
1.A.4.b.	Residential	Biomass	CH_4	978.1	978.1	0.2	97.6
1.A.3.b.	Road Transportation	Diesel oil	N_2O	810.4	810.4	0.2	97.8
3.H.	Urea Application		CO_2	787.7	787.7	0.2	97.9
2.B.8.	Petrochemical and carbon black production		CO_2	748.8	748.8	0.2	98.1
2.B.1.	Ammonia Production		CO_2	736.2	736.2	0.2	98.3
1.A.2.d.	Pulp, Paper and Print	Solid fuels	CO_2	623.8	623.8	0.1	98.4
2.A.3.	Glass Production		CO_2	610.3	610.3	0.1	98.5

Table A3 Key category analysis level assessment without LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emiss 2014	Abs (2014)	Cont. (%)	Cum. Cont. (%)
1.A.3.e.	Pipeline Transportation	Gaseous fuels	CO_2	601.8	601.8	0.1	98.7
1.A.3.c.	Railways	Liquid fuels	CO_2	503.5	503.5	0.1	98.8
5.D.2.	Industrial wastewater		CH_4	475.6	475.6	0.1	98.9
1.B.2.c	Venting and Flaring		CH_4	466.8	466.8	0.1	99.0
2.D.1.	Lubricant Use		CO_2	385.6	385.6	0.1	99.0
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	N_2O	329.5	329.5	0.1	99.1
1.A.2.b.	Non-Ferrous Metals	Solid fuels	CO_2	305.8	305.8	0.1	99.2
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	CO_2	251.3	251.3	0.1	99.2
1.B.2.a	Oil		CH_4	250.6	250.6	0.1	99.3
3.F.	Field burning of agricultural residues		CH_4	249.7	249.7	0.1	99.3
1.A.3.b.	Road Transportation	LPG	CH_4	208.1	208.1	0.0	99.4
1.A.3.b.	Road Transportation	Gasoline	N_2O	198.6	198.6	0.0	99.4
3.C.	Rice cultivation		CH_4	191.1	191.1	0.0	99.5
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	CO_2	188.5	188.5	0.0	99.5
1.A.3.b.	Road Transportation	Gaseous fuels	CO_2	162.0	162.0	0.0	99.5
1.A.4.b.	Residential	Biomass	N_2O	155.5	155.5	0.0	99.6
1.B.2.c	Venting and Flaring		CO_2	139.1	139.1	0.0	99.6
2.B.7.	Soda ash production		CO_2	135.4	135.4	0.0	99.6
2.C.2.	Ferroalloys Production		CO_2	131.8	131.8	0.0	99.7
1.A.2.a.	Iron and Steel Production	Liquid fuels	CO_2	115.0	115.0	0.0	99.7
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO_2	96.1	96.1	0.0	99.7
1.A.4.b.	Residential	Solid fuels	N_2O	95.1	95.1	0.0	99.7
3.F.	Field burning of agricultural residues		N_2O	77.2	77.2	0.0	99.7
2.C.2.	Ferroalloys Production		CH_4	74.7	74.7	0.0	99.8
1.A.2.c.	Chemicals	Liquid fuels	CO_2	73.8	73.8	0.0	99.8
1.A.3.b.	Road Transportation	Diesel oil	CH_4	68.0	68.0	0.0	99.8

Table A3 Key category analysis level assessment without LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emiss 2014	Abs (2014)	Cont. (%)	Cum. Cont. (%)
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	CO_2	66.2	66.2	0.0	99.8
1.A.3.c.	Railways	Liquid fuels	N_2O	58.3	58.3	0.0	99.8
2.C.3.	Aluminium Production		CO_2	54.9	54.9	0.0	99.8
1.A.4.b.	Residential	Gaseous fuels	CH_4	53.5	53.5	0.0	99.8
1.A.3.b.	Road Transportation	Gasoline	CH_4	52.1	52.1	0.0	99.9
1.A.4.c.	Agriculture/Forestry/Fisheries	Solid fuels	CO_2	51.2	51.2	0.0	99.9
1.A.2.f.	Non metalic minerals	Solid fuels	N_2O	48.3	48.3	0.0	99.9
1.A.3.a.	Domestic Aviation	Jet kerosene	N_2O	41.7	41.7	0.0	99.9
2.C.5.	Zinc Production		CO_2	32.9	32.9	0.0	99.9
2.C.1.	Iron and Steel Production		CH_4	30.2	30.2	0.0	99.9
1.A.2.f.	Non metalic minerals	Solid fuels	CH_4	27.0	27.0	0.0	99.9
1.A.2.g.	Other Industries	Solid Fuels	N_2O	26.2	26.2	0.0	99.9
2.B.8.	Petrochemical and carbon black production		CH_4	25.1	25.1	0.0	99.9
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	N_2O	24.0	24.0	0.0	99.9
1.A.2.f.	Non metalic minerals	Liquid fuels	N_2O	20.8	20.8	0.0	99.9
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CH_4	20.1	20.1	0.0	99.9
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CH_4	18.4	18.4	0.0	99.9
2.B.5.	Carbide production		CO_2	15.5	15.5	0.0	99.9
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	CO_2	15.1	15.1	0.0	99.9
1.A.2.g.	Other Industries	Solid Fuels	CH_4	14.5	14.5	0.0	99.9
1.A.3.e.	Pipeline Transportation	Gaseous fuels	CH_4	13.5	13.5	0.0	99.9
1.A.2.c.	Chemicals	Other fossil fuels	CO_2	13.4	13.4	0.0	99.9
1.A.4.b.	Residential	Gaseous fuels	N_2O	12.8	12.8	0.0	99.9
1.A.3.e.	Pipeline Transportation	Gaseous fuels	N_2O	12.6	12.6	0.0	100.0
1.A.2.f.	Non metalic minerals	Other fossil fuels	N_2O	10.3	10.3	0.0	100.0
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N_2O	10.0	10.0	0.0	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CH_4	9.7	9.7	0.0	100.0

Table A3 Key category analysis level assessment without LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emiss 2014	Abs (2014)	Cont. (%)	Cum. Cont. (%)
5.B.1	Composting		CH_4	9.4	9.4	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	N_2O	9.3	9.3	0.0	100.0
1.A.2.f.	Non metalic minerals	Liquid fuels	CH_4	8.7	8.7	0.0	100.0
5.B.1.	Composting		N_2O	8.4	8.4	0.0	100.0
1.A.3.b.	Road Transportation	LPG	N_2O	8.0	8.0	0.0	100.0
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CO_2	7.9	7.9	0.0	100.0
2.C.5.	Lead Production		CO_2	7.5	7.5	0.0	100.0
1.A.2.g.	Other Industries	Liquid Fuels	N_2O	7.1	7.1	0.0	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	N_2O	6.9	6.9	0.0	100.0
1.A.2.a.	Iron and Steel	Solid fuels	N_2O	6.6	6.6	0.0	100.0
1.A.3.b.	Road Transportation	Gaseous fuels	CH_4	6.5	6.5	0.0	100.0
1.A.2.f.	Non metalic minerals	Other fossil fuels	CH_4	6.5	6.5	0.0	100.0
1.A.2.c.	Chemicals	Solid fuels	N_2O	6.4	6.4	0.0	100.0
1.A.4.b.	Residential	Liquid fuels	CH_4	5.2	5.2	0.0	100.0
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	N_2O	3.9	3.9	0.0	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Solid fuels	CH_4	3.9	3.9	0.0	100.0
1.A.3.b.	Road Transportation	Biomass	N_2O	3.7	3.7	0.0	100.0
1.B.2.a	Oil		CO_2	3.6	3.6	0.0	100.0
1.A.2.g.	Other Industries	Gaseous Fuels	N_2O	3.6	3.6	0.0	100.0
1.A.2.g.	Other Industries	Liquid Fuels	CH_4	3.1	3.1	0.0	100.0
1.A.1.a.	Public Electricity and Heat Production	Biomass	N_2O	3.0	3.0	0.0	100.0
1.A.2.g.	Other Industries	Gaseous Fuels	CH_4	3.0	3.0	0.0	100.0
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH_4	3.0	3.0	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	CH_4	2.9	2.9	0.0	100.0
1.A.1.b.	Petroleum Refining	Liquid fuels	N_2O	2.9	2.9	0.0	100.0
1.B.2.b	Natural Gas		CO_2	2.8	2.8	0.0	100.0

Table A3 Key category analysis level assessment without LULUCF, 2014 (cont'd)

Source Category		Fuel	Gas	Emiss 2014	Abs (2014)	Cont. (%)	Cum. Cont. (%)
1.A.2.d.	Pulp, Paper and Print	Solid fuels	N_2O	2.7	2.7	0.0	100.0
2.D.2.	Paraffin Wax Use		CO_2	2.7	2.7	0.0	100.0
1.A.3.b.	Road Transportation	Gaseous fuels	N_2O	2.5	2.5	0.0	100.0
1.A.2.c.	Chemicals	Solid fuels	CH_4	2.5	2.5	0.0	100.0
1.A.1.a.	Public Electricity and Heat Production	Biomass	CH_4	2.0	2.0	0.0	100.0
1.A.2.a.	Iron and Steel	Gaseous fuels	N_2O	1.9	1.9	0.0	100.0
1.A.2.f.	Non metalic minerals	Gaseous fuels	N_2O	1.8	1.8	0.0	100.0
1.A.1.b.	Petroleum Refining	Liquid fuels	CH_4	1.7	1.7	0.0	100.0
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	CH_4	1.6	1.6	0.0	100.0
1.A.2.c.	Chemicals	Gaseous fuels	N_2O	1.6	1.6	0.0	100.0
1.A.2.a.	Iron and Steel Production	Solid fuels	CH_4	1.6	1.6	0.0	100.0
1.A.2.f.	Non metalic minerals	Gaseous fuels	CH_4	1.5	1.5	0.0	100.0
1.A.4.b.	Residential	Liquid fuels	N_2O	1.4	1.4	0.0	100.0
1.A.2.c.	Chemicals	Gaseous fuels	CH_4	1.4	1.4	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	N_2O	1.3	1.3	0.0	100.0
1.A.3.a.	Domestic Aviation	Jet kerosene	CH_4	1.3	1.3	0.0	100.0
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CH_4	1.3	1.3	0.0	100.0
1.A.2.b.	Non-Ferrous Metals	Solid fuels	N_2O	1.2	1.2	0.0	100.0
1.A.2.d.	Pulp, Paper and Print	Biomass	N_2O	1.2	1.2	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	CH_4	1.1	1.1	0.0	100.0
1.A.2.d.	Pulp, Paper and Print	Solid fuels	CH_4	1.1	1.1	0.0	100.0
1.A.1.b.	Petroleum Refining	Gaseous fuels	N_2O	1.0	1.0	0.0	100.0
1.A.1.b.	Petroleum Refining	Gaseous fuels	CH_4	0.9	0.9	0.0	100.0
1.A.3.d.	Domestic Navigation	Residual fuel oil	N_2O	0.7	0.7	0.0	100.0
1.A.3.c.	Railways	Liquid fuels	CH_4	0.7	0.7	0.0	100.0
5.C.2.	Open burning of waste		CH_4	0.7	0.7	0.0	100.0
1.B.2.c.	Venting		N_2O	0.6	0.6	0.0	100.0

Table A3 Key category analysis level assessment without LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emiss 2014	Abs (2014)	Cont. (%)	Cum. Cont. (%)
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	CH_4	0.6	0.6	0.0	100.0
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	N_2O	0.6	0.6	0.0	100.0
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	N_2O	0.5	0.5	0.0	100.0
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	N_2O	0.5	0.5	0.0	100.0
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	CH_4	0.5	0.5	0.0	100.0
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	CH_4	0.4	0.4	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	N_2O	0.4	0.4	0.0	100.0
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	CH_4	0.3	0.3	0.0	100.0
1.A.1.c.	Manufacture of solid fuels	Solid fuels	N_2O	0.3	0.3	0.0	100.0
1.A.3.b.	Road Transportation	Biomass	CH_4	0.3	0.3	0.0	100.0
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CH_4	0.3	0.3	0.0	100.0
1.A.2.a.	Iron and Steel	Liquid fuels	N_2O	0.3	0.3	0.0	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Solid fuels	N_2O	0.2	0.2	0.0	100.0
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH_4	0.2	0.2	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	CH_4	0.2	0.2	0.0	100.0
1.A.2.b.	Non-Ferrous Metals	Solid fuels	CH_4	0.2	0.2	0.0	100.0
1.A.2.c.	Chemicals	Liquid fuels	N_2O	0.2	0.2	0.0	100.0
1.A.2.d.	Pulp, Paper and Print	Biomass	CH_4	0.2	0.2	0.0	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	N_2O	0.1	0.1	0.0	100.0
1.A.2.c.	Chemicals	Other fossil fuels	N_2O	0.1	0.1	0.0	100.0
1.C.	CO_2 Transport and Storage		CO_2	0.1	0.1	0.0	100.0
5.C.2.	Open burning of waste		N_2O	0.1	0.1	0.0	100.0
1.A.2.a.	Iron and Steel Production	Liquid fuels	CH_4	0.1	0.1	0.0	100.0
5.C.2.	Open burning of waste		CO_2	0.1	0.1	0.0	100.0
1.A.2.c.	Chemicals	Other fossil fuels	CH_4	0.1	0.1	0.0	100.0
1.A.2.c.	Chemicals	Liquid fuels	CH_4	0.1	0.1	0.0	100.0
1.A.2.f.	Non metalic minerals	Biomass	N_2O	0.0	0.0	0.0	100.0

Table A3 Key category analysis level assessment without LULUCF, 2014 (cont'd)

Source Category		Fuel	Gas	Emiss 2014	Abs (2014)	Cont. (%)	Cum. Cont. (%)
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	N_2O	0.0	0.0	0.0	100.0
1.A.2.f.	Non metalic minerals	Biomass	CH_4	0.0	0.0	0.0	100.0
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	N_2O	0.0	0.0	0.0	100.0
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	CH_4	0.0	0.0	0.0	100.0
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CH_4	0.0	0.0	0.0	100.0
5.A.	Forest land		CH_4	0.0	0.0	0.0	100.0
1.B.2.c.	Flaring		N_2O	0.0	0.0	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Biomass	N_2O	0.0	0.0	0.0	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Biomass	CH_4	0.0	0.0	0.0	100.0
1.A.3.c.	Railways	Solid fuels	CO_2		0.0	0.0	100.0
1.A.2.c.	Chemicals	Biomass	CH_4	0.0	0.0	0.0	100.0
1.A.3.c.	Railways	Solid fuels	CH_4	0.0	0.0	0.0	100.0
5.A.2.	Unmanaged waste disposal sites		CH_4	0.0	0.0	0.0	100.0
1.A.2.c.	Chemicals	Biomass	N_2O	0.0	0.0	0.0	100.0
1.A.3.c.	Railways	Solid fuels	N_2O	0.0	0.0	0.0	100.0
2.C.3.	Aluminium production		PFCs		0.0	0.0	100.0
Total all gases				**467 550.4**	**467 550.4**		

Table A4 Key category analysis trend assessment with LULUCF, 2014

Source Category		Fuel	Gas	Emisions 1990	Abs (1990)	Emissions 2014	Abs (2014)	Trend	Cont. (%)	Cum. Cont. (%)
4.A.	Forest land		CO_2	-28 322.9	28 322.9	-54 458.4	54 458.4	0.259	13.92	13.9
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CO_2	5 027.4	5 027.4	46 944.6	46 944.6	0.146	7.84	21.8
3.A.	Enteric fermentation		CH_4	24 887.6	24 887.6	27 434.3	27 434.3	0.122	6.58	28.3
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CO_2	21 995.7	21 995.7	75 964.6	75 964.6	0.105	5.64	34.0
1.A.4.b.	Residential	Gaseous fuels	CO_2	95.6	95.6	24 453.2	24 453.2	0.100	5.37	39.3
1.A.4.b.	Residential	Liquid fuels	CO_2	8 733.7	8 733.7	2 517.9	2 517.9	0.072	3.88	43.2
5.A.2.	Unmanaged waste disposal sites		CH_4	6 729.6	6 729.6	0.0	0.0	0.064	3.42	46.7
1.A.3.b.	Road Transportation	Diesel oil	CO_2	15 796.5	15 796.5	51 305.5	51 305.5	0.062	3.33	50.0
1.A.2.g.	Other Industries	Liquid Fuels	CO_2	7 420.9	7 420.9	3 327.2	3 327.2	0.056	3.04	53.0
1.A.3.b.	Road Transportation	Gasoline	CO_2	8 377.4	8 377.4	5 774.6	5 774.6	0.055	2.98	56.0
1.A.2.g.	Other Industries	Solid Fuels	CO_2	8 049.0	8 049.0	5 937.5	5 937.5	0.052	2.78	58.8
1.A.4.b.	Residential	Solid fuels	CO_2	14 594.4	14 594.4	21 310.1	21 310.1	0.050	2.70	61.5
5.A.1.	Managed waste disposal sites		CH_4	0.0	0.0	11 892.7	11 892.7	0.049	2.63	64.1
3.D.	Agricultural soils		N_2O	11 524.0	11 524.0	15 089.9	15 089.9	0.047	2.52	66.6
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CO_2	5 873.1	5 873.1	2 849.4	2 849.4	0.044	2.36	69.0
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CO_2		0.0	10 315.3	10 315.3	0.042	2.28	71.3
2.A.1.	Cement Production (Mineral Products)		CO_2	10 520.8	10 520.8	34 070.3	34 070.3	0.041	2.20	73.5
4.G.	Harvested wood products		CO_2	-4 368.2	4 368.2	-7 809.2	7 809.2	0.037	2.02	75.5
1.A.3.b.	Road Transportation	LPG	CO_2		0.0	8 469.1	8 469.1	0.035	1.88	77.4
1.A.2.c.	Chemicals	Liquid fuels	CO_2	2 626.2	2 626.2	73.8	73.8	0.025	1.32	78.7
1.A.2.g.	Other Industries	Gaseous Fuels	CO_2	622.8	622.8	6 866.6	6 866.6	0.022	1.20	79.9
1.A.2.f.	Non metalic minerals	Liquid fuels	CO_2	2 639.4	2 639.4	11 289.9	11 289.9	0.022	1.16	81.0
2.F.	Product uses as substitutes for ODS		HFCs		0.0	4 916.6	4 916.6	0.020	1.09	82.1
1.A.1.b.	Petroleum Refining	Liquid fuels	CO_2	3 228.3	3 228.3	2 624.3	2 624.3	0.020	1.06	83.2
1.A.4.b.	Residential	Biomass	CH_4	2 263.4	2 263.4	978.1	978.1	0.017	0.93	84.1
1.A.2.a.	Iron and Steel Production	Liquid fuels	CO_2	1 852.4	1 852.4	115.0	115.0	0.017	0.92	85.0

Table A4 Key category analysis trend assessment with LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emisions 1990	Abs (1990)	Emissions 2014	Abs (2014)	Trend	Cont. (%)	Cum. Cont. (%)
5.D.1.	Domestic wastewater		CH_4	2 579.8	2 579.8	1 879.4	1 879.4	0.017	0.90	85.9
4.D.	Wetlands		CO_2	1 741.7	1 741.7		0.0	0.016	0.89	86.8
2.A.2.	Lime Production (Mineral Products)		CO_2	3 787.5	3 787.5	4 966.5	4 966.5	0.015	0.83	87.7
1.A.2.a.	Iron and Steel Production	Solid fuels	CO_2		0.0	3 689.9	3 689.9	0.015	0.82	88.5
1.A.2.f.	Non metalic minerals	Gaseous fuels	CO_2	2.0	2.0	3 449.1	3 449.1	0.014	0.76	89.2
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	CO_2	2 463.3	2 463.3	2 262.6	2 262.6	0.014	0.75	90.0
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CO_2	2 439.2	2 439.2	2 670.1	2 670.1	0.012	0.65	90.6
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	CO_2		0.0	2 561.2	2 561.2	0.011	0.57	91.2
3.B.	Manure management		CH_4	2 352.1	2 352.1	3 178.4	3 178.4	0.009	0.49	91.7
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CO_2	939.5	939.5	7.9	7.9	0.009	0.48	92.2
1.A.3.a.	Domestic Aviation	Jet kerosene	CO_2	913.7	913.7	4 047.0	4 047.0	0.008	0.43	92.6
1.A.1.b.	Petroleum Refining	Gaseous fuels	CO_2		0 .0	1 881.8	1 881.8	0.008	0.42	93.0
4.C.	Grassland		CO_2	84.5	84.5	1 948.2	1 948.2	0.007	0.39	93.4
1.A.2.f.	Non metalic minerals	Solid fuels	CO_2	5 472.1	5 472.1	10 879.7	10 879.7	0.007	0.37	93.8
1.B.2.b	Natural Gas		CH_4	143.7	143.7	2 013.0	2 013.0	0.007	0.37	94.2
2.A.4.	Other process uses of carbonates		CO_2	257.6	257.6	2 237.3	2 237.3	0.007	0.36	94.5
2.C.3.	Aluminium production		PFCs	692.8	692.8		0.0	0.007	0.35	94.9
1.A.2.c.	Chemicals	Solid fuels	CO_2	1 341.5	1 341.5	1 546.5	1 546.5	0.006	0.34	95.2
1.A.2.f.	Non metalic minerals	Other fossil fuels	CO_2		0.0	1 204.1	1 204.1	0.005	0.27	95.5
5.D.1.	Domestic wastewater		N_2O	1 324.6	1 324.6	1 848.0	1 848.0	0.005	0.26	95.7
2.B.8.	Petrochemical and carbon black production		CO_2	821.2	821.2	748.8	748.8	0.005	0.25	96.0
3.B.	Manure management		N_2O	1 584.8	1 584.8	2 513.5	2 513.5	0.005	0.25	96.2
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	CO_2		0.0	1 041.6	1 041.6	0.004	0.23	96.5
4.E.	Settlements		CO_2	683.2	683.2	570.6	570.6	0.004	0.22	96.7
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	CO_2		0.0	995.0	995.0	0.004	0.22	96.9
1.A.2.c.	Chemicals	Gaseous fuels	CO_2	962.0	962.0	3 145.0	3 145.0	0.004	0.21	97.1

Table A4 Key category analysis trend assessment with LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emisions 1990	Abs (1990)	Emissions 2014	Abs (2014)	Trend	Cont. (%)	Cum. Cont. (%)
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	CO_2	1 129.5	1 129.5	1 686.3	1 686.3	0.004	0.20	97.3
1.A.3.c.	Railways	Liquid fuels	CO_2	590.6	590.6	503.5	503.5	0.004	0.19	97.5
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	CO_2	427.4	427.4	188.5	188.5	0.003	0.18	97.7
1.A.4.b.	Residential	Solid fuels	CH_4	1 022.3	1 022.3	1 595.4	1 595.4	0.003	0.17	97.9
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO_2	221.2	221.2	1 240.1	1 240.1	0.003	0.16	98.0
1.A.4.b.	Residential	Biomass	N_2O	359.7	359.7	155.5	155.5	0.003	0.15	98.2
1.B.2.a	Oil		CH_4	399.4	399.4	250.6	250.6	0.003	0.15	98.3
1.A.2.d.	Pulp, Paper and Print	Solid fuels	CO_2		0.0	623.8	623.8	0.003	0.14	98.4
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO_2	282.9	282.9	96.1	96.1	0.002	0.12	98.6
1.A.3.e.	Pipeline Transportation	Gaseous fuels	CO_2	40.0	40.0	601.8	601.8	0.002	0.11	98.7
1.A.3.b.	Road Transportation	Gasoline	N_2O	288.2	288.2	198.6	198.6	0.002	0.10	98.8
1.B.2.c	Venting and Flaring		CO_2	217.6	217.6	139.1	139.1	0.001	0.08	98.9
2.C.1.	Iron and Steel Production		CO_2	5 304.0	5 304.0	11 819.1	11 819.1	0.001	0.08	98.9
3.F.	Field burning of agricultural residues		CH_4	249.8	249.8	249.7	249.7	0.001	0.07	99.0
3.H.	Urea Application		CO_2	459.9	459.9	787.7	787.7	0.001	0.06	99.1
1.B.1.	Coal Mining	Solid fuels	CH_4	2 432.3	2 432.3	5 842.9	5 842.9	0.001	0.06	99.1
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	CO_2		0.0	251.3	251.3	0.001	0.06	99.2
1.A.3.b.	Road Transportation	Diesel oil	N_2O	249.5	249.5	810.4	810.4	0.001	0.05	99.2
2.B.2.	Nitric acid production		N_2O	695.7	695.7	1 808.1	1 808.1	0.001	0.05	99.3
1.A.3.b.	Road Transportation	LPG	CH_4	0 .0	0 .0	208.1	208.1	0.001	0.05	99.3
1.B.2.c	Venting and Flaring		CH_4	127.0	127.0	466.8	466.8	0.001	0.04	99.4
2.C.3.	Aluminium Production		CO_2	99.2	99.2	54.9	54.9	0.001	0.04	99.4
1.A.3.b.	Road Transportation	Gaseous fuels	CO_2		0.0	162.0	162.0	0.001	0.04	99.4
5.C.2.	Open burning of waste		CH_4	67.3	67.3	0 .7	0 .7	0.001	0.03	99.5
4.B.	Cropland		CO_2	- 47.6	47.6	- 131.5	131.5	0.001	0.03	99.5
1.A.3.c.	Railways	Solid fuels	CO_2	61.7	61.7		0 .0	0.001	0.03	99.5

Table A4 Key category analysis trend assessment with LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emisions 1990	Abs (1990)	Emissions 2014	Abs (2014)	Trend	Cont. (%)	Cum. Cont. (%)
2.B.7.	Soda ash production		CO_2		0.0	135.4	135.4	0.001	0.03	99.6
1.A.3.b.	Road Transportation	Gasoline	CH_4	75.6	75.6	52.1	52.1	0.000	0.03	99.6
2.B.5.	Carbide production		CO_2	58.1	58.1	15.5	15.5	0.000	0.03	99.6
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	N_2O	94.0	94.0	329.5	329.5	0.000	0.03	99.7
3.F.	Field burning of agricultural residues		N_2O	77.2	77.2	77.2	77.2	0.000	0.02	99.7
1.A.3.c.	Railways	Liquid fuels	N_2O	68.4	68.4	58.3	58.3	0.000	0.02	99.7
2.A.3.	Glass Production		CO_2	229.7	229.7	610.3	610.3	0.000	0.02	99.7
2.C.2.	Ferroalloys Production		CH_4	0.0	0.0	74.7	74.7	0.000	0.02	99.7
2.B.1.	Ammonia Production		CO_2	353.0	353.0	736.2	736.2	0.000	0.02	99.7
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	CO_2		0.0	66.2	66.2	0.000	0.01	99.8
2.C.2.	Ferroalloys Production		CO_2	81.2	81.2	131.8	131.8	0.000	0.01	99.8
1.A.2.b.	Non-Ferrous Metals	Solid fuels	CO_2	156.9	156.9	305.8	305.8	0.000	0.01	99.8
1.A.4.b.	Residential	Gaseous fuels	CH_4	0.2	0.2	53.5	53.5	0.000	0.01	99.8
1.A.4.c.	Agriculture/Forestry/Fisheries	Solid fuels	CO_2		0.0	51.2	51.2	0.000	0.01	99.8
1.A.2.g.	Other Industries	Solid Fuels	N_2O	32.9	32.9	26.2	26.2	0.000	0.01	99.8
1.A.4.b.	Residential	Liquid fuels	CH_4	22.5	22.5	5.2	5.2	0.000	0.01	99.8
1.A.4.b.	Residential	Solid fuels	N_2O	60.9	60.9	95.1	95.1	0.000	0.01	99.8
2.B.8.	Petrochemical and carbon black production		CH_4	28.4	28.4	25.1	25.1	0.000	0.01	99.9
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CH_4	20.0	20.0	9.7	9.7	0.000	0.01	99.9
2.C.5.	Zinc Production		CO_2	0.3	0.3	32.9	32.9	0.000	0.01	99.9
1.A.2.g.	Other Industries	Liquid Fuels	N_2O	16.8	16.8	7.1	7.1	0.000	0.01	99.9
1.A.2.g.	Other Industries	Solid Fuels	CH_4	17.8	17.8	14.5	14.5	0.000	0.01	99.9
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	N_2O	14.3	14.3	6.9	6.9	0.000	0.01	99.9
1.A.4.b.	Residential	Liquid fuels	N_2O	11.8	11.8	1.4	1.4	0.000	0.01	99.9
5.C.2.	Open burning of waste		N_2O	10.8	10.8	0.1	0 .1	0.000	0.01	99.9
1.A.3.a.	Domestic Aviation	Jet kerosene	N_2O	8.9	8.9	41.7	41.7	0.000	0.00	99.9
1.A.3.b.	Road Transportation	Diesel oil	CH_4	20.9	20.9	68.0	68.0	0.000	0.00	99.9

Table A4 Key category analysis trend assessment with LULUCF, 2014 (cont'd)

Source Category		Fuel	Gas	Emisions 1990	Abs (1990)	Emissions 2014	Abs (2014)	Trend	Cont. (%)	Cum. Cont. (%)
3.C.	Rice cultivation		CH_4	91.4	91.4	191.1	191.1	0.000	0.00	99.9
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	N_2O	2.6	2.6	24.0	24.0	0.000	0.00	99.9
2.D.1.	Lubricant Use		CO_2	175.1	175.1	385.6	385.6	0.000	0.00	99.9
5.B.1	Composting		CH_4	11.0	11.0	9.4	9.4	0.000	0.00	99.9
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CH_4	2.2	2.2	20.1	20.1	0.000	0.00	99.9
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	CO_2		0.0	15.1	15.1	0.000	0.00	99.9
5.B.1.	Composting		N_2O	9.8	9.8	8.4	8.4	0.000	0.00	99.9
1.A.2.c.	Chemicals	Liquid fuels	N_2O	6.1	6.1	0 .2	0 .2	0.000	0.00	99.9
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	N_2O	9.9	9.9	9.3	9.3	0.000	0.00	99.9
1.A.2.c.	Chemicals	Other fossil fuels	CO_2		0.0	13.4	13.4	0.000	0.00	99.9
1.A.2.g.	Other Industries	Liquid Fuels	CH_4	7.1	7.1	3.1	3.1	0.000	0.00	99.9
1.A.4.b.	Residential	Gaseous fuels	N_2O	0.1	0.1	12.8	12.8	0.000	0.00	99.9
1.A.3.e.	Pipeline Transportation	Gaseous fuels	CH_4	0.9	0.9	13.5	13.5	0.000	0.00	99.9
1.A.1.b.	Petroleum Refining	Liquid fuels	N_2O	6.2	6.2	2.9	2.9	0.000	0.00	100.0
1.A.3.e.	Pipeline Transportation	Gaseous fuels	N_2O	0.6	0.6	12.6	12.6	0.000	0.00	100.0
1.A.2.f.	Non metalic minerals	Other fossil fuels	N_2O	0.0	0.0	10.3	10.3	0.000	0.00	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	CH_4	5.5	5.5	2.9	2.9	0.000	0.00	100.0
1.A.2.a.	Iron and Steel	Liquid fuels	N_2O	4.2	4.2	0 .3	0 .3	0.000	0.00	100.0
1.A.3.b.	Road Transportation	LPG	N_2O	0.0	0.0	8.0	8.0	0.000	0.00	100.0
1.A.2.f.	Non metalic minerals	Liquid fuels	N_2O	5.6	5.6	20.8	20.8	0.000	0.00	100.0
2.C.1.	Iron and Steel Production		CH_4	16.3	16.3	30.2	30.2	0.000	0.00	100.0
1.A.2.f.	Non metalic minerals	Solid fuels	N_2O	24.2	24.2	48.3	48.3	0.000	0.00	100.0
1.A.2.a.	Iron and Steel	Solid fuels	N_2O	0.0	0.0	6.6	6.6	0.000	0.00	100.0
1.A.3.b.	Road Transportation	Gaseous fuels	CH_4	0.0	0.0	6.5	6.5	0.000	0.00	100.0
1.A.2.f.	Non metalic minerals	Other fossil fuels	CH_4	0.0	0.0	6.5	6.5	0.000	0.00	100.0
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CH_4	5.3	5.3	18.4	18.4	0.000	0.00	100.0
5.C.2.	Open burning of waste		CO_2	2.8	2.8	0.1	0.1	0.000	0.00	100.0

Table A4 Key category analysis trend assessment with LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emisions 1990	Abs (1990)	Emissions 2014	Abs (2014)	Trend	Cont. (%)	Cum. Cont. (%)
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N_2O	1.8	1.8	10.0	10.0	0.000	0.00	100.0
1.A.2.c.	Chemicals	Liquid fuels	CH_4	2.5	2.5	0.1	0.1	0.000	0.00	100.0
1.A.2.c.	Chemicals	Solid fuels	N_2O	5.3	5.3	6.4	6.4	0.000	0.00	100.0
5.D.2.	Industrial wastewater		CH_4	209.2	209.2	475.6	475.6	0.000	0.00	100.0
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	N_2O	2.1	2.1	0.0	0.0	0.000	0.00	100.0
1.A.1.b.	Petroleum Refining	Liquid fuels	CH_4	2.7	2.7	1.7	1.7	0.000	0.00	100.0
1.A.2.c.	Chemicals	Solid fuels	CH_4	2.9	2.9	2.5	2.5	0.000	0.00	100.0
1.A.3.d.	Domestic Navigation	Residual fuel oil	N_2O	2.1	2.1	0.7	0.7	0.000	0.00	100.0
1.A.2.f.	Non metalic minerals	Solid fuels	CH_4	13.5	13.5	27.0	27.0	0.000	0.00	100.0
1.A.2.a.	Iron and Steel Production	Liquid fuels	CH_4	1.8	1.8	0.1	0.1	0.000	0.00	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Solid fuels	CH_4	0.0	0.0	3.9	3.9	0.000	0.00	100.0
1.A.3.b.	Road Transportation	Biomass	N_2O	0.0	0.0	3.7	3.7	0.000	0.00	100.0
1.A.2.f.	Non metalic minerals	Liquid fuels	CH_4	2.3	2.3	8.7	8.7	0.000	0.00	100.0
2.C.5.	Lead Production		CO_2	1.9	1.9	7.5	7.5	0.000	0.00	100.0
1.A.1.a.	Public Electricity and Heat Production	Biomass	N_2O	0.0	0.0	3.0	3.0	0.000	0.00	100.0
1.A.2.g.	Other Industries	Gaseous Fuels	N_2O	0.3	0.3	3.6	3.6	0.000	0.00	100.0
1.A.2.d.	Pulp, Paper and Print	Solid fuels	N_2O	0.0	0.0	2.7	2.7	0.000	0.00	100.0
1.A.3.b.	Road Transportation	Gaseous fuels	N_2O	0.0	0.0	2.5	2.5	0.000	0.00	100.0
1.A.2.g.	Other Industries	Gaseous Fuels	CH_4	0.3	0.3	3.0	3.0	0.000	0.00	100.0
1.B.2.b	Natural Gas		CO_2	0.3	0.3	2.8	2.8	0.000	0.00	100.0
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	N_2O	2.6	2.6	3.9	3.9	0.000	0.00	100.0
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CH_4	0.9	0.9	0.0	0.0	0.000	0.00	100.0
1.A.1.a.	Public Electricity and Heat Production	Biomass	CH_4	0.0	0.0	2.0	2.0	0.000	0.00	100.0
1.A.2.a.	Iron and Steel	Gaseous fuels	N_2O	0.0	0.0	1.9	1.9	0.000	0.00	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	N_2O	1.0	1.0	0.4	0.4	0.000	0.00	100.0
1.B.2.a	Oil		CO_2	2.4	2.4	3.6	3.6	0.000	0.00	100.0
1.A.2.f.	Non metalic minerals	Gaseous fuels	N_2O	0.0	0.0	1.8	1.8	0.000	0.00	100.0

Table A4 Key category analysis trend assessment with LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emisions 1990	Abs (1990)	Emissions 2014	Abs (2014)	Trend	Cont. (%)	Cum. Cont. (%)
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH_4	0.5	0.5	3.0	3.0	0.000	0.00	100.0
1.A.2.a.	Iron and Steel Production	Solid fuels	CH_4	0.0	0.0	1.6	1.6	0.000	0.00	100.0
1.B.2.c.	Venting		N_2O	0.9	0.9	0.6	0.6	0.000	0.00	100.0
1.A.2.f.	Non metalic minerals	Gaseous fuels	CH_4	0.0	0.0	1.5	1.5	0.000	0.00	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	N_2O	0.0	0.0	1.3	1.3	0.000	0.00	100.0
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CH_4	0.0	0.0	1.3	1.3	0.000	0.00	100.0
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH_4	0.6	0.6	0.2	0.2	0.000	0.00	100.0
1.A.3.c.	Railways	Liquid fuels	CH_4	0.8	0.8	0.7	0.7	0.000	0.00	100.0
1.A.2.d.	Pulp, Paper and Print	Biomass	N_2O	0.0	0.0	1.2	1.2	0.000	0.00	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	CH_4	0.0	0.0	1.1	1.1	0.000	0.00	100.0
2.D.2.	Paraffin Wax Use		CO_2	1.7	1.7	2.7	2.7	0.000	0.00	100.0
1.A.2.d.	Pulp, Paper and Print	Solid fuels	CH_4	0.0	0.0	1.1	1.1	0.000	0.00	100.0
1.A.1.b.	Petroleum Refining	Gaseous fuels	N_2O	0.0	0.0	1.0	1.0	0.000	0.00	100.0
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	CH_4	1.1	1.1	1.6	1.6	0.000	0.00	100.0
1.A.1.b.	Petroleum Refining	Gaseous fuels	CH_4	0.0	0.0	0.9	0.9	0.000	0.00	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	CH_4	0.4	0.4	0.2	0.2	0.000	0.00	100.0
1.A.3.c.	Railways	Solid fuels	N_2O	0.3	0.3	0.0	0.0	0.000	0.00	100.0
1.A.2.b.	Non-Ferrous Metals	Solid fuels	CH_4	0.3	0.3	0.2	0.2	0.000	0.00	100.0
1.A.3.a.	Domestic Aviation	Jet kerosene	CH_4	0.3	0.3	1.3	1.3	0.000	0.00	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	CH_4	0.0	0.0	0.6	0.6	0.000	0.00	100.0
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	N_2O	0.0	0.0	0.6	0.6	0.000	0.00	100.0
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	N_2O	0.0	0.0	0.5	0.5	0.000	0.00	100.0
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	N_2O	0.0	0.0	0.5	0.5	0.000	0.00	100.0
1.A.2.c.	Chemicals	Gaseous fuels	N_2O	0.5	0.5	1.6	1.6	0.000	0.00	100.0
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	CH_4	0.0	0.0	0.5	0.5	0.000	0.00	100.0
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	CH_4	0.0	0.0	0.4	0.4	0.000	0.00	100.0

Table A4 Key category analysis trend assessment with LULUCF, 2014 (cont'd)

Source Category		Fuel	Gas	Emisions 1990	Abs (1990)	Emissions 2014	Abs (2014)	Trend	Cont. (%)	Cum. Cont. (%)
1.A.2.c.	Chemicals	Gaseous fuels	CH_4	0.4	0.4	1.4	1.4	0.000	0.00	100.0
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	CH_4	0.0	0.0	0.3	0.3	0.000	0.00	100.0
1.A.1.c.	Manufacture of solid fuels	Solid fuels	N_2O	0.3	0.3	0.3	0.3	0.000	0.00	100.0
1.A.3.b.	Road Transportation	Biomass	CH_4	0.0	0.0	0.3	0.3	0.000	0.00	100.0
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CH_4	0.2	0.2	0.3	0.3	0.000	0.00	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Solid fuels	N_2O	0.0	0.0	0.2	0.2	0.000	0.00	100.0
1.A.2.b.	Non-Ferrous Metals	Solid fuels	N_2O	0.6	0.6	1.2	1.2	0.000	0.00	100.0
1.C.	CO_2 Transport and Storage		CO_2	0.1	0.1	0.1	0.1	0.000	0.00	100.0
1.A.2.d.	Pulp, Paper and Print	Biomass	CH_4	0.0	0.0	0.2	0.2	0.000	0.00	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	N_2O	0.0	0.0	0.1	0.1	0.000	0.00	100.0
1.A.2.c.	Chemicals	Other fossil fuels	N_2O	0.0	0.0	0.1	0.1	0.000	0.00	100.0
1.A.2.c.	Chemicals	Other fossil fuels	CH_4	0.0	0.0	0.1	0.1	0.000	0.00	100.0
1.A.3.c.	Railways	Solid fuels	CH_4	0.0	0.0	0.0	0.0	0.000	0.00	100.0
5.A.	Forest land		CH_4	0.0	0.0	0.0	0.0	0.000	0.00	100.0
1.A.2.f.	Non metalic minerals	Biomass	N_2O	0.0	0.0	0.0	0.0	0.000	0.00	100.0
4.A.	Forest land		N_2O	0.0	0.0	0.0	0.0	0.000	0.00	100.0
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	N_2O	0.0	0.0	0.0	0.0	0.000	0.00	100.0
1.A.2.f.	Non metalic minerals	Biomass	CH_4	0.0	0.0	0.0	0.0	0.000	0.00	100.0
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	CH_4	0.0	0.0	0.0	0.0	0.000	0.00	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Biomass	N_2O	0.0	0.0	0.0	0.0	0.000	0.00	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Biomass	CH_4	0.0	0.0	0.0	0.0	0.000	0.00	100.0
1.B.2.c.	Flaring		N_2O	0.0	0.0	0.0	0.0	0.000	0.00	100.0
1.A.2.c.	Chemicals	Biomass	CH_4	0.0	0.0	0.0	0.0	0.000	0.00	100.0
1.A.2.c.	Chemicals	Biomass	N_2O	0.0	0.0	0.0	0.0	0.000	0.00	100.0
Total all gases				**177 544**	**243 021**	**407 670**	**532 468**	**1.86**		

Table A5 Key category analysis trend assessment without LULUCF, 2014

Source	Category	Fuel	Gas	Emiss 1990	Abs (1990)	Emiss 2014	Abs (2014)	Trend	Cont (%)	Cum. Cont. (%)
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CO_2	5 027.4	5 027.4	46 944.6	46 944.6	0.1715	9.66	9.7
3.A.	Enteric fermentation		CH_4	24 887.6	24 887.6	27 434.3	27 434.3	0.1375	7.74	17.4
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CO_2	21 995.7	21 995.7	75 964.6	75 964.6	0.1274	7.17	24.6
1.A.4.b.	Residential	Gaseous fuels	CO_2	95.6	95.6	24 453.2	24 453.2	0.1167	6.57	31.1
1.A.4.b.	Residential	Liquid fuels	CO_2	8 733.7	8 733.7	2 517.9	2 517.9	0.0825	4.64	35.8
1.A.3.b.	Road Transportation	Diesel oil	CO_2	15 796.5	15 796.5	51 305.5	51 305.5	0.0758	4.27	40.1
5.A.2.	Unmanaged waste disposal sites		CH_4	6 729.6	6 729.6	0.0	0.0	0.0729	4.10	44.2
1.A.2.g.	Other Industries	Liquid Fuels	CO_2	7 420.9	7 420.9	3 327.2	3 327.2	0.0644	3.62	47.8
1.A.3.b.	Road Transportation	Gasoline	CO_2	8 377.4	8 377.4	5 774.6	5 774.6	0.0629	3.54	51.3
1.A.2.g.	Other Industries	Solid Fuels	CO_2	8 049.0	8 049.0	5 937.5	5 937.5	0.0586	3.30	54.6
5.A.1.	Managed waste disposal sites		CH_4	0.0	0.0	11 892.7	11 892.7	0.0572	3.22	57.9
1.A.4.b.	Residential	Solid fuels	CO_2	14 594.4	14 594.4	21 310.1	21 310.1	0.0555	3.13	61.0
3.D.	Agricultural soils		N_2O	11 524.0	11 524.0	15 089.9	15 089.9	0.0522	2.94	63.9
2.A.1.	Cement Production (Mineral Products)		CO_2	10 520.8	10 520.8	34 070.3	34 070.3	0.0500	2.82	66.7
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CO_2	5 873.1	5 873.1	2 849.4	2 849.4	0.0499	2.81	69.6
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CO_2		0.0	10 315.3	10 315.3	0.0496	2.80	72.3
1.A.3.b.	Road Transportation	LPG	CO_2		0.0	8 469.1	8 469.1	0.0408	2.30	74.6
1.A.2.c.	Chemicals	Liquid fuels	CO_2	2 626.2	2 626.2	73.8	73.8	0.0281	1.58	76.2
1.A.2.g.	Other Industries	Gaseous Fuels	CO_2	622.8	622.8	6 866.6	6 866.6	0.0263	1.48	77.7
1.A.2.f.	Non metalic minerals	Liquid fuels	CO_2	2 639.4	2 639.4	11 289.9	11 289.9	0.0258	1.45	79.2
2.F.	Product uses as substitutes for ODS		HFCs		0.0	4 916.6	4 916.6	0.0237	1.33	80.5
1.A.1.b.	Petroleum Refining	Liquid fuels	CO_2	3 228.3	3 228.3	2 624.3	2 624.3	0.0223	1.26	81.7
1.A.4.b.	Residential	Biomass	CH_4	2 263.4	2 263.4	978.1	978.1	0.0198	1.12	82.9
1.A.2.a.	Iron and Steel Production	Liquid fuels	CO_2	1 852.4	1 852.4	115.0	115.0	0.0195	1.10	84.0
5.D.1.	Domestic wastewater		CH_4	2 579.8	2 579.8	1 879.4	1 879.4	0.0189	1.06	85.0
1.A.2.a.	Iron and Steel Production	Solid fuels	CO_2		0.0	3 689.9	3 689.9	0.0178	1.00	86.0
2.A.2.	Lime Production (Mineral Products)		CO_2	3 787.5	3 787.5	4 966.5	4 966.5	0.0171	0.96	87.0
1.A.2.f.	Non metalic minerals	Gaseous fuels	CO_2	2.0	2.0	3 449.1	3 449.1	0.0166	0.93	87.9
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	CO_2	2 463.3	2 463.3	2 262.6	2 262.6	0.0158	0.89	88.8

Table A5 Key category analysis trend assessment without LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emiss 1990	Abs (1990)	Emiss 2014	Abs (2014)	Trend	Cont (%)	Cum. Cont. (%)
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CO_2	2 439.2	2 439.2	2 670.1	2 670.1	0.0136	0.76	89.6
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	CO_2		0.0	2 561.2	2 561.2	0.0123	0.69	90.3
3.B.	Manure management		CH_4	2 352.1	2 352.1	3 178.4	3 178.4	0.0102	0.57	90.8
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CO_2	939.5	939.5	7.9	7.9	0.0101	0.57	91.4
1.A.3.a.	Domestic Aviation	Jet kerosene	CO_2	913.7	913.7	4 047.0	4 047.0	0.0096	0.54	92.0
1.A.1.b.	Petroleum Refining	Gaseous fuels	CO_2		0.0	1 881.8	1 881.8	0.0091	0.51	92.5
1.B.2.b	Natural Gas		CH_4	143.7	143.7	2 013.0	2 013.0	0.0081	0.46	92.9
2.A.4.	Other process uses of carbonates		CO_2	257.6	257.6	2 237.3	2 237.3	0.0080	0.45	93.4
2.C.3.	Aluminium production		PFCs	692.8	692.8		.0	0.0075	0.42	93.8
1.A.2.c.	Chemicals	Solid fuels	CO_2	1 341.5	1 341.5	1 546.5	1 546.5	0.0071	0.40	94.2
1.A.2.f.	Non metalic minerals	Solid fuels	CO_2	5 472.1	5 472.1	10 879.7	10 879.7	0.0069	0.39	94.6
1.A.2.f.	Non metalic minerals	Other fossil fuels	CO_2		0.0	1 204.1	1 204.1	0.0058	0.33	94.9
5.D.1.	Domestic wastewater		N_2O	1 324.6	1 324.6	1 848.0	1 848.0	0.0055	0.31	95.2
2.B.8.	Petrochemical and carbon black production		CO_2	821.2	821.2	748.8	748.8	0.0053	0.30	95.5
3.B.	Manure management		N_2O	1 584.8	1 584.8	2 513.5	2 513.5	0.0051	0.29	95.8
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	CO_2		0.0	1 041.6	1 041.6	0.0050	0.28	96.1
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	CO_2		0.0	995.0	995.0	0.0048	0.27	96.4
1.A.2.c.	Chemicals	Gaseous fuels	CO_2	962.0	962.0	3 145.0	3 145.0	0.0047	0.27	96.6
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	CO_2	1 129.5	1 129.5	1 686.3	1 686.3	0.0041	0.23	96.9
1.A.3.c.	Railways	Liquid fuels	CO_2	590.6	590.6	503.5	503.5	0.0040	0.22	97.1
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	CO_2	427.4	427.4	188.5	188.5	0.0037	0.21	97.3
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO_2	221.2	221.2	1 240.1	1 240.1	0.0036	0.20	97.5
1.A.4.b.	Residential	Solid fuels	CH_4	1 022.3	1 022.3	1 595.4	1 595.4	0.0034	0.19	97.7
1.A.4.b.	Residential	Biomass	N_2O	359.7	359.7	155.5	155.5	0.0031	0.18	97.9
1.B.2.a	Oil		CH_4	399.4	399.4	250.6	250.6	0.0031	0.18	98.0
1.A.2.d.	Pulp, Paper and Print	Solid fuels	CO_2		0.0	623.8	623.8	0.0030	0.17	98.2
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO_2	282.9	282.9	96.1	96.1	0.0026	0.15	98.3
1.A.3.e.	Pipeline Transportation	Gaseous fuels	CO_2	40.0	40.0	601.8	601.8	0.0025	0.14	98.5

Table A5 Key category analysis trend assessment without LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emiss 1990	Abs (1990)	Emiss 2014	Abs (2014)	Trend	Cont (%)	Cum. Cont. (%)
1.A.3.b.	Road Transportation	Gasoline	N_2O	288.2	288.2	198.6	198.6	0.0022	0.12	98.6
1.B.1.	Coal Mining	Solid fuels	CH_4	2 432.3	2 432.3	5 842.9	5 842.9	0.0018	0.10	98.7
1.B.2.c	Venting and Flaring		CO_2	217.6	217.6	139.1	139.1	0.0017	0.10	98.8
3.F.	Field burning of agricultural residues		CH_4	249.8	249.8	249.7	249.7	0.0015	0.08	98.9
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	CO_2		0.0	251.3	251.3	0.0012	0.07	99.0
1.A.3.b.	Road Transportation	Diesel oil	N_2O	249.5	249.5	810.4	810.4	0.0012	0.07	99.0
3.H.	Urea Application		CO_2	459.9	459.9	787.7	787.7	0.0012	0.07	99.1
2.B.2.	Nitric acid production		N_2O	695.7	695.7	1 808.1	1 808.1	0.0012	0.07	99.2
1.A.3.b.	Road Transportation	LPG	CH_4	0.0	0.0	208.1	208.1	0.0010	0.06	99.2
1.B.2.c	Venting and Flaring		CH_4	127.0	127.0	466.8	466.8	0.0009	0.05	99.3
2.C.3.	Aluminium Production		CO_2	99.2	99.2	54.9	54.9	0.0008	0.05	99.3
1.A.3.b.	Road Transportation	Gaseous fuels	CO_2		0.0	162.0	162.0	0.0008	0.04	99.3
5.C.2.	Open burning of waste		CH_4	67.3	67.3	0.7	0.7	0.0007	0.04	99.4
1.A.3.c.	Railways	Solid fuels	CO_2	61.7	61.7		0.0	0.0007	0.04	99.4
2.B.7.	Soda ash production		CO_2		0.0	135.4	135.4	0.0007	0.04	99.5
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	N_2O	94.0	94.0	329.5	329.5	0.0006	0.03	99.5
1.A.3.b.	Road Transportation	Gasoline	CH_4	75.6	75.6	52.1	52.1	0.0006	0.03	99.5
2.C.1.	Iron and Steel Production		CO_2	5 304.0	5 304.0	11 819.1	11 819.1	0.0006	0.03	99.6
2.B.5.	Carbide production		CO_2	58.1	58.1	15.5	15.5	0.0006	0.03	99.6
3.F.	Field burning of agricultural residues		N_2O	77.2	77.2	77.2	77.2	0.0005	0.03	99.6
1.A.3.c.	Railways	Liquid fuels	N_2O	68.4	68.4	58.3	58.3	0.0005	0.03	99.6
2.A.3.	Glass Production		CO_2	229.7	229.7	610.3	610.3	0.0004	0.03	99.7
2.C.2.	Ferroalloys Production		CH_4	0.0	0.0	74.7	74.7	0.0004	0.02	99.7
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	CO_2		0.0	66.2	66.2	0.0003	0.02	99.7
2.B.1.	Ammonia Production		CO_2	353.0	353.0	736.2	736.2	0.0003	0.02	99.7
1.A.4.b.	Residential	Gaseous fuels	CH_4	0.2	0.2	53.5	53.5	0.0003	0.01	99.7
1.A.4.c.	Agriculture/Forestry/Fisheries	Solid fuels	CO_2		0.0	51.2	51.2	0.0002	0.01	99.8
2.C.2.	Ferroalloys Production		CO_2	81.2	81.2	131.8	131.8	0.0002	0.01	99.8

Table A5 Key category analysis trend assessment without LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emiss 1990	Abs (1990)	Emiss 2014	Abs (2014)	Trend	Cont (%)	Cum. Cont. (%)
1.A.2.g.	Other Industries	Solid Fuels	N_2O	32.9	32.9	26.2	26.2	0.0002	0.01	99.8
1.A.2.b.	Non-Ferrous Metals	Solid fuels	CO_2	156.9	156.9	305.8	305.8	0.0002	0.01	99.8
1.A.4.b.	Residential	Liquid fuels	CH_4	22.5	22.5	5.2	5.2	0.0002	0.01	99.8
1.A.4.b.	Residential	Solid fuels	N_2O	60.9	60.9	95.1	95.1	0.0002	0.01	99.8
2.B.8.	Petrochemical and carbon black production		CH_4	28.4	28.4	25.1	25.1	0.0002	0.01	99.8
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CH_4	20.0	20.0	9.7	9.7	0.0002	0.01	99.8
2.C.5.	Zinc Production		CO_2	0.3	0.3	32.9	32.9	0.0002	0.01	99.8
1.A.2.g.	Other Industries	Liquid Fuels	N_2O	16.8	16.8	7.1	7.1	0.0001	0.01	99.9
1.A.2.g.	Other Industries	Solid Fuels	CH_4	17.8	17.8	14.5	14.5	0.0001	0.01	99.9
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	N_2O	14.3	14.3	6.9	6.9	0.0001	0.01	99.9
1.A.4.b.	Residential	Liquid fuels	N_2O	11.8	11.8	1.4	1.4	0.0001	0.01	99.9
5.C.2.	Open burning of waste		N_2O	10.8	10.8	0.1	0.1	0.0001	0.01	99.9
1.A.3.a.	Domestic Aviation	Jet kerosene	N_2O	8.9	8.9	41.7	41.7	0.0001	0.01	99.9
1.A.3.b.	Road Transportation	Diesel oil	CH_4	20.9	20.9	68.0	68.0	0.0001	0.01	99.9
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	N_2O	2.6	2.6	24.0	24.0	0.0001	0.00	99.9
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CH_4	2.2	2.2	20.1	20.1	0.0001	0.00	99.9
5.B.1	Composting		CH_4	11.0	11.0	9.4	9.4	0.0001	0.00	99.9
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	CO_2		0.0	15.1	15.1	0.0001	0.00	99.9
3.C.	Rice cultivation		CH_4	91.4	91.4	191.1	191.1	0.0001	0.00	99.9
5.B.1.	Composting		N_2O	9.8	9.8	8.4	8.4	0.0001	0.00	99.9
1.A.2.c.	Chemicals	Liquid fuels	N_2O	6.1	6.1	0.2	0.2	0.0001	0.00	99.9
1.A.2.c.	Chemicals	Other fossil fuels	CO_2		0.0	13.4	13.4	0.0001	0.00	99.9
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	N_2O	9.9	9.9	9.3	9.3	0.0001	0.00	99.9
1.A.2.g.	Other Industries	Liquid Fuels	CH_4	7.1	7.1	3.1	3.1	0.0001	0.00	99.9
1.A.4.b.	Residential	Gaseous fuels	N_2O	0.1	0.1	12.8	12.8	0.0001	0.00	99.9
1.A.3.e.	Pipeline Transportation	Gaseous fuels	CH_4	0.9	0.9	13.5	13.5	0.0001	0.00	99.9
1.A.3.e.	Pipeline Transportation	Gaseous fuels	N_2O	0.6	0.6	12.6	12.6	0.0001	0.00	99.9
1.A.1.b.	Petroleum Refining	Liquid fuels	N_2O	6.2	6.2	2.9	2.9	0.0001	0.00	99.9
1.A.2.f.	Non metalic minerals	Other fossil fuels	N_2O	0.0	0.0	10.3	10.3	0.0000	0.00	99.9

Table A5 Key category analysis trend assessment without LULUCF, 2014 (cont'd)

Source Category		Fuel	Gas	Emiss 1990	Abs (1990)	Emiss 2014	Abs (2014)	Trend	Cont (%)	Cum. Cont. (%)
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	CH_4	5.5	5.5	2.9	2.9	0.0000	0.00	99.9
1.A.2.a.	Iron and Steel	Liquid fuels	N_2O	4.2	4.2	0.3	0.3	0.0000	0.00	99.9
2.D.1.	Lubricant Use		CO_2	175.1	175.1	385.6	385.6	0.0000	0.00	100.0
1.A.2.f.	Non metalic minerals	Liquid fuels	N_2O	5.6	5.6	20.8	20.8	0.0000	0.00	100.0
1.A.3.b.	Road Transportation	LPG	N_2O	0.0	0.0	8.0	8.0	0.0000	0.00	100.0
1.A.2.a.	Iron and Steel	Solid fuels	N_2O	0.0	0.0	6.6	6.6	0.0000	0.00	100.0
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CH_4	5.3	5.3	18.4	18.4	0.0000	0.00	100.0
1.A.3.b.	Road Transportation	Gaseous fuels	CH_4	0.0	0.0	6.5	6.5	0.0000	0.00	100.0
2.C.1.	Iron and Steel Production		CH_4	16.3	16.3	30.2	30.2	0.0000	0.00	100.0
1.A.2.f.	Non metalic minerals	Other fossil fuels	CH_4	0.0	0.0	6.5	6.5	0.0000	0.00	100.0
5.C.2.	Open burning of waste		CO_2	2.8	2.8	0.1	0.1	0.0000	0.00	100.0
1.A.2.f.	Non metalic minerals	Solid fuels	N_2O	24.2	24.2	48.3	48.3	0.0000	0.00	100.0
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N_2O	1.8	1.8	10.0	10.0	0.0000	0.00	100.0
1.A.2.c.	Chemicals	Liquid fuels	CH_4	2.5	2.5	0.1	0.1	0.0000	0.00	100.0
1.A.2.c.	Chemicals	Solid fuels	N_2O	5.3	5.3	6.4	6.4	0.0000	0.00	100.0
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	N_2O	2.1	2.1	0.0	0.0	0.0000	0.00	100.0
5.D.2.	Industrial wastewater		CH_4	209.2	209.2	475.6	475.6	0.0000	0.00	100.0
1.A.1.b.	Petroleum Refining	Liquid fuels	CH_4	2.7	2.7	1.7	1.7	0.0000	0.00	100.0
1.A.2.c.	Chemicals	Solid fuels	CH_4	2.9	2.9	2.5	2.5	0.0000	0.00	100.0
1.A.3.d.	Domestic Navigation	Residual fuel oil	N_2O	2.1	2.1	0.7	0.7	0.0000	0.00	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Solid fuels	CH_4	0.0	0.0	3.9	3.9	0.0000	0.00	100.0
1.A.2.a.	Iron and Steel Production	Liquid fuels	CH_4	1.8	1.8	0.1	0.1	0.0000	0.00	100.0
1.A.3.b.	Road Transportation	Biomass	N_2O	0.0	0.0	3.7	3.7	0.0000	0.00	100.0
1.A.2.f.	Non metalic minerals	Liquid fuels	CH_4	2.3	2.3	8.7	8.7	0.0000	0.00	100.0
1.A.2.f.	Non metalic minerals	Solid fuels	CH_4	13.5	13.5	27.0	27.0	0.0000	0.00	100.0
2.C.5.	Lead Production		CO_2	1.9	1.9	7.5	7.5	0.0000	0.00	100.0
1.A.1.a.	Public Electricity and Heat Production	Biomass	N_2O	0.0	0.0	3.0	3.0	0.0000	0.00	100.0
1.A.2.g.	Other Industries	Gaseous Fuels	N_2O	0.3	0.3	3.6	3.6	0.0000	0.00	100.0

Table A5 Key category analysis trend assessment without LULUCF, 2014 (cont'd)

Source	Category	Fuel	Gas	Emiss 1990	Abs (1990)	Emiss 2014	Abs (2014)	Trend	Cont (%)	Cum. Cont. (%)
1.A.2.d.	Pulp, Paper and Print	Solid fuels	N_2O	0.0	0.0	2.7	2.7	0.0000	0.00	100.0
1.A.3.b.	Road Transportation	Gaseous fuels	N_2O	0.0	0.0	2.5	2.5	0.0000	0.00	100.0
1.A.2.g.	Other Industries	Gaseous Fuels	CH_4	0.3	0.3	3.0	3.0	0.0000	0.00	100.0
1.B.2.b	Natural Gas		CO_2	0.3	0.3	2.8	2.8	0.0000	0.00	100.0
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	N_2O	2.6	2.6	3.9	3.9	0.0000	0.00	100.0
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CH_4	0.9	0.9	0.0	0.0	0.0000	0.00	100.0
1.A.1.a.	Public Electricity and Heat Production	Biomass	CH_4	0.0	0.0	2.0	2.0	0.0000	0.00	100.0
1.A.2.a.	Iron and Steel	Gaseous fuels	N_2O	0.0	0.0	1.9	1.9	0.0000	0.00	100.0
1.A.2.f.	Non metalic minerals	Gaseous fuels	N_2O	0.0	0.0	1.8	1.8	0.0000	0.00	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	N_2O	1.0	1.0	0.4	0.4	0.0000	0.00	100.0
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH_4	0.5	0.5	3.0	3.0	0.0000	0.00	100.0
1.B.2.a	Oil		CO_2	2.4	2.4	3.6	3.6	0.0000	0.00	100.0
1.A.2.a.	Iron and Steel Production	Solid fuels	CH_4	0.0	0.0	1.6	1.6	0.0000	0.00	100.0
1.A.2.f.	Non metalic minerals	Gaseous fuels	CH_4	0.0	0.0	1.5	1.5	0.0000	0.00	100.0
1.B.2.c.	Venting		N_2O	0.9	0.9	0.6	0.6	0.0000	0.00	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	N_2O	0.0	0.0	1.3	1.3	0.0000	0.00	100.0
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CH_4	0.0	0.0	1.3	1.3	0.0000	0.00	100.0
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH_4	0.6	0.6	0.2	0.2	0.0000	0.00	100.0
1.A.2.d.	Pulp, Paper and Print	Biomass	N_2O	0.0	0.0	1.2	1.2	0.0000	0.00	100.0
1.A.3.c.	Railways	Liquid fuels	CH_4	0.8	0.8	0.7	0.7	0.0000	0.00	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	CH_4	0.0	0.0	1.1	1.1	0.0000	0.00	100.0
1.A.2.d.	Pulp, Paper and Print	Solid fuels	CH_4	0.0	0.0	1.1	1.1	0.0000	0.00	100.0
1.A.1.b.	Petroleum Refining	Gaseous fuels	N_2O	0.0	0.0	1.0	1.0	0.0000	0.00	100.0
2.D.2.	Paraffin Wax Use		CO_2	1.7	1.7	2.7	2.7	0.0000	0.00	100.0
1.A.1.b.	Petroleum Refining	Gaseous fuels	CH_4	0.0	0.0	0.9	0.9	0.0000	0.00	100.0
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	CH_4	1.1	1.1	1.6	1.6	0.0000	0.00	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	CH_4	0.4	0.4	0.2	0.2	0.0000	0.00	100.0
1.A.3.c.	Railways	Solid fuels	N_2O	0.3	0.3	0.0	0.0	0.0000	0.00	100.0
1.A.2.b.	Non-Ferrous Metals	Solid fuels	CH_4	0.3	0.3	0.2	0.2	0.0000	0.00	100.0

Table A5 Key category analysis trend assessment without LULUCF, 2014 (cont'd)

Source Category		Fuel	Gas	Emiss 1990	Abs (1990)	Emiss 2014	Abs (2014)	Trend	Cont (%)	Cum. Cont. (%)
1.A.3.a.	Domestic Aviation	Jet kerosene	CH_4	0.3	0.3	1.3	1.3	0.0000	0.00	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	CH_4	0.0	0.0	0.6	0.6	0.0000	0.00	100.0
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	N_2O	0.0	0.0	0.6	0.6	0.0000	0.00	100.0
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	N_2O	0.0	0.0	0.5	0.5	0.0000	0.00	100.0
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	N_2O	0.0	0.0	0.5	0.5	0.0000	0.00	100.0
1.A.2.c.	Chemicals	Gaseous fuels	N_2O	0.5	0.5	1.6	1.6	0.0000	0.00	100.0
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	CH_4	0.0	0.0	0.5	0.5	0.0000	0.00	100.0
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	CH_4	0.0	0.0	0.4	0.4	0.0000	0.00	100.0
1.A.2.c.	Chemicals	Gaseous fuels	CH_4	0.4	0.4	1.4	1.4	0.0000	0.00	100.0
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	CH_4	0.0	0.0	0.3	0.3	0.0000	0.00	100.0
1.A.1.c.	Manufacture of solid fuels	Solid fuels	N_2O	0.3	0.3	0.3	0.3	0.0000	0.00	100.0
1.A.3.b.	Road Transportation	Biomass	CH_4	0.0	0.0	0.3	0.3	0.0000	0.00	100.0
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CH_4	0.2	0.2	0.3	0.3	0.0000	0.00	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Solid fuels	N_2O	0.0	0.0	0.2	0.2	0.0000	0.00	100.0
1.A.2.b.	Non-Ferrous Metals	Solid fuels	N_2O	0.6	0.6	1.2	1.2	0.0000	0.00	100.0
1.C.	CO_2 Transport and Storage		CO_2	0.1	0.1	0.1	0.1	0.0000	0.00	100.0
1.A.2.d.	Pulp, Paper and Print	Biomass	CH_4	0.0	0.0	0.2	0.2	0.0000	0.00	100.0
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	N_2O	0.0	0.0	0.1	0.1	0.0000	0.00	100.0
1.A.2.c.	Chemicals	Other fossil fuels	N_2O	0.0	0.0	0.1	0.1	0.0000	0.00	100.0
1.A.2.c.	Chemicals	Other fossil fuels	CH_4	0.0	0.0	0.1	0.1	0.0000	0.00	100.0
1.A.3.c.	Railways	Solid fuels	CH_4	0.0	0.0	0.0	0.0	0.0000	0.00	100.0
5.A.	Forest land		CH_4	0.0	0.0	0.0	0.0	0.0000	0.00	100.0
1.A.2.f.	Non metalic minerals	Biomass	N_2O	0.0	0.0	0.0	0.0	0.0000	0.00	100.0
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	N_2O	0.0	0.0	0.0	0.0	0.0000	0.00	100.0
1.A.2.f.	Non metalic minerals	Biomass	CH_4	0.0	0.0	0.0	0.0	0.0000	0.00	100.0
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	CH_4	0.0	0.0	0.0	0.0	0.0000	0.00	100.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Biomass	N_2O	0.0	0.0	0.0	0.0	0.0000	0.00	100.0

Table A5 Key category analysis trend assessment without LULUCF, 2014 (cont'd)

Source Category		Fuel	Gas	Emiss 1990	Abs (1990)	Emiss 2014	Abs (2014)	Trend	Cont (%)	Cum. Cont. (%)
1.A.2.e.	Food Processing, Beverages and Tobacco	Biomass	CH_4	0.0	0.0	0.0	0.0	0.0000	0.00	100.0
1.B.2.c.	Flaring		N_2O	0.0	0.0	0.0	0.0	0.0000	0.00	100.0
1.A.2.c.	Chemicals	Biomass	CH_4	0.0	0.0	0.0	0.0	0.0000	0.00	100.0
1.A.2.c.	Chemicals	Biomass	N_2O	0.0	0.0	0.0	0.0	0.0000	0.00	100.0
Total all gases				**207 773**	**207 773**	**467 550**	**467 550**	**1.78**		

Annex 2: Uncertainty

All Annex I Parties to the UNFCCC are required to report estimated uncertainties associated with both annual estimates of emissions and emission trends over time in their respective national inventory reports. Uncertainty analysis helps to prioritize improvements of future inventories and to guide decisions on methodological choice (IPCC 2006).

For the calculation of uncertainty, the error propagation method (Approach 1) for combining uncertainties, as outlined in Volume 1 (Chapter 3) of the 2006 IPCC Guidelines for National GHG Inventories (IPCC 2006) was applied,

Table A1.5. shows the uncertainty assessment of the Turkish GHG emissions inventory excluding LULUCF. According to the calculations; the total uncertainty of the inventory, excluding LULUCF, is 11.34 percent.

Table A6 Uncertainty assessment

Source Category		Fuel	Gas	Emissions in 1990 (kt CO_2 eq.)	Emissions in 2014 (kt CO_2 eq.)	AD Unc. (%)	EF Unc. (%)	A(1) (%)	B(2) (%)	C(3)	D(4) (%)	E(5) (%)	F(6) (%)	G(7) (%)
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	CO_2	1 129.5	1 686.3	5.0	4.1	6.48	0.03	0.00	0.07	-0.02	0.07	0.00
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CO_2	21 995.7	75 964.6	5.0	4.8	6.95	1.29	1.68	3.03	0.69	3.10	9.63
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CO_2	5 027.4	46 944.6	5.0	3.6	6.16	0.71	0.50	1.87	0.72	2.00	4.01
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	CO_2		66.2	14.1	7.0	15.78	0.00	0.00	0.01	0.00	0.01	0.00
1.A.1.b.	Petroleum Refining	Liquid fuels	CO_2	3 228.3	2 624.3	2.0	7.0	7.28	0.05	0.00	0.04	-0.19	0.19	0.04
1.A.1.b.	Petroleum Refining	Gaseous fuels	CO_2		1 881.8	2.0	7.0	7.28	0.03	0.00	0.03	0.07	0.08	0.01
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CO_2	2 439.2	2 670.1	2.0	7.0	7.28	0.05	0.00	0.04	-0.12	0.12	0.02
1.A.2.a.	Iron and Steel Production	Liquid fuels	CO_2	1 852.4	115.0	11.2	100.0	100.62	0.03	0.00	0.01	-2.33	2.33	5.43
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CO_2		10 315.3	14.1	100.0	101.00	2.56	6.53	1.16	5.81	5.93	35.11
1.A.2.a.	Iron and Steel Production	Solid fuels	CO_2		3 689.9	11.2	100.0	100.62	0.91	0.83	0.33	2.08	2.10	4.43
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CO_2	939.5	7.9	21.2	7.0	22.34	0.00	0.00	0.00	-0.08	0.08	0.01
1.A.2.b.	Non-Ferrous Metals	Solid fuels	CO_2	156.9	305.8	21.2	7.0	22.34	0.02	0.00	0.05	0.00	0.05	0.00
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	CO_2		995.0	21.2	7.0	22.34	0.05	0.00	0.17	0.04	0.17	0.03
1.A.2.c.	Chemicals	Liquid fuels	CO_2	2 626.2	73.8	15.8	7.0	17.29	0.00	0.00	0.01	-0.23	0.23	0.06
1.A.2.c.	Chemicals	Solid fuels	CO_2	1 341.5	1 546.5	15.8	7.0	17.29	0.07	0.00	0.19	-0.06	0.20	0.04
1.A.2.c.	Chemicals	Gaseous fuels	CO_2	962.0	3 145.0	15.8	7.0	17.29	0.13	0.02	0.40	0.04	0.40	0.16
1.A.2.c.	Chemicals	Other fossil fuels	CO_2		13.4	2.0	7.0	7.28	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	CO_2		15.1	18.0	7.0	19.34	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.d.	Pulp, Paper and Print	Solid fuels	CO_2		623.8	18.0	7.0	19.34	0.03	0.00	0.09	0.02	0.09	0.01
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	CO_2		1 041.6	18.0	7.0	19.34	0.05	0.00	0.15	0.04	0.16	0.02
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	CO_2	427.4	188.5	5.0	7.0	8.60	0.00	0.00	0.01	-0.03	0.03	0.00
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	CO_2	2 463.3	2 262.6	18.0	7.0	19.34	0.11	0.01	0.32	-0.13	0.35	0.12
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	CO_2		2 561.2	14.1	7.0	15.78	0.10	0.01	0.29	0.10	0.31	0.09
1.A.2.f.	Non metalic minerals	Liquid fuels	CO_2	2 639.4	11 289.9	27.8	7.0	28.67	0.79	0.63	2.50	0.21	2.51	6.29
1.A.2.f.	Non metalic minerals	Solid fuels	CO_2	5 472.1	10 879.7	25.5	7.0	26.44	0.71	0.50	2.21	-0.07	2.21	4.89

Table A6 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	Emissions in 1990 (kt CO_2 eq.)	Emissions in 2014 (kt CO_2 eq.)	AD Unc. (%)	EF Unc. (%)	A[1] (%)	B[2] (%)	C[3]	D[4] (%)	E[5] (%)	F[6] (%)	G[7] (%)
1.A.2.f.	Non metalic minerals	Gaseous fuels	CO_2	2.0	3 449.1	29.2	7.0	30.03	0.25	0.06	0.80	0.14	0.81	0.66
1.A.2.f.	Non metalic minerals	Other fossil fuels	CO_2		1 204.1	2.0	7.0	7.28	0.02	0.00	0.02	0.05	0.05	0.00
1.A.2.g.	Other Industries	Liquid Fuels	CO_2	7 420.9	3 327.2	70.7	7.0	71.06	0.58	0.34	1.87	-0.54	1.95	3.80
1.A.2.g.	Other Industries	Solid Fuels	CO_2	8 049.0	5 937.5	70.7	7.0	71.06	1.03	1.07	3.34	-0.49	3.38	11.43
1.A.2.g.	Other Industries	Gaseous Fuels	CO_2	622.8	6 866.6	70.7	7.0	71.06	1.20	1.43	3.87	0.21	3.87	15.00
1.A.3.a.	Domestic Aviation	Jet kerosene	CO_2	913.7	4 047.0	5.5	5.0	7.42	0.07	0.01	0.18	0.05	0.18	0.03
1.A.3.b.	Road Transportation	Gasoline	CO_2	8 377.4	5 774.6	10.0	5.0	11.22	0.16	0.03	0.46	-0.38	0.60	0.36
1.A.3.b.	Road Transportation	Diesel oil	CO_2	15 796.5	51 305.5	10.0	5.0	11.22	1.41	2.00	4.11	0.42	4.13	17.05
1.A.3.b.	Road Transportation	LPG	CO_2		8 469.1	10.0	5.0	11.22	0.23	0.05	0.68	0.24	0.72	0.52
1.A.3.b.	Road Transportation	Gaseous fuels	CO_2		162.0	7.0	356.0	356.07	0.14	0.02	0.01	0.32	0.32	0.11
1.A.3.c.	Railways	Liquid fuels	CO_2	590.6	503.5	5.0	1.5	5.22	0.01	0.00	0.02	-0.01	0.02	0.00
1.A.3.c.	Railways	Solid fuels	CO_2	61.7		5.0	14.0	14.87	0.00	0.00	0.00	-0.01	0.01	0.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO_2	282.9	96.1	15.0	1.5	15.07	0.00	0.00	0.01	0.00	0.01	0.00
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO_2	221.2	1 240.1	15.0	1.5	15.07	0.05	0.00	0.15	0.01	0.15	0.02
1.A.3.e.	Pipeline Transportation	Gaseous fuels	CO_2	40.0	601.8	15.0	1.5	15.07	0.02	0.00	0.07	0.00	0.07	0.01
1.A.4.b.	Residential	Liquid fuels	CO_2	8 733.7	2 517.9	7.1	7.0	9.95	0.06	0.00	0.14	-0.69	0.71	0.50
1.A.4.b.	Residential	Solid fuels	CO_2	14 594.4	21 310.1	14.1	7.0	15.78	0.82	0.68	2.40	-0.48	2.45	5.99
1.A.4.b.	Residential	Gaseous fuels	CO_2	95.6	24 453.2	5.0	7.0	8.60	0.52	0.27	0.97	0.96	1.36	1.86
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CO_2	5 873.1	2 849.4	14.1	7.0	15.78	0.11	0.01	0.32	-0.42	0.53	0.28
1.A.4.c.	Agriculture/Forestry/Fisheries	Solid fuels	CO_2		51.2	0.0	7.0	7.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	CO_2		251.3	7.1	7.0	9.95	0.01	0.00	0.01	0.01	0.02	0.00
1.B.2.a	Oil		CO_2	2.4	3.6	7.0	334.0	334.07	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2.b	Natural Gas		CO_2	0.3	2.8	7.0	334.0	334.07	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2.c	Venting and Flaring		CO_2	217.6	139.1	7.0	334.0	334.07	0.11	0.01	0.01	-0.68	0.68	0.46
1.C.	CO_2 Transport and Storage		CO_2	0.1	0.1	2.0	200.0	200.01	0.00	0.00	0.00	0.00	0.00	0.00

Table A6 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	Emissions in 1990 (kt CO_2 eq.)	Emissions in 2014 (kt CO_2 eq.)	AD Unc. (%)	EF Unc. (%)	A(1) (%)	B(2) (%)	C(3)	D(4) (%)	E(5) (%)	F(6) (%)	G(7) (%)
2.A.1.	Cement Production (Mineral Products)		CO_2	10 520.8	34 070.3	10.0	5.0	11.36	0.95	0.90	2.77	0.28	2.78	7.74
2.A.2.	Lime Production (Mineral Products)		CO_2	3 787.5	4 966.5	25.1	2.0	25.16	0.31	0.09	0.99	-0.04	0.99	0.99
2.A.3.	Glass Production		CO_2	229.7	610.3	15.0	10.0	18.03	0.03	0.00	0.07	0.00	0.07	0.01
2.A.4.	Other process uses of carbonates		CO_2	257.6	2 237.3	10.0	2.0	10.20	0.06	0.00	0.18	0.02	0.18	0.03
2.B.1.	Ammonia Production		CO_2	353.0	736.2	5.0	2.0	5.39	0.01	0.00	0.03	0.00	0.03	0.00
2.B.5.	Carbide production		CO_2	58.1	15.5	10.0	5.0	11.18	0.00	0.00	0.00	0.00	0.00	0.00
2.B.7.	Soda ash production		CO_2		135.4	5.0	5.0	7.07	0.00	0.00	0.01	0.00	0.01	0.00
2.B.8.	Petrochemical and carbon black production		CO_2	821.2	748.8	10.0	10.0	14.14	0.03	0.00	0.06	-0.06	0.09	0.01
2.C.1.	Iron and Steel Production		CO_2	5 304.0	11 819.1	5.0	5.0	7.07	0.21	0.04	0.47	-0.01	0.47	0.22
2.C.2.	Ferroalloys Production		CO_2	81.2	131.8	20.0	20.0	28.28	0.01	0.00	0.02	-0.01	0.02	0.00
2.C.3.	Aluminium Production		CO_2	99.2	54.9	5.0	2.0	5.39	0.00	0.00	0.00	0.00	0.00	0.00
2.C.5.	Lead Production		CO_2	1.9	7.5	30.0	10.0	31.62	0.00	0.00	0.00	0.00	0.00	0.00
2.C.5.	Zinc Production		CO_2	0.3	32.9	10.0	50.0	50.99	0.00	0.00	0.00	0.01	0.01	0.00
2.D.1.	Lubricant Use		CO_2	175.1	385.6	15.0	5.0	15.81	0.01	0.00	0.05	0.00	0.05	0.00
2.D.2.	Paraffin Wax Use		CO_2	1.7	2.7	15.0	5.0	15.81	0.00	0.00	0.00	0.00	0.00	0.00
3.H.	Urea Application		CO_2	459.9	787.7	50.0	3.0	50.09	0.10	0.01	0.31	0.00	0.31	0.10
4.A.	Forest land		CO_2	-28 322.9	-54 458.4	23.5	4.5	23.92	-3.20	10.21	-10.19	0.27	10.20	103.99
4.B.	Cropland		CO_2	-47.6	-131.5	23.5	4.5	23.92	-0.01	0.00	-0.02	0.00	0.02	0.00
4.C.	Grassland		CO_2	84.5	1948.2	23.5	4.5	23.92	0.11	0.01	0.36	0.04	0.37	0.13
4.D.	Wetlands		CO_2	1 741.7		23.5	4.5	23.92	0.00	0.00	0.00	-0.10	0.10	0.01
4.E.	Settlements		CO_2	683.2	570.6	23.5	4.5	23.92	0.03	0.00	0.11	-0.03	0.11	0.01
4.G.	Harvested wood products		CO_2	-4 368.2	-7 809.2	23.5	4.5	23.92	-0.46	0.21	-1.46	0.06	1.46	2.14
5.C.2.	Open burning of waste		CO_2	2.8	0.1	30.4	40.0	50.25	0.00	0.00	0.00	0.00	0.00	0.00
Total	**Total CO_2**			**116 521**	**322 333**	**0.79**				**5.31**				**15.62**

Table A6 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	Emissions in 1990 (kt CO_2 eq.)	Emissions in 2014 (kt CO_2 eq.)	AD Unc. (%)	EF Unc. (%)	A(1) (%)	B(2) (%)	C(3)	D(4) (%)	E(5) (%)	F(6) (%)	G(7) (%)
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	CH_4	1.1	1.6	5.0	100.0	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CH_4	5.3	18.4	5.0	100.0	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CH_4	2.2	20.1	5.0	100.0	100.12	0.00	0.00	0.00	0.01	0.01	0.00
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	CH_4	0.0	0.3	14.1	100.0	100.99	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.a.	Public Electricity and Heat Production	Biomass	CH_4	0.0	2.0	14.1	100.0	100.99	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.b.	Petroleum Refining	Liquid fuels	CH_4	2.7	1.7	5.0	100.0	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.b.	Petroleum Refining	Gaseous fuels	CH_4	0.0	0.9	5.0	100.0	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CH_4	0.2	0.3	2.0	100.0	100.02	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.a.	Iron and Steel Production	Liquid fuels	CH_4	1.8	0.1	11.2	100.0	100.62	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CH_4	0.0	1.3	14.1	100.0	101.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.a.	Iron and Steel Production	Solid fuels	CH_4	0.0	1.6	11.2	100.0	100.62	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CH_4	0.9	0.0	21.2	100.0	102.23	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.b.	Non-Ferrous Metals	Solid fuels	CH_4	0.3	0.2	21.2	100.0	102.23	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	CH_4	0.0	0.4	21.2	100.0	102.23	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.c.	Chemicals	Liquid fuels	CH_4	2.5	0.1	15.8	100.0	101.24	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.c.	Chemicals	Solid fuels	CH_4	2.9	2.5	15.8	100.0	101.24	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.c.	Chemicals	Gaseous fuels	CH_4	0.4	1.4	15.8	100.0	101.24	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.c.	Chemicals	Other fossil fuels	CH_4	0.0	0.1	2.0	100.0	100.02	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.c.	Chemicals	Biomass	CH_4	0.0	0.0	300.0	100.0	316.23	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	CH_4	0.0	0.0	18.0	100.0	101.61	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.d.	Pulp, Paper and Print	Solid fuels	CH_4	0.0	1.1	18.0	100.0	101.61	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	CH_4	0.0	0.5	18.0	100.0	101.61	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.d.	Pulp, Paper and Print	Biomass	CH_4	0.0	0.2	300.0	100.0	316.23	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	CH_4	0.4	0.2	0.0	100.0	100.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	CH_4	5.5	2.9	18.0	100.0	101.61	0.00	0.00	0.00	-0.01	0.01	0.00

Table A6 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	Emissions in 1990 (kt CO_2 eq.)	Emissions in 2014 (kt CO_2 eq.)	AD Unc. (%)	EF Unc. (%)	A[(1)] (%)	B[(2)] (%)	C[(3)]	D[(4)] (%)	E[(5)] (%)	F[(6)] (%)	G[(7)] (%)
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	CH_4	0.0	1.1	14.1	100.0	101.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.e.	Food Processing, Beverages and Tobacco	Biomass	CH_4	0.0	0.0	300.0	100.0	316.23	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.f.	Non metalic minerals	Liquid fuels	CH_4	2.3	8.7	27.8	100.0	103.79	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.f.	Non metalic minerals	Solid fuels	CH_4	13.5	27.0	25.5	100.0	103.20	0.01	0.00	0.01	0.00	0.01	0.00
1.A.2.f.	Non metalic minerals	Gaseous fuels	CH_4	0.0	1.5	29.2	100.0	104.18	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.f.	Non metalic minerals	Other fossil fuels	CH_4	0.0	6.5	2.0	100.0	100.02	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.f.	Non metalic minerals	Biomass	CH_4	0.0	0.0	300.0	100.0	316.23	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.g.	Other Industries	Liquid Fuels	CH_4	7.1	3.1	70.7	100.0	122.47	0.00	0.00	0.00	-0.01	0.01	0.00
1.A.2.g.	Other Industries	Solid Fuels	CH_4	17.8	14.5	70.7	100.0	122.47	0.00	0.00	0.01	-0.01	0.02	0.00
1.A.2.g.	Other Industries	Gaseous Fuels	CH_4	0.3	3.0	70.7	100.0	122.47	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.a.	Domestic Aviation	Jet kerosene	CH_4	0.3	1.3	5.5	80.0	80.19	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b.	Road Transportation	Gasoline	CH_4	75.6	52.1	10.0	250.0	250.20	0.03	0.00	0.00	-0.17	0.17	0.03
1.A.3.b.	Road Transportation	Diesel oil	CH_4	20.9	68.0	10.0	250.0	250.20	0.04	0.00	0.01	0.03	0.03	0.00
1.A.3.b.	Road Transportation	LPG	CH_4	0.0	208.1	10.0	250.0	250.20	0.13	0.02	0.02	0.29	0.29	0.09
1.A.3.b.	Road Transportation	Gaseous fuels	CH_4	0.0	6.5	10.0	250.0	250.20	0.00	0.00	0.00	0.01	0.01	0.00
1.A.3.b.	Road Transportation	Biomass	CH_4	0.0	0.3	10.0	250.0	250.20	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.c.	Railways	Liquid fuels	CH_4	0.8	0.7	5.0	105.0	105.12	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.c.	Railways	Solid fuels	CH_4	0.0	0.0	5.0	135.0	135.09	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH_4	0.6	0.2	15.0	50.0	52.20	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH_4	0.5	3.0	15.0	50.0	52.20	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.e.	Pipeline Transportation	Gaseous fuels	CH_4	0.9	13.5	15.0	1.5	15.07	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.b.	Residential	Liquid fuels	CH_4	22.5	5.2	7.1	100.0	100.25	0.00	0.00	0.00	-0.03	0.03	0.00
1.A.4.b.	Residential	Solid fuels	CH_4	1 022.3	1 595.4	14.1	100.0	101.00	0.40	0.16	0.18	-0.42	0.46	0.21
1.A.4.b.	Residential	Gaseous fuels	CH_4	0.2	53.5	5.0	100.0	100.12	0.01	0.00	0.00	0.03	0.03	0.00
1.A.4.b.	Residential	Biomass	CH_4	2 263.4	978.1	300.0	100.0	316.23	0.76	0.58	2.34	-2.38	3.33	11.11

Table A6 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	Emissions in 1990 (kt CO_2 eq.)	Emissions in 2014 (kt CO_2 eq.)	AD Unc. (%)	EF Unc. (%)	A[(1)] (%)	B[(2)] (%)	C[(3)]	D[(4)] (%)	E[(5)] (%)	F[(6)] (%)	G[(7)] (%)
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CH_4	20.0	9.7	14.1	100.0	101.00	0.00	0.00	0.00	-0.02	0.02	0.00
1.A.4.c.	Agriculture/Forestry/Fisheries	Solid fuels	CH_4	0.0	3.9	0.0	100.0	100.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	CH_4	0.0	0.6	7.1	100.0	100.25	0.00	0.00	0.00	0.00	0.00	0.00
1.B.1.	Coal Mining	Solid fuels	CH_4	2 432.3	5 842.9	16.6	557.0	557.25	7.99	63.79	0.77	0.81	1.12	1.25
1.B.2.a	Oil		CH_4	399.4	250.6	7.0	356.0	356.07	0.22	0.05	0.01	-1.34	1.34	1.79
1.B.2.b	Natural Gas		CH_4	143.7	2 013.0	7.0	356.0	356.07	1.76	3.09	0.11	3.37	3.38	11.40
1.B.2.c	Venting and Flaring		CH_4	127.0	466.8	7.0	356.0	356.07	0.41	0.17	0.03	0.35	0.35	0.12
2.B.8.	Petrochemical and carbon black production		CH_4	28.4	25.1	30.0	10.0	31.62	0.00	0.00	0.01	0.00	0.01	0.00
2.C.1.	Iron and Steel Production		CH_4	16.3	30.2	5.0	5.0	7.07	0.00	0.00	0.00	0.00	0.00	0.00
2.C.2.	Ferroalloys Production		CH_4	0.0	74.7	20.0	20.0	28.28	0.01	0.00	0.01	0.01	0.01	0.00
3.A.	Enteric fermentation		CH_4	24 887.6	27 434.3	14.1	30.0	33.17	2.23	4.98	3.09	-5.01	5.89	34.69
3.B.	Manure management		CH_4	2 352.1	3 178.4	14.1	30.0	33.17	0.26	0.07	0.36	-0.38	0.52	0.27
3.C.	Rice cultivation		CH_4	91.4	191.1	7.1	55	7.09	0.00	0.00	0.01	0.00	0.01	0.00
3.F.	Field burning of agricultural residues		CH_4	249.8	249.7	30.4	10.0	32.02	0.02	0.00	0.06	-0.02	0.06	0.00
4.A.	Forest land		CH_4	0.0	0.0	23.5	1.7	23.56	0.00	0.00	0.00	0.00	0.00	0.00
5.A.1.	Managed waste disposal sites		CH_4	0.0	11 892.7	30.4	32.0	44.16	1.29	1.66	2.88	2.14	3.59	12.90
5.A.2.	Unmanaged waste disposal sites		CH_4	6 729.6	0.0	30.0	41.5	51.23	0.00	0.00	0.00	-3.61	3.61	13.06
5.B.1	Composting		CH_4	11.0	9.4	10.0	20.0	22.38	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2.	Open burning of waste		CH_4	67.3	0.7	30.4	100.0	104.52	0.00	0.00	0.00	-0.09	0.09	0.01
5.D.1.	Domestic wastewater		CH_4	2 579.8	1 879.4	5.0	37.7	38.01	0.18	0.03	0.07	-0.86	0.86	0.74
5.D.2.	Industrial wastewater		CH_4	209.2	475.6	11.2	39.1	40.62	0.05	0.00	0.04	0.00	0.04	0.00
Total	**Total CH_4**			**43 820**	**57 138**					**8.64**				**9.36**
Cumulative	**Cumulative CO_2 and CH_4**			**160 342**	**379 471**					**10.14**				**18.21**

Table A6 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	Emissions in 1990 (kt CO_2 eq.)	Emissions in 2014 (kt CO_2 eq.)	AD Unc. (%)	EF Unc. (%)	A(1) (%)	B(2) (%)	C(3)	D(4) (%)	E(5) (%)	F(6) (%)	G(7) (%)
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	N_2O	2.6	3.9	5.0	100.0	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	N_2O	94.0	329.5	5.0	100.0	100.12	0.08	0.01	0.01	0.06	0.07	0.00
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	N_2O	2.6	24.0	5.0	100.0	100.12	0.01	0.00	0.00	0.01	0.01	0.00
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	N_2O	0.0	0.6	14.1	100.0	101.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.a.	Public Electricity and Heat Production	Biomass	N_2O	0.0	3.0	14.1	100.0	101.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.b.	Petroleum Refining	Liquid fuels	N_2O	6.2	2.9	5.0	100.0	100.12	0.00	0.00	0.00	-0.01	0.01	0.00
1.A.1.b.	Petroleum Refining	Gaseous fuels	N_2O	0.0	1.0	5.0	100.0	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.c.	Manufacture of solid fuels	Solid fuels	N_2O	0.3	0.3	2.0	100.0	100.02	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.a.	Iron and Steel	Liquid fuels	N_2O	4.2	0.3	11.2	100.0	100.62	0.00	0.00	0.00	-0.01	0.01	0.00
1.A.2.a.	Iron and Steel	Solid fuels	N_2O	0.0	6.6	14.1	100.0	101.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.a.	Iron and Steel	Gaseous fuels	N_2O	0.0	1.9	11.2	100.0	100.62	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	N_2O	2.1	0.0	21.2	100.0	102.23	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.b.	Non-Ferrous Metals	Solid fuels	N_2O	0.6	1.2	21.2	100.0	102.23	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	N_2O	0.0	0.5	21.2	100.0	102.23	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.c.	Chemicals	Liquid fuels	N_2O	6.1	0.2	300.0	100.0	316.23	0.00	0.00	0.00	-0.01	0.01	0.00
1.A.2.c.	Chemicals	Solid fuels	N_2O	5.3	6.4	15.8	100.0	101.24	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.c.	Chemicals	Gaseous fuels	N_2O	0.5	1.6	15.8	100.0	101.24	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.c.	Chemicals	Other fossil fuels	N_2O	0.0	0.1	15.8	100.0	101.24	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.c.	Chemicals	Biomass	N_2O	0.0	0.0	2.0	100.0	100.02	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	N_2O	0.0	0.0	300.0	100.0	316.23	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.d.	Pulp, Paper and Print	Solid fuels	N_2O	0.0	2.7	18.0	100.0	101.61	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	N_2O	0.0	0.5	18.0	100.0	101.61	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.d.	Pulp, Paper and Print	Biomass	N_2O	0.0	1.2	18.0	100.0	101.61	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	N_2O	1.0	0.4	300.0	100.0	316.23	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	N_2O	9.9	9.3	5.0	100.0	100.12	0.00	0.00	0.00	-0.01	0.01	0.00
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	N_2O	0.0	1.3	18.0	100.0	101.61	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.e.	Food Processing, Beverages and Tobacco	Biomass	N_2O	0.0	0.0	14.1	100.0	101.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.f.	Non metalic minerals	Liquid fuels	N_2O	5.6	20.8	300.0	100.0	316.23	0.02	0.00	0.05	0.00	0.05	0.00
1.A.2.f.	Non metalic minerals	Solid fuels	N_2O	24.2	48.3	27.8	100.0	103.79	0.01	0.00	0.01	0.00	0.01	0.00
1.A.2.f.	Non metalic minerals	Gaseous fuels	N_2O	0.0	1.8	25.5	100.0	103.20	0.00	0.00	0.00	0.00	0.00	0.00

Table A6 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	Emissions in 1990 (kt CO_2 eq.)	Emissions in 2014 (kt CO_2 eq.)	AD Unc. (%)	EF Unc. (%)	A[1] (%)	B[2] (%)	C[3]	D[4] (%)	E[5] (%)	F[6] (%)	G[7] (%)
1.A.2.f.	Non metalic minerals	Other fossil fuels	N_2O	0.0	10.3	29.2	100.0	104.18	0.00	0.00	0.00	0.01	0.01	0.00
1.A.2.f.	Non metalic minerals	Biomass	N_2O	0.0	0.0	2.0	100.0	100.02	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.g.	Other Industries	Liquid Fuels	N_2O	16.8	7.1	300.0	100.0	316.23	0.01	0.00	0.02	-0.02	0.02	0.00
1.A.2.g.	Other Industries	Solid Fuels	N_2O	32.9	26.2	70.7	100.0	122.47	0.01	0.00	0.01	-0.03	0.03	0.00
1.A.2.g.	Other Industries	Gaseous Fuels	N_2O	0.3	3.6	70.7	100.0	122.47	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.a.	Domestic Aviation	Jet kerosene	N_2O	8.9	41.7	70.7	100.0	122.47	0.01	0.00	0.02	0.01	0.03	0.00
1.A.3.b.	Road Transportation	Gasoline	N_2O	288.2	198.6	5.5	85.0	85.18	0.04	0.00	0.01	-0.22	0.22	0.05
1.A.3.b.	Road Transportation	Diesel oil	N_2O	249.5	810.4	10.0	250.0	250.20	0.50	0.25	0.06	0.33	0.34	0.12
1.A.3.b.	Road Transportation	LPG	N_2O	0.0	8.0	10.0	250.0	250.20	0.00	0.00	0.00	0.01	0.01	0.00
1.A.3.b.	Road Transportation	Gaseous fuels	N_2O	0.0	2.5	10.0	250.0	250.20	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b.	Road Transportation	Biomass	N_2O	0.0	3.7	10.0	250.0	250.20	0.00	0.00	0.00	0.01	0.01	0.00
1.A.3.c.	Railways	Liquid fuels	N_2O	68.4	58.3	5.0	142.0	142.09	0.02	0.00	0.00	-0.08	0.08	0.01
1.A.3.c.	Railways	Solid fuels	N_2O	0.3	0.0	5.0	150.0	150.08	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	N_2O	2.1	0.7	15.0	140.0	140.80	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N_2O	1.8	10.0	15.0	140.0	140.80	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.e.	Pipeline Transportation	Gaseous fuels	N_2O	0.6	12.6	15.0	1.5	15.07	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.b.	Residential	Liquid fuels	N_2O	11.8	1.4	7.1	100.0	100.25	0.00	0.00	0.00	-0.01	0.01	0.00
1.A.4.b.	Residential	Solid fuels	N_2O	60.9	95.1	14.1	100.0	101.00	0.02	0.00	0.01	-0.03	0.03	0.00
1.A.4.b.	Residential	Gaseous fuels	N_2O	0.1	12.8	5.0	100.0	100.12	0.00	0.00	0.00	0.01	0.01	0.00
1.A.4.b.	Residential	Biomass	N_2O	359.7	155.5	300.0	100.0	316.23	0.12	0.01	0.37	-0.38	0.53	0.28
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	N_2O	14.3	6.9	14.1	100.0	101.00	0.00	0.00	0.00	-0.01	0.01	0.00
1.A.4.c.	Agriculture/Forestry/Fisheries	Solid fuels	N_2O	0.0	0.2	0.0	100.0	100.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	N_2O	0.0	0.1	7.1	100.0	100.25	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2.c.	Venting		N_2O	0.9	0.6	7.0	356.0	356.07	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2.c.	Flaring		N_2O	0.0	0.0	7.0	356.0	356.07	0.00	0.00	0.00	0.00	0.00	0.00
2.B.2.	Nitric acid production		N_2O	695.7	1808.1	2.0	20.0	18.03	0.08	0.01	0.03	0.02	0.04	0.00
3.B.	Manure management		N_2O	1 584.8	2 513.5	14.1	50.0	51.96	0.32	0.10	0.28	-0.32	0.42	0.18
3.D.	Agricultural soils		N_2O	11 524.0	15 089.9	14.1	135.0	135.74	5.02	25.24	1.70	-8.64	8.81	77.55
3.F.	Field burning of agricultural residues		N_2O	77.2	77.2	30.4	10.0	32.02	0.01	0.00	0.02	-0.01	0.02	0.00
4.A.	Forest land		N_2O	0.0	0.0	23.5	0.9	23.52	0.00	0.00	0.00	0.00	0.00	0.00
5.B.1.	Composting		N_2O	9.8	8.4	10.0	20.0	22.38	0.00	0.00	0.00	0.00	0.00	0.00

Table A6 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	Emissions in 1990 (kt CO_2 eq.)	Emissions in 2014 (kt CO_2 eq.)	AD Unc. (%)	EF Unc. (%)	A(1) (%)	B(2) (%)	C(3)	D(4) (%)	E(5) (%)	F(6) (%)	G(7) (%)
5.C.2.	Open burning of waste		N_2O	10.8	0.1	30.4	100.0	104.52	0.00	0.00	0.00	-0.01	0.01	0.00
5.D.1.	Domestic wastewater		N_2O	1 324.6	1 848.0	30.0	42.4	51.97	0.24	0.06	0.44	-0.29	0.53	0.28
	Total N_2O			**16 510**	**23 283**					**5.07**				**8.86**
	Cumulative CO_2 , CH_4, N2O			**176 851**	**402 754**					**11.33**				**20.25**
2.F.	Product uses as substitutes for ODS		HFCs		4916.6	25.0	5.0	25.50	0.31	0.10	0.97	0.14	0.98	0.96
2.C.3.	Aluminium production		PFCs	692.8		25.0	5.0	25.50	0.00	0.00	0.00	-0.04	0.04	0.00
	Cumulative CO_2, CH_4, N_2O, HFCs, PFCs			**177 544**	**407 670**					**0.31**				**0.98**
Total all gases				**177 544**	**407 670**	**Overall uncertainty in emissions**				**11.34**	**Trend uncertainty**			**20.27**

(1) Combined Uncertainty
(2) Combined Uncertainty as % of Emissions in 2014
(3) Combined Emissions Uncertainty Squared
(4) Uncertainty in Trend in Total Emissions due to AD
(5) Uncertainty in Trend in Total Emissions due to EF
(6) Combined Uncertainty in Trend in Total Emissions
(7) Combined Trend Uncertainty Squared

Annex 3: Country Specific Carbon Emission Factor Calculation

In Turkey we do not have ETS registry yet. Therefore in order to calculate country specific EFs, we lean on data obtained from a number of plants that carry out fuel analysis on voluntarily basis. Publicly owned power plants mostly conduct coal/lignite analyses. BOTAŞ which is responsible authority for the pipeline transmission of petroleum and natural gas and some public university laboratories carry out gas chromatography and liquid fuel concentration analysis. Those analyses are the basis of country specific Carbon contents.

To explain how country specific EFs are calculated, we first have a look at how its multipliers are calculated separately.

Natural gas;

In order for carbon content of natural gas to be calculated, densities of gases included in it must be known to convert volumetric compositions to mass fractions.

Gas	Formula	M_i [g/mol]	$\rho^{*)}$ [kg/m^3]
Hydrogen	H_2	2	0.089
Carbon dioxide	CO_2	44	1.963
Carbon monoxide	CO	28	1.249
Methane	CH_4	16	0.714
Ethane	C_2H_6	30	1.339
Propane	C_3H_8	44	1.963
Butane	C_4H_{10}	58	2.588
Ethylene	C_2H_4	28	1.249
Propene	C_3H_6	42	1.874
Acetylene	C_2H_2	26	1.160
Nitrogen	N_2	32	1.428
Oxygen	O_2	28	1.249

Source: *"Emissions of Carbon Dioxide of Gaseous Fuels Calculated From Their Composition"*, František KOLÁŘ F., FOTT P., and SVÍTILOVÁ J., December 2003.

Annual weighted averages of gas chromatography analysis (averages of all gas pipelines) for gas compositon and net calorific values for 1990-2014 periods are provided by BOTAŞ. 2014 gas compositions and calculation of mass of Carbon in the gas is given in the below table.

Gas composition			Densities (1) (kg/m³)	Mass (kg)	C/Mol ratio	Mass of C (kg)
A	B	% C	D	E=C*D	F	G= E*F
CH_4	**Methane**	94.719	0.714	0.6762953	0.75	0.507221
C_2H_6	**Ethane**	2.779	1.339	0.0372135	0.80	0.029771
C_3H_8	**Propane**	0.717	1.963	0.0140685	0.82	0.011511
C_4H_{10}	**i-Butane**	0.113	2.588	0.0029208	0.83	0.002417
C_4H_{10}	**n-Butane**	0.113	2.588	0.0029208	0.83	0.002417
C_5H_{12}	**i-Pentane**	0.034	2.626	0.0008934	0.83	0.000744
C_5H_{12}	**n-Pentane**	0.034	2.626	0.0008934	0.83	0.000744
CO_2	**Carbondioxide**	0.167	1.963	0.0032804	0.27	0.000895
					TOTAL	0.555721

(1) For 1A1a category, literature densities of each gas in the natural gas is used however, for other 1A categories average natural gas density provided by BOTAŞ is used for all gas type listed in the table.

Total carbon mass in 1 cubic meter of natural gas is 0.555721 kg. The mass of total carbon is divided by average net calorific values of natural gas and the result is the carbon content of natural gas as kg C/GJ of gas.

An example for calculation of natural gas oxidation rate

Bursa Natural Gas Combined Heat Power Plant (2014)		
Annual stack gas average CO concentration	8.1325	**mg/Nm³**
Annual working hours	44 882	**hours**
Stack gas flow	1 730 000	**Nm³/h**
Annual CO outlet (total)	631 454 956 450	**mg CO**
	631 454.9565	**kg CO**
C amount in CO (1) **C/CO= 12/28**	270 623.5528	**kg C**
Annual natural gas consumption amount	1 716 715 672	**Sm³**
C amount in 1 Sm³ natural gas	0.539963397	**kg C**
C amount in anually burnt natural gas (2)	926 963 625.8	**kg C**
Oxidation rate (2-1)/(2)*100	**99.9708054**	

Oxidation rate of natural gas is calculated based on power plants data. Assuming the combustion technology in the power plants is not the same in other 1A sectors, country specific oxidation rates of natural gas are used only 1A1a sector. Other 1A sectors it is used as 1 as provided in the 2006 IPCC guidelines.

Turkey Lignite;

An example for calculation of carbon content of Turkey Lignite

Coal analyses are received from coal fired power plants. An example of analysis report is given below. In the analysis report Carbon content together with, Hydrogen, Sulphur, Oxygen moisture, ash, volatile substances contents are measured. Also net and gross calorific values are provided in the same reports. Carbon contents and net calorific values (circulated figures in the below analysis report) are used for calculating carbon content of Turkey lignite.

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YAZININ TARİH VE SAYISI : 12.11.2012 / 3551
NUMUNENİN GELİŞ TARİHİ : 16.11.2012
ANALİZİN YAPILIŞ TARİHİ : 19.11.2012 - 06.12.2012

KÖMÜR ANALİZ RAPORU

RAPOR TARİHİ: 10.12.2012
RAPOR NO: YAK 12-095

NUMUNENİN ADI / GELİŞ NOKTASI		(GELEN KÖMÜR) 12/278 A				(YANAN KÖMÜR) 12/278 B							
NUMUNENİN ALINDIĞI TARİH													
ANALİZLER	STANDART METOD NO	ORJİNAL KÖMÜR	HAVADA KURU KÖMÜR	KURU KÖMÜR	KURU KÜLSÜZ KÖMÜR	ORJİNAL KÖMÜR	HAVADA KURU KÖMÜR	KURU KÖMÜR	KURU KÜLSÜZ KÖMÜR	ORJİNAL KÖMÜR	HAVADA KURU KÖMÜR	KURU KÖMÜR	KURU KÜLSÜZ KÖMÜR
HAVADA KURUTMA KAYBI (%)	ASTM D 2013 TS 4744	25,45				23,99							
ENDÜSTRİYEL ANALİZ (%) * Ortam Sıcaklığı/Nem : 24 °C % 58													
NEM *	ASTM D 7582	31,15	7,64	0	0	31,76	7,8	0	0	0,00		0	0
KÜL *		31,48	42,23	45,7	0	29,33	39,63	43,0	0	0,00		0,0	0
UÇUCU MADDE *		24,86	33,35	36,1	66,51	24,63	33,28	36,1	63,31	0,00		0,0	0,00
SABİT KARBON		12,52	16,79	18,2	33,49	14,28	19,29	20,9	36,69	100,00	100	100,0	100,00
TOPLAM		100	100	100	100	100	100	100	100	100	100	100	100
ISIL DEĞER(cal/gr) * Ortam Sıcaklığı/Nem : 21 °C % 24	ASTM D 5865												
ÜST ISIL DEĞER *		2333	3130	3389	6243	[illegible]	3315	3595	6306	0		0	0
ALT ISIL DEĞER *		2042	2934	3224	5940	2155	3112	3424	6005	0	0	0	0
ELEMENTEL ANALİZ(%) Ortam Sıcaklığı/Nem : 21,8 °C % 20	ASTM D 5373												
NEM	ASTM D 7582	31,15	7,64	0	0	31,76	7,8	0	0	0,00	0	0	0
KÜL		31,48	42,225	45,72	0	[illegible]	39,63	42,98	0	0,00	0	0,00	0
KARBON *	ASTM D 5373	24,83	33,3	36,05	66,42	25,98	35,1	38,07	66,77	0,00		0,00	0,00
HİDROJEN *		2,20	2,95	3,19	5,88	[illegible]	3,07	3,33	5,84	0,00		0,00	0,00
KÜKÜRT (yanabilir)	ASTM D 5016	0,54	0,73	0,79	1,46	0,53	0,72	0,78	1,37	0,00	0	0,00	0,00
AZOT *	ASTM D 5373	0,35	0,47	0,51	0,94	0,35	0,47	0,51	0,89	0,00		0,00	0,00
OKSİJEN	ASTM D 121	9,46	12,685	13,73	25,30	9,78	13,21	14,33	25,13	100,00	100	100,00	100,00
TOPLAM		100	100	100	100	100	100	100	100	100	100	100	100
KÜKÜRT ŞEKİLLERİ(%) Ortam Sıcaklığı/Nem : 26 °C % 18													
TOPLAM KÜKÜRT *	ASTM D 4239	1,42	1,91	2,07		1,49	2,01	2,18		0,00		0,00	
KÜLDEKİ KÜKÜRT (kömür bazında)	ASTM D 5016	0,88	1,18	1,28		0,95	1,29	1,40		0,00		0,00	
HARDGROVE ÖĞÜTÜLEBİLİRLİK İNDEKSİ	D 409		53,5				80						
KÜL ERGİME DEĞERLERİ (°C) Ortam Sıcaklığı/Nem : 24,5 °C % 19	ASTM D 1857	İLK DEFORMASYON	YUMUŞAMA	ERİME	AKMA	İLK DEFORMASYON	YUMUŞAMA	ERİME	AKMA	İLK DEFORMASYON	YUMUŞAMA	ERİME	AKMA
İNDİRGEN ATM. *													
YÜKSELTGEN ATM. *		1180	1205	1265	1330	1210	1225	1255	1340				

Read from the analysis report:
NCV: 2 155 kcal/kg= 0.009 Gj/kg => 1 kg lignite gives a heat of 0.009 Gj
C (m/m) %= 25.98 => 1 kg Turkey lignite includes 0.2598 kg of C(1)
C content= 0.2598 kg C/0.009 Gj=28.73kgC/Gj
Ash (m/m) %= 29.33 => 1 kg lignite gives an ash-slag amount of 0.2933 kg

An example for calculation of oxidation Rate of Turkey Lignite

Oxidation rates of lignite are calculated by using ash/slag analysis of power plants. Unburned carbon in ash and slag is measured by the power plants operators. An example of ash/slag analysis report is given below.

E.Ü.A.Ş
TERMİK SANTRALLAR DAİRE BAŞKANLIĞI
TEKNİK KONTROL ve LABORATUVARLAR İŞLETME MÜDÜRLÜĞÜ

YAKIT LABORATUVARI ANALİZ RAPORU

NUMUNENİN GELDİĞİ YER : Orhaneli Termik Santralı İşletme Müdürlüğü
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RAPOR TARİHİ 10.12.2012
RAPOR NO YAK 12-095

YAZININ TARİH VE SAYISI : 12.11.2012 / 3557

TOPLAM YANMAMIŞ KARBON ANALİZİ (% AĞIRLIK) ASTM 6316 (ASTM D-5373)	NUMUNENİN ADI	
	CURUF (13/278 C)	KÜL (12/278 D)
	2,64	2,05

DENEYİ YAPAN	RAPOR VEREN		KONTROL EDEN	ONAY
Sezai ALPTEKİN Kimya Baştekniisyeni	Kudbay BOZCAN Kimyager	Gülen YAKIN Teknik Şef	Rıfkı ODABAŞI İşl.Md. Yrd.(Teknik)	Şükrü DEMİR İşletme Müdürü

Read from the ash-slag report:
Unburnt C in ash, %: 2.05
Unburnt C in slag, %: 2.64
According to expert judgement from the specialists of EÜAŞ (Electricity Generation Company), ash content of original lignite is divided into ash and slag with a ratio of 8/2 at the disposal.
0.23464 kg of ash and 0.0586 kg of slag come out from 1 kg of Turkey lignite.
Unburnt C in ash, %: 2.05=> 0.0048102 kg C
Unburnt C in slag, %: 2.64=> 0.00155 kg C
Unburnt C amount= 0.00636012 kg C(2)
Unburnt C rate= 0.00636012/0.2598=0.02448
Oxidation rate 1- ((2)/(1))=1-0.02448=%97.5

Country specific carbon content and oxidation rates of lignite calculated based on power plants coal analysis are used for all 1A categories.

Hard coal;

Carbon contents and ozidation rates of hard coal is calculated in the same way as in Turkey Lignite. Country specific carbon content and oxidation rates of hard coal calculated based on power plants coal analysis are used for all 1A categories.

Coke oven coke;

Country specific Carbon content of coke oven coke is calculated based on carbon content and net calorific values provided by the integrated iron&steel facilities in Turkey. There are 3 integreated iron&steel facilities in Turkey and there are coke production plants in all of them. Carbon contents of all carbonaceous material used for iron and steel production is measured by all the facilities. Carbon content of coke oven coke is also measured since it is used as reducing agent in pig iron production. Annual average carbon content of coke oven coke as kg C/ton of coke and net calorific values are compiled from integrated facilities. The mass of carbon is divided by net calorific values of coke oven coke and the result is the carbon content as kg C/GJ of coke. Calculated country specific carbon content is used for estimation of CO_2 emissions from coke combustion of all other sectors using coke as a fuel.

Gas/diesel oil and Residual fuel oil;

Carbon content of gas/diesel oil and residual fuel oil is calculated based on fuel analysis made by Petroleum Research Centre at Middle East Technical University (METU) in Ankara. The Research Center was founded by METU Petroleum Engineering Department and General Directorate of Petroleum Affairs (under the Ministry of Energy and Natural Resources). The main objective of the Center is to make research on the oil and gas exploration and production, refining and transportation and to conduct projects on topics requested by public and private organizations.

Based on the fuel analysis of Petroleum Research Center, an example for calculation of carbon content of gas diesel oil and residual fuel oil is given below.

Sample A	Number of Sample B	C, normalized (%) C	NCV kcal/kg (avarage) D	NCV GJ/kg (avarage) E	C mass/kg fuel F (C/100)	C content kg C/GJ G (F/E)
Diesel	639/06-1106	86.261	10233	0.0428435	0.86261	20.133975
Fuel Oil	255/06-330	86.611	9901	0,0414535	0.86611	20.893530

Source:METU, Petroleum Research Laboratory, 2006.

An example for oxidation rate for gas diesel oil and residual fuel oil;

Oxidation rate of gas/diesel oil and residual fuel oil is calculated based on stack gas analysis of oil fired power plants. In stack gas analysis, CO percentage in stack gas is measured. Based on the inlet carbon already provided in fuel analysis report and outlet C derived from stack gas analysis, oxidation rates are calculated. An example calculation is given below.

		Fuel oil density (kg/m3)	0.9757
CO (average v/v %)	3.25	**C inlet (m/m) %**	86.611
C (outlet v/v %) (*12/28)	1.39	**C inlet (v/v) %**	88.768

Oxidation rate, %: ((C inlet - C outlet)/C inlet)*100 = 98.43

Petroleum coke;

Petroleum coke is used in mostly in cement factories. There are around 50 cement factories in Turkey. Availability of fuel analysis report is asked to the factories via official letters. Net calorific values are available in most of the factories but a few of them has carbon content analysis. Averages of all available data are used as country specific carbon content of petroleum coke.

Annex 4: National Energy Balance Sheets

Annex 4: National Energy Balance Sheets

Table A4.1 National energy balance table, 2014 (original mass unit)

Energy Resources Energy Supply/Demand Balance	Hard Coal (kt)	Lignite (kt)	Asphaltite (kt)	Coke (kt)	Petrocoke (kt)	Wood (kt)	Animal and Veg. Waste (kt)	Oil (kt)	Natural Gas ($10^6 Sm^3$)	Hydro power (GWh)	Bio fuel (kt)	Wind (GWh)	Electricity (GWh)	Geo thermal Heat (ktoe)	Solar (Ktoe)
Domestic Production (+)	1833	62572.754	842.814			7206	4577	2354	502	40645	91.15	8520		3523.93944	803
Import (+)	29816			352	4074			36785	49262				7805		
Export (-)	64			5				5293	633				2696		
Bunkers (-)								4027	0						
Stock Changes (+/-)	-121	2082.643	-71.781		-233			240	-380		-3.795				
Statistical Differences (+/-) (%)	1.1%	1.5%	0.1%	0.0%	1.3%	0.0%	0.0%	-5.3%	1.1%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%
Primary Energy Supply	31464	64655.397	771.033	347	3841	7206	4577	30059	48751	40645	87.355	8520	5109	3523.93944	803
Transformation Sector	-20408.954	-57461	-457.8	4388	0	0	-245	-2854	-26849.87	-40645	0	-8520	202304.7	-2033	0
Electricity Plants	-14044.2	-57411	-457.8				-245	-874	-25426	-40645		-8520	251963	-2033	
Coking Plants	-5721.754			4388											
Petrochemical Feedstock								-1193							
Petroleum Refinery								-787	-1180.97				-1009.1		
Own Use and Loses	-643	-50							-242.9				-48649.2		
Total Final Energy Consumption	11055.046	7194.397	313.233	4735	3841	7206	4332	27205	21901.13	0	87.355	0	207413.7	1490.93944	803
Sectors Total	10937	7087	313	4735	3790	7206	4332	28649	21660.44	0	87	0	207376.25	1490.89944	803
Industry Consumption	5304	4077	156.75	4647	3790	0	0	947	8691.1	0	0	0	99990.8	0	280
Food and Tobacco	75	341			6			12	636.02				5973		
Sugar	5	66		48				19	221.56				630		
Textile and Leather	51	682						2	734				15621		
Paper, Pulp and Printing	44	165						5	231				5377		
Ceramic	58	227			44			8	799.98				876.75		
Glass and Glass Products	0	0						3	700.12				715.05		
Chemical and Petrochemical	104	382						4	521.65				10722		
Fertilizer	0	0						0	634				252		
Cement	2791	1687			3540			25	101.36				10603		
Iron and Steel	942	0		4360				14	1368				20684		
Non-Ferrous Metals	8	0		8				2	487				2417		
Motor Vehicle Industry	1	7						4	194.9				5963		
Other Industry	1225	520	156.75	231	200			849	2061.51				20157		280
Transport	0	0	0	0	0	0	0	22705	459.49	0	87	0	917.32	0	0
Rail								157					237.32		
Domestic Navigation								417							
Domestic Aviation								1284							
Pipeline Transportation									376.49				250		
Road								20847	83		87		430		
Other Sectors	5633	3010	156.25	88	0	7206	4332	1735	12509.85	0	0	0	106468.13	1490.89944	523
Residential, Commercial and Public Service	5616	3007	156.25	88		7206	4332	841	12382				101306.72	1081.82496	523
Agriculture	17	3						894	127.85				5161.41	409.07448	
Non-Energy								3262					0		
Electricity Generation (GWh)	38693.1	36615.4	954.2				1432.6	2145.3	120576	40645		8520	251963	2364	17.4
Electricity Installed Capacity (MW)	6398	8281	135				299	1057.64	25631.211	23643		3630	69519.851	405	40

2 National energy balance table, 2014
(ktoe)

Energy Resources **Energy Supply/Demand** **Balance**	**Hard Coal**	**Lignite**	**Asphaltite**	**Coke**	**Petrocoke**	**Wood**	**Animal and Veg. Waste**	**Oil**	**Natural Gas**	**Hydro power**	**Biofuel**	**Wind**	**Electricity**	**Geo thermal Heat**	**Solar**
Domestic Production (+)	1118.13	14829.7427	410.871825			2161.8	1006.94	2471	414.15	3495.47	80.66775	732.72		3523.93944	803
Import (+)	19201.504			237.2128	3100.314			38524	40641.15				671.23		
Export (-)	38.08			3.329				4539	522.225				231.856		
Bunkers (-)								4262	0						
Stock Changes (+/-)	-62.0004	466.512032	-34.9932375		-177.313			234	-313.5		-3.358575				
Statistical Differences (+/-)	0.012278302	0.01234883	0.000743855	0.000828481	0.013277792	0	1.19289E-16	-0.01564413	0.010989844	0	0.004063877	0	0.003459029	2.68287E-05	0
Primary Energy Supply	**20219.5536**	**15296.2547**	**375.878588**	**233.8838**	**2923.001**	**2161.8**	**1006.94**	**32428**	**40219.575**	**3495.47**	**77.309175**	**732.72**	**439.374**	**3523.93944**	**803**
Transformation Sector	**-13174.1339**	**-12237.493**	**-223.1775**	**2921.5304**	**0**	**0**	**-53.9**	**-3024**	**-22151.1428**	**-3495.47**	**0**	**-732.72**	**17398.2042**	**-2033**	**0**
Electricity Plants	-8651.2272	-12228.543	-223.1775				-53.9	-837	-20976.45	-3495.47		-732.72	21668.818	-2033	
Coking Plants	-4163.14821			2921.5304											
Petrochemical Feedstock								-1282							
Petroleum Refinery								-905	-974.30025				-86.7826		
Own Use and Loses	-359.7585	-8.95							-200.3925				-4183.8312		
Total Final Energy Consumpt	**7045.41969**	**3058.76173**	**152.701088**	**3155.4142**	**2923.001**	**2161.8**	**953.04**	**29404**	**18068.4323**	**0**	**77.309175**	**0**	**17837.5782**	**1490.93944**	**803**
Sectors Total	**6958.9139**	**3020.9896**	**152.5875**	**3152.8**	**2884.19**	**2161.8**	**953.04**	**29864**	**17869.863**	**0**	**76.995**	**0**	**17775.8775**	**1490.89944**	**803**
Industry Consumption	**3298.0272**	**1726.6095**	**76.415625**	**3091.2**	**2884.19**	**0**	**0**	**986**	**7170.1575**	**0**	**0**	**0**	**8599.2088**	**0**	**280**
Food and Tobacco	46.635	144.4135			4.566			12	524.7165				513.678		
Sugar	3.109	27.951		33.6				18	182.787				54.18		
Textile and Leather	31.7118	288.827						2	605.55				1343.406		
Paper, Pulp and Printing	27.3592	69.8775			0			5	190.575				462.422		
Ceramic	36.0644	96.1345			33.484			7	659.9835				75.4005		
Glass and Glass Products	0	0						3	577.599				61.4943		
Chemical and Petrochemical	64.6672	161.777						4	430.36125				922.092		
Fertilizer	0	0						0	523.05				21.672		
Cement	1735.4438	714.4445			2693.94			25	83.622				911.858		
Iron and Steel	585.7356	0		3052				15	1128.6				1778.824		
Non-Ferrous Metals	4.9744	0		5.6				3	401.775				207.862		
Motor Vehicle Industry	0.6218	2.9645						4	160.7925				512.818		
Other Industry	761.705	220.22	76.415625		152.2			888	1700.74575				1733.502		280
Transport	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**23875**	**379.07925**	**0**	**76.995**	**0**	**20.40952**	**0**	**0**
Rail								163	0				20.40952		
Domestic Navigation								432	0						
Domestic Aviation								1367	0						
Pipeline Transportation									310.60425						
Road								21913	68.475		76.995				
Other Sectors	**3660.8867**	**1294.3801**	**76.171875**	**61.6**	**0**	**2161.8**	**953.04**	**1872**	**10320.6263**	**0**	**0**	**0**	**9156.25918**	**1490.89944**	**523**
Residential, Commercial and Pub	3649.8384	1293.01	76.171875	61.6		2161.8	953.04	947	10215.15				8712.37792	1081.82496	523
Agriculture	11.0483	1.3701						925	105.47625				443.88126	409.07448	
Non-Energy								**3131**	**0**						

Energy balance sheets for 1972-2013 are available on the MENR website (http://www.eigm.gov.tr/en-US/Balance-Sheets?page=1).

Annex 5: Completeness

Table A7 Completeness

GHG	Sector	Source/sink category
CO_2	Agriculture	3.G Liming/3.G.1 Limestone $CaCO_3$
CO_2	Agriculture	3.G Liming/3.G.2 Dolomite $CaMg(CO_3)2$
CO_2	Agriculture	3.I Other Carbon-containing Fertilizers
CO_2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.1 Underground Mines/1.B.1.a.1.i Mining Activities
CO_2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.1 Underground Mines/1.B.1.a.1.ii Post-Mining Activities
CO_2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.1 Underground Mines/1.B.1.a.1.iii Abandoned Underground Mines
CO_2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.2 Surface Mines/1.B.1.a.2.i Mining Activities
CO_2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.2 Surface Mines/1.B.1.a.2.ii Post-Mining Activities
CO_2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.b Solid Fuel Transformation
CO_2	Energy	1.C CO_2 Transport and Storage/Injection and Storage/Injection
CO_2	LULUCF	4.F Other Land 4.F Other Land/4(V) Biomass Burning
CO_2	LULUCF	4.B Cropland/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Mineral Soils/Rewetted Mineral Soils
CO_2	LULUCF	4.B Cropland/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Organic Soils/Drained Organic Soils
CO_2	LULUCF	4.B Cropland/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Organic Soils/Rewetted Organic Soils
CO_2	LULUCF	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Controlled Burning
CO_2	LULUCF	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Wildfires
CO_2	LULUCF	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Controlled Burning
CO_2	LULUCF	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Wildfires
CO_2	LULUCF	4.C Grassland/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Organic Soils/Drained Organic Soils
CO_2	LULUCF	4.C Grassland/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Organic Soils/Rewetted Organic Soils
CO_2	LULUCF	4.C Grassland/4.C.1 Grassland Remaining Grassland/4(V) Biomass Burning/Controlled Burning
CO_2	LULUCF	4.C Grassland/4.C.1 Grassland Remaining Grassland/4(V) Biomass Burning/Wildfires
CO_2	LULUCF	4.C Grassland/4.C.2 Land Converted to Grassland/4(V) Biomass Burning/Wildfires

Table A7 Completeness (cont'd)

GHG	Sector	Source/sink category
CO_2	LULUCF	4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Peat Extraction Lands/Total Mineral Soils/Rewetted Mineral Soils
CO_2	LULUCF	4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Peat Extraction Lands/Total Organic Soils/Drained Organic Soils
CO_2	LULUCF	4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Peat Extraction Lands/Total Organic Soils/Rewetted Organic Soils
CO_2	LULUCF	4.G Harvested Wood Products/Approach A/Information Item/HWP in SWDS
CO_2	LULUCF	4.G Harvested Wood Products/Approach A/Total HWP Consumed Domestically/Other
CO_2	LULUCF	4.G Harvested Wood Products/Approach A/Total HWP Consumed Domestically/Paper and Paperboard
CO_2	LULUCF	4.H Other
CH_4	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.1 Underground Mines/1.B.1.a.1.iii Abandoned Underground Mines
CH_4	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.b Solid Fuel Transformation
CH_4	LULUCF	4.F Other Land 4.F Other Land/4(V) Biomass Burning
CH_4	LULUCF	4.B Cropland/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Mineral Soils/Rewetted Mineral Soils
CH_4	LULUCF	4.B Cropland/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Organic Soils/Drained Organic Soils
CH_4	LULUCF	4.B Cropland/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Organic Soils/Rewetted Organic Soils
CH_4	LULUCF	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Controlled Burning
CH_4	LULUCF	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Wildfires
CH_4	LULUCF	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Controlled Burning
CH_4	LULUCF	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Wildfires
CH_4	LULUCF	4.C Grassland/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Organic Soils/Drained Organic Soils
CH_4	LULUCF	4.C Grassland/4.C.1 Grassland Remaining Grassland/4(V) Biomass Burning/Controlled Burning
CH_4	LULUCF	4.C Grassland/4.C.1 Grassland Remaining Grassland/4(V) Biomass Burning/Wildfires
CH_4	LULUCF	4.C Grassland/4.C.2 Land Converted to Grassland/4(V) Biomass Burning/Wildfires
CH_4	LULUCF	4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Peat Extraction Lands/Total Mineral Soils/Rewetted Mineral Soils
CH_4	LULUCF	4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Peat Extraction Lands/Total Organic Soils/Drained Organic Soils
CH_4	LULUCF	4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Peat Extraction Lands/Total Organic Soils/Rewetted Organic Soils
CH_4	LULUCF	4.H Other
N_2O	Agriculture	3.D Agricultural Soils/3.D.1 Direct N_2O Emissions From Managed Soils/3.D.1.2 Organic N Fertilizers/3.D.1.2.b Sewage Sludge Applied to Soils

Table A7 Completeness (cont'd)

GHG	Sector	Source/sink category
N_2O	Agriculture	3.D Agricultural Soils/3.D.1 Direct N_2O Emissions From Managed Soils/3.D.1.6 Cultivation of Organic Soils
N_2O	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling
N_2O	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.b Solid Fuel Transformation
N_2O	IPPU	2.G Other Product Manufacture and Use/2.G.3 N_2O from Product Uses/2.G.3.a Medical Applications
N_2O	LULUCF	4.F Other Land 4.F Other Land/4(III) Direct N_2O Emissions from N Mineralization/Immobilization
N_2O	LULUCF	4.F Other Land 4.F Other Land/4(V) Biomass Burning
N_2O	LULUCF	4(IV) Indirect N_2O Emissions from Managed Soils/Atmospheric Deposition
N_2O	LULUCF	4(IV) Indirect N_2O Emissions from Managed Soils/Nitrogen Leaching and Run-off
N_2O	LULUCF	4.A Forest Land/4.A.1 Forest Land Remaining Forest Land/4(I) Direct N_2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers
N_2O	LULUCF	4.A Forest Land/4.A.1 Forest Land Remaining Forest Land/4(I) Direct N_2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers
N_2O	LULUCF	4.A Forest Land/4.A.1 Forest Land Remaining Forest Land/4(III) Direct N_2O Emissions from N Mineralization/Immobilization 4.A Forest Land
N_2O	LULUCF	4.A Forest Land/4.A.2 Land Converted to Forest Land/4(I) Direct N_2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers
N_2O	LULUCF	4.A Forest Land/4.A.2 Land Converted to Forest Land/4(I) Direct N_2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers
N_2O	LULUCF	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Controlled Burning
N_2O	LULUCF	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Wildfires
N_2O	LULUCF	4.B Cropland/4.B.2 Land Converted to Cropland/4(III) Direct N2O Emissions from N Mineralization/Immobilization/4.B.2.2 Grassland converted to cropland
N_2O	LULUCF	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Controlled Burning
N_2O	LULUCF	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Wildfires
N_2O	LULUCF	4.C Grassland/4.C.1 Grassland Remaining Grassland/4(III) Direct N_2O Emissions from N Mineralization/Immobilization 4.C Grassland
N_2O	LULUCF	4.C Grassland/4.C.1 Grassland Remaining Grassland/4(V) Biomass Burning/Controlled Burning
N_2O	LULUCF	4.C Grassland/4.C.1 Grassland Remaining Grassland/4(V) Biomass Burning/Wildfires
N_2O	LULUCF	4.C Grassland/4.C.2 Land Converted to Grassland/4(V) Biomass Burning/Wildfires
N_2O	LULUCF	4.D Wetlands 4.D Wetlands/4.D.1 Wetlands Remaining Wetlands/4(III) Direct N_2O Emissions from N Mineralization/Immobilization
N_2O	LULUCF	4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Peat Extraction Lands/Total Mineral Soils/Rewetted Mineral Soils
N_2O	LULUCF	4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Peat Extraction Lands/Total Organic Soils/Drained Organic Soils
N_2O	LULUCF	4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Peat Extraction Lands/Total Organic Soils/Rewetted Organic Soils

Table A7 Completeness (cont'd)

GHG	Sector	Source/sink category
N_2O	LULUCF	4.D Wetlands/4.D.1 Wetlands Remaining Wetlands/4(I) Direct N_2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers
N_2O	LULUCF	4.D Wetlands/4.D.1 Wetlands Remaining Wetlands/4(I) Direct N_2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers
N_2O	LULUCF	4.D Wetlands/4.D.2 Land Converted to Wetlands/4(I) Direct N_2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers
N_2O	LULUCF	4.D Wetlands/4.D.2 Land Converted to Wetlands/4(I) Direct N_2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers
N_2O	LULUCF	4.D Wetlands/4.D.2 Land Converted to Wetlands/4(III) Direct N_2O Emissions from N Mineralization/Immobilization 4.D Wetlands
N_2O	LULUCF	4.E Settlements/4.E.1 Settlements Remaining Settlements/4(I) Direct N_2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers
N_2O	LULUCF	4.E Settlements/4.E.1 Settlements Remaining Settlements/4(I) Direct N_2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers
N_2O	LULUCF	4.E Settlements/4.E.1 Settlements Remaining Settlements/4(III) Direct N_2O Emissions from N Mineralization/Immobilization 4.E Settlements
N_2O	LULUCF	4.E Settlements/4.E.2 Land Converted to Settlements/4(I) Direct N_2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers
N_2O	LULUCF	4.E Settlements/4.E.2 Land Converted to Settlements/4(I) Direct N_2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers
N_2O	LULUCF	4.H Other
SF_6	IPPU	2.G Other Product Manufacture and Use/2.G.1 Electrical Equipment/SF6

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