NATIONAL GREENHOUSE GAS INVENTORY REPORT 1990-2015

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

TURKISH STATISTICAL INSTITUTE

TÜRKİYE İSTATİSTİK KURUMU

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EXECUTIVE SUMMARY

ES.1 Background Information on Greenhouse Gas Inventories

The United Nations Framework Convention on Climate Change (UNFCCC) is an international treaty established in 1992 to cooperatively address climate change issues. The ultimate objective of the UNFCCC is to stabilize atmospheric greenhouse gas (GHG) concentrations at a level that would prevent dangerous interference with the climate system. Turkey ratified the UNFCCC in May 2004.

To achieve its objective and implement its provisions, the UNFCCC lays out several guiding principles and commitments. Specifically, Articles 4 and 12 commit all Parties to develop, periodically update, publish and make available to the COP their national inventories of anthropogenic emissions by sources and removals by sinks of all GHGs not controlled by the Montreal Protocol.

Turkey’s National Inventory is prepared and submitted annually to the UNFCCC by April 15 of each year, in accordance with revised Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories (UNFCCC Reporting Guidelines). The annual inventory submission consists of the National Inventory Report (NIR) and the Common Reporting Format (CRF) tables.

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 1990-2015.

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, accuracy, consistency, comparability and completeness of inventories and support the independent review process.

This inventory submission follows the revised UNFCCC Reporting Guidelines, adopted through Decision 24/CP.19 at COP 19.

Together with the common reporting format (CFR) 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 CRF tables, 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 National inventory focal point of Turkey 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),
- Ministry of Energy and Natural Resources (MENR).
- Ministry of Transport, Maritime Affairs and Communications (MTMAC),
- Ministry of Environment and Urbanization (MoEU),
- Ministry of Forestry and Water Affairs (MFWA),
- Ministry of Food, Agriculture and Livestock (MFAL),

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), fluorinated gases (F gases); Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6), NF_3 and indirect GHGs as nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), and 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 475.1 Mt of CO_2 equivalent (CO_2 eq.) in 2015. This represents an increase of 19.4 Mt, or 4.3%, in emissions compared to 2014, and an increase of 122% above 1990 levels (Table ES 1).

Table ES 1 Greenhouse gas emissions (Excluding LULUCF), 1990-2015

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Total (Mt CO_2 eq.)	214.0	246.6	296.5	337.2	407.1	436.4	448.9	442.2	455.6	475.1
Change compared to 1990 (%)	-	15.2	38.6	57.6	90.2	103.9	109.8	106.6	112.9	122.0

Turkey's total GHG emissions, including the LULUCF sector, were 411.0 Mt CO_2 eq. in 2015. Thus, LULUCF included total emissions increased 3.8% as compared to 2014 emissions. There is a 123.7% increase from 1990 to 2015 (Table ES 2).

Table ES 2 Overview of GHG emissions and removals, 1990-2015

(Mt CO_2 eq.)

GHG emissions	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
CO_2 emissions including LULUCF	118.0	151.3	191.5	220.2	275.5	299.0	305.3	289.7	299.7	319.4
CO_2 emissions excluding LULUCF	148.2	165.2	227.7	263.9	322.3	348.0	355.5	347.7	359.2	383.4
CH_4 emissions including LULUCF	41.2	41.2	42.3	44.4	51.2	53.4	56.8	55.6	56.8	51.4
CH_4 emissions excluding LULUCF	41.2	41.2	42.3	44.4	51.2	53.4	56.8	55.6	56.8	51.4
N_2O emissions including LULUCF	23.9	23.3	25.1	26.3	28.8	29.7	30.7	32.8	32.7	33.3
N_2O emissions excluding LULUCF	23.9	23.3	25.1	26.3	28.8	29.7	30.7	32.8	32.7	33.3
HFCs	NO	NO	0.12	1.15	3.05	3.43	4.26	4.47	4.93	4.81
PFCs	0.69	0.59	0.59	0.56	0.51	0.48	0.36	0.27	0.26	0.12
SF_6	NO	NO	0.67	0.88	1.17	1.26	1.32	1.34	1.64	1.98
Total (including LULUCF)	183.8	216.4	260.3	293.4	360.2	387.4	398.7	384.1	396.1	411.0
Total (excluding LULUCF)	214.0	246.6	296.5	337.2	407.1	436.4	448.9	442.2	455.6	475.1

Total GHG emissions as CO_2 eq. for the year 2015 were 475.1 Mt (excluding LULUCF). In overall 2015 emissions, the energy sector had the largest portion with 71.6%. The energy sector was followed by the sectors of IPPU with 12.8%, the agriculture with 12.1% and the waste with 3.6%. GHG emissions by sectors are given in Table ES 3.

Table ES 3 Greenhouse gas emissions by sectors, 1990-2015

(Mt CO_2 eq.)

Year	Energy	Industrial processes and product use	Agriculture	LULUCF	Waste	Total (Excluding LULUCF)	Total (Including LULUCF)
1990	134.4	23.7	44.8	-30.2	11.1	214.0	183.8
1991	138.5	25.4	45.8	-31.8	11.3	221.1	189.2
1992	144.7	25.1	46.1	-24.2	11.5	227.4	203.2
1993	152.2	26.0	46.8	-31.2	11.8	236.7	205.5
1994	148.9	25.3	44.0	-33.1	12.0	230.3	197.2
1995	163.5	27.3	43.4	-30.2	12.4	246.6	216.4
1996	179.2	28.1	44.2	-30.7	12.7	264.2	233.5
1997	191.2	29.0	42.1	-31.2	13.2	275.6	244.5
1998	191.0	29.3	43.7	-34.6	13.5	277.6	243.0
1999	190.2	27.8	44.4	-33.8	14.0	276.4	242.6
2000	211.7	27.8	42.5	-36.2	14.5	296.5	260.3
2001	195.0	27.9	39.8	-40.4	15.0	277.7	237.3
2002	201.9	29.3	38.0	-37.3	15.4	284.6	247.3
2003	216.6	30.5	41.2	-43.0	15.9	304.1	261.1
2004	223.3	33.1	42.2	-42.0	16.5	315.1	273.1
2005	241.0	35.9	43.3	-43.8	16.9	337.2	293.4
2006	260.5	39.0	44.8	-46.7	17.5	361.7	315.0
2007	291.4	41.5	44.4	-45.1	17.7	395.0	349.9
2008	288.5	43.4	42.1	-41.7	17.8	391.8	350.1
2009	294.6	45.1	43.4	-45.0	17.9	400.9	355.9
2010	292.1	51.0	45.8	-46.8	18.2	407.1	360.2
2011	313.9	55.8	48.1	-49.0	18.5	436.4	387.4
2012	319.3	57.7	53.8	-50.2	18.1	448.9	398.7
2013	308.3	60.2	57.2	-58.1	16.5	442.2	384.1
2014	321.2	60.8	57.2	-59.5	16.4	455.6	396.1
2015	340.0	60.7	57.4	-64.0	16.9	475.1	411.0

As shown in Table ES 3, emissions from energy increased by 5.9% to 340.0 Mt CO_2 eq. in 2015 as compared to 2014. However, there is 153% increase as compared to 1990. Emissions in the IPPU sector decreased to 60.7 Mt CO_2 eq. in 2015 which is 0.1% lower than the emissions in 2014. Emissions in the agriculture and waste sectors were 57.4 and 16.9 Mt CO_2 eq. respectively in 2015.

ES.3 Overview of Emission Estimates and Trends

The highest portion of total CO_2 emissions originated from energy sector with 86.1%. The remaining 13.7% originated from IPPU and 0.2% from agriculture in 2015. CO_2 emissions from energy increased 7.8% compared to 2014 while increased 163% as compared to 1990. CO_2 emissions from industrial processes increased 0.4% compared to 2014 and increased 139% as compared to 1990.

The largest portion of CH_4 emissions originated from agriculture activities with 59.4% while 28.9% from waste, and 11.7% from energy and industrial processes. CH_4 emissions from agriculture decreased 0.6% compared to 2014. It increased 22.0% as compared to 1990. CH_4 emissions from waste increased 3.4% compared to 2014. However, it increased 54.6% as compared to 1990 depending on increase in the amount of managed waste.

While 78.4% of N_2O emission was from agricultural activities, 11.2% was from energy, 6.1% was from waste and 4.3% was from IPPU. There is a 1.6% increase and 39.6% increase in total N_2O emissions as compared to 2014 and 1990 respectively. GHG emissions by sectors are given in Table ES 4.

Table ES 4 GHG emissions, 1990-2015

(kt)

GHG sources	1990	1995	2000	2005	2010	2012	2013	2014	2015
CO_2									
Total	148 195	181 419	227 719	263 941	322 057	355 492	347 747	359 220	383 427
Energy	125 801	155 299	201 534	230 776	276 856	304 896	294 679	306 320	330 280
IPPU	21 907	25 667	25 544	32 544	44 550	49 952	52 257	52 111	52 336
Agriculture	460	426	617	613	645	640	807	788	811
Waste	27.4	26.8	22.9	8.1	6	4.7	2.4	0.5	0.5
CH_4									
Total	1 650	1 649	1 692	1 775	2 049	2 271	2 224	2 273	2 058
Energy	264	235	305	284	441	461	426	470	241
IPPU	1.5	1.6	1.6	1.3	2	1.9	1.9	1.6	2.3
Agriculture	1 000	982	873	881	952	1 161	1 217	1 227	1 220
Waste	384	431	513	608	654	647	579	574	593
N_2O									
Total	80	78.2	84.2	88.1	96.6	103	109	110	112
Energy	6.5	7.9	8.5	10.5	13.1	9.7	10.1	10.6	12.5
IPPU	3.6	3.4	2.8	2.5	5.6	6	6	6.1	4.8
Agriculture	65	61.7	67.4	69.4	71.6	80.9	87.2	86.4	87.6
Waste	4.9	5.3	5.5	5.8	6.2	6.6	6.7	6.8	6.8

ES.4 Indirect GHG Emissions

Emissions of CO, NO_x, NMVOC and SO_2 are also included in the report because they influence climate change indirectly. Table ES 5 shows the indirect GHG emissions. CO emissions are 2.35 Mt in 2015 with more than 99% of them from energy sector. NO_x emissions are 0.88 Mt in 2015 and more than 99% of which is from energy. NMVOC emissions are about 1.02 Mt in 2015. The largest portion of NMVOC emissions is from agriculture with 41% and this figure is followed by energy with 29%. SO_2 emissions are 1.9 Mt and more than 99% is sourced from energy sector in 2015.

Table ES 5 Indirect GHG emissions, 1990-2015

(kt)

Indirect GHG sources	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
CO Emissions										
Total	**2 023**	**2 008**	**2 875**	**2 365**	**2 833**	**2 725**	**2 917**	**2 107**	**1 991**	**2 347**
Energy	1 998	1 977	2 847	2 347	2 818	2 711	2 905	2 093	1 986	2 343
Industrial processes	8.60	8.75	8.54	8.12	7.70	8.14	6.66	10.7	5.23	3.88
Waste	16.4	22.6	20.0	9.74	7.48	6.67	5.86	3.04	0.22	0.22
NO_x Emissions										
Total	**562**	**700**	**672**	**720**	**769**	**876**	**831**	**797**	**783**	**878**
Energy	560.2	689.2	662.8	716.0	764.4	872.0	826.3	792.7	778.9	873.9
Industrial processes	0.95	9.53	7.62	3.60	3.70	4.04	3.93	3.87	3.89	3.75
Waste	0.93	1.29	1.14	0.55	0.43	0.38	0.33	0.17	0.01	0.01
NMVOC Emissions										
Total	**942**	**1 035**	**1 108**	**1 015**	**1 046**	**1 066**	**1 125**	**1 073**	**1 078**	**1 017**
Energy	347.9	374.6	400.6	317.9	343.0	333.7	350.2	262.7	247.3	293.5
Industrial processes	250.8	274.9	315.4	317.6	330.5	337.1	340.4	345.1	350.3	260.3
Agriculture	338.4	354.1	353.7	341.1	333.4	356.1	394.3	423.7	437.0	420
Waste	4.92	31.7	38.4	38.6	39.1	39.6	40.0	41.8	43.5	43.5
SO_2 Emissions										
Total	**1 747**	**1 887**	**2 239**	**2 003**	**2 558**	**2 638**	**2 713**	**1 941**	**2 145**	**1 935**
Energy	1 746.3	1 885.6	2 327.9	2 101.8	2 557.4	2 636.7	2 712.7	1 939.7	2 144.3	1 935.1
Industrial processes	0.82	0.85	0.79	0.72	0.75	0.82	0.76	0.96	0.68	0.19
Waste	0.03	0.04	0.04	0.02	0.01	0.01	0.01	0.01	0.00	0.00

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TABLES

FIGURES

SYMBOL AND ABBREVIATIONS

AD	Activity data
AFOLU	Agriculture, Forestry and Other Land Use
AIS	Automatic Identification System
ALPA	Anatolian Lime Producers Association
AWMS	Animal waste management systems
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 of dry matter
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
DOM	Dead Organic Matter
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
Florinated gases	F gases
FOD	First Order Decay
g	gram
GDF	General Directoriate of Forestry
GDP	Gross Domestic Product
GE	Gross energy intake
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
MoEF	Ministry of Environment and Forestry
MoEU	Ministry of Environment and Urbanization
MRV	Monitoring, Reporting, Verification
MS	Manure Management System Usage
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
SF_p	Scaling factor regarding water regime before the cultivation period
SF_w	Scaling factor regarding water regime during the cultivation period
SO_2	Sulphur dioxide
SO_x	Sulphur oxide
SOM	Soil Organic Matter
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
TTGV	Technology Development Foundation of Turkey
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
Y_m	Methane conversion factor
yr	year

1. INTRODUCTION

1.1. Background Information on GHG Inventories

The UNFCCC and the Kyoto Protocol were ratified by 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. National Greenhouse Gas Inventory of Turkey was set up in 2006. Inventory covers all emissions and removals sources described in 2006 IPCC Guidelines. Emissions and removals have been estimated and reported in line with the 2006 IPCC Guidelines for National GHG Inventories. The National GHG Inventory consists of the national inventory report (NIR) and the common reporting format (CRF) tables in accordance with the UNFCCC reporting guidelines (24/CP.19). Time series of emissions and removals from 1990 to latest inventory year are covered in the Common Reporting Format (CRF).

2006 IPCC Guidelines were provided for the following sectors:

- Energy
- Industrial Processes and Product Use (IPPU)
- Agriculture
- Land Use, Land Use Change and Forestry (LULUCF)
- Waste

The Emission Inventory includes direct GHGs as CO_2, CH_4, N_2O, HFCs, SF_6, PFCs, NF_3 and indirect gases as NO_x, NMVOC, 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. Indirect CO_2 emissions that are a consequence of the activities of the reporting entity, but available at sources owned or controlled by another entity are not occur.

In this report, the national GHG emissions and removals from 1990 to 2015, emission and removal 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 Turkish national inventory system is featured by centralised governance. Ministry of Environment and Urbanization (MoEU) is the National Focal Point of the UNFCCC, and is responsible for climate change and air pollution policies and measures. Turkey established the Coordination Board on Climate Change (CBCC) in 2001 with the Prime Ministerial Circular no.2001/2 in order to determine the policies, measures and activities to be pursued by Turkey on climate change. Under the chairmanship of Minister of Environment and Urbanization, this board is composed of high level representatives (Undersecretary and President) from Ministres related to foreign relations, finance, economy, energy, transport, industry, agriculture, forestry, health, education, TurkStat, and NGOs from business sector. The CBCC was restructured in 2013, and renamed as Coordination Board on Climate Change and Air Management (CBCCAM). The CBCCAM, a public body created by Prime Minister Circular 2013/11, is competent for taking decisions and measures related to climate change and air management.

Coordination Board on Climate Change and Air Management Decisions is the first legal means for national inventory system.

Under the Coordination Board currently there are seven working groups (WGs):

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

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. TurkStat was formally appointed as single national responsible authority to coordinate and implement national inventory activities from planning to management by Desicion 2009/1 of the CBCC in 2009. TurkStat is also in charge of annual inventory submission to the UNFCCC Secretariat and of responding to the ERT recommendations.

Also, the legal basis of the national inventory system is currently provided by the Statistics Law of Turkey through the Official Statistics Programme (OSP). The OSP is based on the Statistics Law of

Turkey No. 5429 and was first prepared in 2007 for a 5-year-period and updated every 5 years. OSP identifies the basic principles and standards dealing with the production and dissemination of official statistics and produce reliable, timely, transparent and impartial data required at national and international level. For all kind of official statistics, the responsible and related institutions are defined, data compilation methodology and the publication periodicity/schedule of official statistics are specified. TurkStat is the responsible institution for the compilation of the national GHG inventory through the OSP and coordinates the activities of the GHG emission inventory working group established in the scope of OSP with the same composition as the GHG emission inventory working group under CBCCAM.

The GHG national inventory is compiled by GHG Emission Inventory working group under the coordination of TurkStat.

The institutions included in the working group are:

- Turkish Statistical Institute (TurkStat),
- Ministry of Energy and Natural Resources (MENR),
- Ministry of Transport, Maritime Affairs and Communications (MTMAC),
- Ministry of Environment and Urbanization (MoEU),
- Ministry of Food, Agriculture and Livestock (MFAL),
- Ministry of Forestry and Water Affairs (MFWA),

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

Responsibilities of the institutions involved in the national GHG inventory are shown in Table 1.1.

Table 1.1 Institutions by Responsiblities for National GHG Inventory

Sector	CRF Category	Collection of Activity Data	Selection of Methods and Emission Factors	GHG Emission Calculation	Filling in CRF tables and preparing NIR	Quality control
Energy	1-Energy (Excluding 1.A.1.a- public electricity and heat production and 1.A.3-Transport)	MENR TurkStat	TurkStat	TurkStat	TurkStat	TurkStat
	Public electricity and heat production - 1.A.1.a	MENR	MENR	MENR	MENR	MENR
	Transport	MTMAC TurkStat	MTMAC	MTMAC	MTMAC	MTMAC
Industrial Processes and Other Product Uses	2- IPPU (except F-gases)	TurkStat	TurkStat	TurkStat	TurkStat	TurkStat
	F-Gases	MoEU	MoEU	MoEU	MoEU	MoEU
Agriculture	3-Agriculture	TurkStat	TurkStat	TurkStat	TurkStat	TurkStat
Land Use, Land Use Change and Forestry	4-A Forest Land	MoFWA,	MoFWA,	MoFWA,	MoFWA,	MoFWA,
	4-B-F Other land use	MoFAL	MoFAL	MoFAL	MoFAL	MoFAL
Waste	5-Waste	TurkStat	TurkStat	TurkStat	TurkStat	TurkStat
Cross cutting issues						
Key category Analysis	TurkStat					
Uncertainty analysis	TurkStat					

National Inventory Official Consideration and Approval;

The national GHG inventory is subject to an official consideration and approval procedure before its submission to the UNFCCC. The national inventory is subject to a two-step official consideration and approval process. The final version of the NIR and CRF tables is first approved by the TurkStat Presidency and published in the official TurkStat press release. Subsequently, The MoEU as National Focal Point to the UNFCCC provides final checks and approval of the CRF tables via CRF web application tool as a final step prior to its submission to the UNFCCC.

TurkStat, as the Single National Entity, is responsible from official inventory submission to UNFCCC, and also responsible for responding to the UNFCCC expert review team (ERT) recommendations on national inventory improvement and ensuring they are incorporated in the current and following NIR(s) in the broader context of its continuous improvement.

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, UNFCCC expert review team (ERT) recommendations, 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. Distribution of work for data gathering, processing and estimation of emissions are shown in Table 1.1. Emissions originating from energy, industrial processes and other product use, agricultural activities and waste, and emissions and removals from LULUCF are calculated at national level annually by using recommended approaches in 2006 IPCC Guidelines. Fuel combustion emissions other than electricity generation and transport are calculated by TurkStat via using the energy balance tables of the Ministry of Energy and Natural Resources. Emissions from industrial process (excluding F-gases), agricultural activities, waste and fugitive emissions from coal mining, oil and gas systems are also calculated by TurkStat. The emissions originating from public electricity and heat production are calculated on the basis of plant level data by the General Directorate of Energy Affairs of The Ministry of Energy and Natural Resources; the emissions originating from transportation are calculated by The Ministry of Transport, Maritime Affairs and Communication. The fluorinated gases are calculated by the Ministry of Environment and Urbanization. Emissions and removals from land use, land-use change and forestry are estimated by The Ministry of Forestry and Water Affairs, and the Ministry of Food, Agriculture and Livestock.

Also country specific (CS) CO_2 EFs of natural gas, Turkey lignite, hard coal, fuel oil and diesel oil are calculated by using fuel, slag and ash analyses and gas chromatography results, by the MENR.

Every sector expert that performs the emission estimation has responsible for the data entry to CRF reporter, and prepare related section or sub-section of NIR. TurkStat compiles and make key source and uncertainty analysis and do final quality checks, and submits the national GHG inventory to the UNFCCC Secretariat.

TurkStat is also responsible from archieving the GHG inventory. Central archiving is carried out by TurkStat. EFs, AD, calculation sheets, CRF and NIR outputs, etc. regarding the emission inventory are archieved on TurkStat main server. All inventory related documents are also archieved by the in line Ministries for the CRF categories under their responsibilities.

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. The quality of the national inventory system is ensured by the QA/QC system, through the QA/QC plan adopted by the CBCCAM decision in 2014. The QA/QC plan introduces the structure and purpose of the QA/QC system, endorse the quality objectives. The main objective of the QA/QC plan is to ensure that the national GHG inventory is prepared in accordance with the quality objectives: transparency, accuracy, comparability, consistency, completeness (TACCC) as defined in UNFCCC reporting guideline (24/CP.19). Turkey also considers three additional quality objectives as improvement, sustainability and timeliness.

Improvement: Processes ensure that the inventory represents the best possible estimates of GHG emissions and sinks for all categories, given the current state of scientific knowledge, data availability and national resources, taking into account information gained and lessons learned from reporting and review in the latest GHG inventory cycle.

Sustainability: Processes ensure the continuity of the GHG inventory system through institutional memory by establishing a documentation/archiving system and methodological manuals,

Timeliness: All of the QA/QC procedures are developed with a view to enabling the timely submission of the NIR and the accompanying CRF tables to the UNFCCC by 15 April each year. In addition, inventory inputs, references and materials should be transparently documented and accessible, to enable timely responses to external requests for information, including during formal and informal inventory review processes.

Together with verification, the implementation of QA/QC procedures are considered integral part of national inventory preparation and play a pivotal role not only to achieve the quality objectives but also for continuous reassessing and improving the national inventory where needed.

TurkStat is the designated body for overall implementation of the QA/QC system and for ensuring coordination of the QA/QC activities.

Quality Control (QC) is a system of routine technical activities to assess and maintain the quality of the inventory as it is being compiled. It is performed by personnel compiling the inventory. QC activities include general methods such as accuracy checks on data acquisition and calculations, and the use of approved standardised procedures for emission and removal calculations, measurements, estimating uncertainties, archiving information and reporting. QC activities also include technical reviews of categories, activity data, emission factors, other estimation parameters, and methods.

The data used in the preparation of the national GHG inventory for the agriculture, waste, and industrial processes sectors are optained from agricultural statistics, industrial production statistics, and waste statistics databases of TurkStat. TurkStat is producing all its statistics according to the European Statistics Code of Practice which covers a common quality framework in the European Statistical System. Therefore high quality data are used in the inventory.

In Turkey, in addition to data available from national statistics, some plant-level data are used to estimate input parameters for emissions calculations. No QC procedures are available for data providers at the moment. If data are official statistics from TurkStat, then it is ensured that the statistics are produced in line with the EU code of practice. However, if the data source is not from the official statistics QC can be performed by the inventory team.

In detail, with regard to QC the following rules and steps apply:

- Each Institution involved in national inventory development is responsible for its own QC general and category specific activities,
- Both general and category specific QC activities are carried out by sectorial QC experts within the Institutions, using the ad hoc check lists attached in Annex II (general QC) and Annex III (category specific) of the QA/QC Plan,
- Check lists are filled in by sectorial QC experts for the CRF categories under their responsibility and sent to TurkStat with an official letter,
- TurkStat files the letters,
- QC sectorial experts make the corrections needs emerging from the QC activities,
- TurkStat prepares a summary of the QC results,
- An improvement plan is prepared by the national inventory team under TurkStat coordination.

Criteria for assessing achievement of quality objectives is given below in Table 1.2.

Table 1.2 Criteria for Assessing Achievement of Quality Objectives

Data Quality Objective	Criteria For Assessing Achievement Of Quality Objective
Accuracy	• Emissions are neither overestimated or underestimated as far as can be judged, • Uncertainty estimates are provided for AD, EF, and emissions in each category for the base year, the most recent year, and the trend.
Comparability	• Turkey applies methods from the 2006 IPCC Guidelines, in accordance with the significance of the category in the country (e.g., whether or not it is a key category) and national circumstances.
Completeness	• All categories for which methods are provided in the 2006 IPCC Guidelines are included in the national GHG inventory, • Emissions estimates cover the entire geographic area of Turkey, • Emissions values or notation keys are provided for each cell in the CRF tables, • If despite the best efforts, emissions for a category for which methods are provided in the 2006 IPCC Guidelines cannot be provided, the situation regarding the lack of reporting is transparently described in the NIR.
Consistency	• Turkey has applied the same method across the time series for a given category and can explain the trends observed in the time series, • If the same method is not used for the entire time series in a category, Turkey can explain (and documents in the NIR) why the selected method(s) ensure time series consistency.
Improvement	• The national inventory improvement plan is updated with the recommendations and encouragements from the relevant review processes (e.g. UNFCCC) and QA/QC summary reports, • Turkey implements findings from review processes where feasible.
Sustainability	• All inventory related documents (NIR, data sheets, EFs, CRF tables) are archived annually, • All information on choice of methodology, EFs and parameters, assumptions used, are documented and updated as needed, • All methodological manuals are prepared and updated as needed.

Table 1.2 Criteria for Assessing Achievement of Quality Objectives (cont'd)

Data Quality Objective	Criteria for assessing achievement of quality objective
Timeliness	• Inventory is submitted to the UNFCCC by 15 April annually, • Turkey is able to timely respond to questions from the UNFCCC ERT.
Transparency	• Information necessary to reproduce the emissions estimates is either provided in the annual submission or referenced therein, • The elements required to be included in the NIR per paragraph 50 of the annex to decision 24/CP.19 are included, in particular clear descriptions of: • All methods selected and models used • Values and sources of AD, EFs and other parameters • Relevant information on key categories and uncertainties • Recalculations are clearly explained • Completeness of the inventory • Changes in response to the review process • Description of the national inventory arrangements.

General QC Procedures;

General QC procedures include generic quality checks related to calculations; data processing, completeness, and documentation that are applicable to all inventory source and sink categories. General QC procedures are applied routinely to all categories by sector experts using the check lists attached in Annex II of the QA/QC Plan during the acquisition of data and the emissions calculation procedures and during the compilation of NIR and the CRF tables.

Each sector expert should fill and sign the check list that the necessary QC checks were undertaken. Each sector expert should carry out immediate corrections of the input data/emissions calculations where errors are found. If an issue cannot be resolved during the current inventory submission, the sector experts should include an explanation for aspects still posing problems along with a recommendation(s) for future work on these issues. Such issues may then be incorporated into the inventory improvement plan. A copy of the completed checklist is sent to TurkStat and is archived in TurkStat.

The types of activities and procedures undertaken by sectoral experts include, but are not limited to:

- Cross-check descriptions of AD, EFs and other estimation parameters with information on categories and ensure that these are properly recorded and archived. This step includes ensuring that definitions and assumptions for the underlying AD match the definitions of categories used in the GHG inventory. In some cases, data collected from national statistics may have different coverage than that required for inventory preparation,
- Ensure that the time series of input EF, AD and other parameters are justifiable, and that any outliers can be explained by national circumstances;
- Ensure that proper bibliographic information is available and documented in the archives for all input parameters,
- Cross-check a sample of input data to ensure that there are no transcription errors;
- Where AD or EF data are obtained from plant operators Turkey plant level data are compared with previous data and related indicators (kwh/TJ, kwh/m^3 CH_4) and published national data,
- Check that units are properly labeled for all input data and, for a subset of parameters, correctly transcribed and applied in the emissions calculation spreadsheets,
- Where a parameter is based on expert judgement, is identifying information for the expert (including their affiliation and any relevant expertise) documented and archived,
- Has the sector expert identified where recalculations of previous input data have been undertaken? Qualitative reasons for, and the quantitative impacts of, these recalculations should be documented in the NIR.

Category-Specific QC Procedures;

Category-specific QC procedures complement general inventory QC procedures and are directed at specific types of data used in calculating GHG emissions for individual source or sink categories. These procedures require knowledge of the specific category, the types of data available and the parameters associated with emissions or removals, and are performed in addition to the general QC checks. Category specific QC procedures are also applied by sector experts using the check lists attached in Annex III of the QA/QC Plan.

Each sector expert should fill and sign the check list that the necessary QC checks were undertaken, and summarizes the unsolved issues. A copy of the completed checklist is sent to TurkStat and is archived in TurkStat.

The types of activities and procedures undertaken by sectoral experts include, but are not limited to:

- Assumptions for AD, EFs and other parameters are compared with IPCC values and significant differences are noted,
- National and regional comparability and trends of AD, EF or other assumptions are checked against alternative data sources,
- Conduct of an in-depth review of the background data used to develop a country-specific EF, including the adequacy of any plant-level measurement programmes upon which the country-specific EF was developed. Such an in-depth review may also involve an assessment of any national literature used in support of the development of the country-specific factor,
- Evaluate any peer reviewed literature evaluating national or plant level statistics and suitability for the use in the GHG inventory,
- Hand-checking the accuracy of random calculations,
- To the extent possible, are the only hardwired data in the spreadsheets the basic input data (e.g., AD, EFs and assumptions) with all other spreadsheets using spreadsheet tools to link and calculate emissions,
- Reviewing the time series consistency of emissions calculations for any outliers and compare whether the values are within the minimum – maximum interval of other Parties,
- Checking a random sampling of conversion factors to ensure proper calculation from input data to emissions calculations,
- Is the IEF calculated reasonable compared with the previous annual submission and with the 2006 IPCC Guidelines,
- Is the time series of the IEF reasonable- are any large changes explainable,
- Checking that confidentiality is assured by Statistics Law of Turkey,
- Are emissions estimates (or notation keys) available for all years of the time series for mandatory categories, from 1990 to the year T-2 and do the emissions estimates cover all sources in the category (as determined by cross checks using other publicly available information),
- Identify parameters (e.g., AD, constants) that are common to multiple categories and confirm that there is consistency in the values used for these parameters in the emission/removal calculations. This is particularly important when reviewing calculations for the agriculture and LULUCF sector, as well as when reviewing input data between the reference and the sectoral approach.

QC Procedures Applied to Compiled NIR and CRF Tables;

TurkStat undertakes further quality checks on compiled CRF and NIR. The types of activities and procedures undertaken include:

CRF tables;

- Completeness of all cells in the CRF tables with either a value or a notation key,
- Appropriateness of notation keys used ,
- Where the notation key "NE" or "IE" is used, whether an appropriate description is included in CRF table 9 to indicate why data are not reported (in the case of "NE") or where data are reported (in case of "IE"),
- Where emissions data are reported as confidential, it is ensured that emissions are included elsewhere (properly aggregated to assure confidentiality of information) and, therefore, included in national totals,
- Check whether appropriate tiers are used for key categories, in accordance with the decision trees in the 2006 IPCC Guidelines. Where appropriate tiers are not used, is an appropriate discussion included in the NIR to document the national circumstances surrounding the methodological choice?
- Review of documentation boxes of the CRF tables for appropriate content and language.

NIR;

- All tables, figures and text have been updated to reflected the latest annual data,
- Does the description of trends match the trends seen taking into account the latest year, and any recalculations of earlier years' data,
- Check the introductory chapters and annex to make sure that the data contained therein match the latest inventory data,
- Have all recalculations identified been documented in the NIR and the impacts of the recalculation described?
- Assessment of completeness of the category described in the NIR,
- Consistent use of units in the NIR and the CRF tables,
- A general check of the NIR should be done for consistency,
- All references should be included in the NIR and the same reference should be referred to consistently across chapters,
- Ensure that all web links are active and direct the readers to the appropriate content. After inventory submission to UNFCCC,
- Ensures that all inventory related materials were archived by inventory sectoral experts .

Quality Assurance

Quality Assurance (QA) is a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. Reviews, preferably by independent third parties, are performed upon a completed inventory following the implementation of QC procedures. Reviews verify that measurable objectives (data quality objectives) were met, ensure that the inventory represents the best possible estimates of emissions and removals given the current state of scientific knowledge and data availability, and support the effectiveness of the QC programme.

Due to the comprehensive and costly nature of QA activities, these procedures are only applied for selected categories and selected years, and generally only for key categories.

Turkey's approach to QA is to prioritize:

- The categories that have high uncertainty,
- The categories that are recalculated,
- The categories that were included in the improvement plan.

In Turkey, QA activities are conducted by experts in the scope of European Union (EU) funded Projects. For this purpose first, in the scope of EU funded Upgrading the Statistical System of Turkey project, external experts from EU countries were invited to review Turkish GHG Inventory for all categories before in-country review in 2014. Some improvements has been achieved based on review outputs of the EU inventory experts.

Also the EU funded Project named as Technical Assistance For Support to Mechanisms for Monitoring Turkey's GHG Emissions, project period is January 2015 April 2017, 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.

Under the technical assistances of experts from project team national GHG inventory was reviewed and improved through workshops, mentor style trainings, and meetings organized.

In addition, Turkey's GHG inventory submission is subject to review by an international team of experts on an annual basis in accordance with decision 13/CP.20. During the review week, Turkey ensures that all institutions, organizations and responsible sector experts are available to provide necessary information and supporting documentation to the review team in a timely manner. The ERT then develops an annual review report based on the findings of the review. These annual review reports are considered as supplementary to the QA procedures undertaken by experts in Turkey.

Findings in the annual review reports are considered feedback for improvement of the GHG inventory, and as such are included in Turkey's inventory improvement plan. Improvements regarding the recommendations identified by the expert review team in the most recent review are generally summarized in chapter 10 (Table 10.2-10.4) of the current submission.

Verification

Verification activities typically include comparing inventory estimates with independent estimates to either confirm the reasonableness of the inventory estimates or identify major discrepancies. Verification activities may be directed at specific categories or the inventory as a whole, and their application will depend on the availability of independent estimation methodologies that can be used for comparison.

Each Institution involved in national inventory development is responsible for its own verification activities. Sectorial experts within the Institution carry out the activities.

In Turkey, some level of verification happens on an annual basis, as Turkey estimates and reports CO2 emissions from fossil fuel combustion based on both the reference approach and the sectoral approach. Differences in the emissions estimated using these two approaches are described in the NIR.

The national GHG emissions in the energy sector are estimated by using fuel consumption data taken from energy balance tables produced 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.

Also lower tier IPCC methods applied for comparison in especially energy sector. Emissions calculated and reported on the basis of higher tiers (Tier 2 or Tier 3) are compared with emissions calculated by Tier1 method.

In current situation, in Turkey, there is no other emission calculation to compare whole inventory or sub-sectors. However, Regulation on the Monitoring of Greenhouse Gases has been came into force since 2012. In the scope of that Regulation, companies will report their verified GHG emissions to the MoEU from 2017 onwards. GHG emissions from most of the IPCC categories could be compared with those emissions reported under the MRV Regulation for next submissions.

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 their own institutions.

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

Turkey's inventory preparation starts with inventory planning which covers recalculations, methodological improvements and refinements according to quality management and improvement plans based on learning from previous inventory cycle, UNFCCC review reports and collaborations with government institutions. Reviewing the calculation methods are finalized by the end of November and the data collection process is completed by the end of December. After that, in January and February, emissions are estimated. QC checks and estimates are done by experts in mid-February. NIR text and CRF tables are then prepared according to UNFCCC guidelines. The inventory process also involves key category assessment, recalculations, uncertainty assessment, documentation and archiving. Main steps in the annual inventory preparation process are summarized below in Table 1.3 with starting and ending dates.

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 Inventory 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 press release on TurkStat webpage.	01.04.XX	15.04.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 excepting 1A1a category are calculated by using Tier 1 (T1). Technology specific EFs are used for CH_4 and N_2O emissions from 1A1a category. 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. T3 methodology is used for CO_2 emissions from iron and steel production and GHG emissions from aluminium production. For the emissions from rest of the IPPU categories, T1 methodology was used.

For agriculture sector; T2 is used for emissions from enteric fermentation. For the other categories T1 methodology was used.

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

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. All tier methodologies are summarized on sector basis in below Table 1.4.

Table 1.4 Summary For Methods and Emission Factors Used, 2015

Greenhouse Gas Source And Sınk Categorıes	CO_2 Method applied	CO_2 Emission factor	CH_4 Method applied	CH_4 Emission factor	N_2O Method applied	N_2O Emission factor
1. Energy	T1,T2,T3	CS,D,PS	T1,T2,T3	D,PS	T1,T2,T3	D,PS
A. Fuel combustion	T1,T2,T3	CS,D,PS	T1,T2,T3	D,PS	T1,T2,T3	D,PS
1. Energy industries	T2,T3	CS,D,PS	T2,T3	D,PS	T2,T3	D,PS
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	NE	NE	T1	D	NE	NE
2. Oil and natural gas	T1	D	T1	D	T1	D
C. CO_2 transport and storage	T1	D				
2. Industrial processes	T1,T2,T3	CS,D	T1	D	T1	D
A. Mineral industry	T1,T2	CS,D				
B. Chemical industry	T1,T2	CS,D	T1	D	T1	D
C. Metal industry	T1,T2,T3	CS	T1	D	NE	NE
D. Non-energy products from fuels and solvent use	T1	D	NE	NE	NE	NE
E. Electronic industry						
F. Product uses as ODS substitutes						
G. Other product manufacture and use	NA	NA	NA	NA	NA	NA
H. Other	NA	NA	NA	NA	NA	NA
3. Agriculture	T1	D	T1,T2	CS,D	T1	D
A. Enteric fermentation			T1,T2	CS,D		
B. Manure management			T1	D	T1	D
C. Rice cultivation			T1	D		
D. Agricultural soils(3)					T1	D
E. Prescribed burning of savannas			NO	NO	NO	NO
F. Field burning of agricultural residues			T1	D	T1	D
G. Liming	NE	NE				
H. Urea application	T1	D				
I. Other carbon-containing fertilizers	NE	NE				
J. Other	NO	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry	CS,D,T1, T2	CS,D	T2	D	T1,T2	D
A. Forest land	T2	CS	T2	D	T2	D
B. Cropland	T1,T2	D	NE	NE	T1	D
C. Grassland	D,T1,T2	CS,D	NE	NE	NE	NE
D. Wetlands	NE	NE	NE	NE	NE	NE
E. Settlements	CS	D	NE	NE	NE	NE
F. Other land	NO	NO	NO	NO	NO	NO
G. Harvested wood products	T2	D				
H. Other	NO	NO	NO	NO	NO	NO
5. Waste	T2	CS,D	T1,T2	CS,D	T1	D
A. Solid waste disposal	NA	NA	T2	CS,D		
B. Biological treatment of solid waste			T1	D	T1	D
C. Incineration and open burning of waste	T2	CS,D	T1	D	T1	D
D. Waste water treatment and discharge			T2	CS	T1	D

Table 1.5 provides an overview for inventory data sources by sectors.

Table 1.5 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 Energy balance sheet-sectoral fuel consumption data (for sectoral approach) and fuel supply data (for reference approach) Waste incinerations – Waste incineration data
	Public electricity and heat production – 1.A.1.a	MENR_ Facility base electricity and heat production statistics
	Petroleum Refining – 1.A.1.b	TÜPRAŞ-fuel consumption data
	Manufacture of solid fuels and other energy industries – 1.A.1.c	Integrated iron and steel plants- fuel consumption for coke production
	Transportation – 1.A.3	TurkStat-road vehicle fleet and vehicle-km travelled, MENR, EMRA, Petroleum Pipeline Corporation - fuel consumption by transport mode MTMAC/DG of State Airports Authority - air traffic data
Industrial Process and Product Use	2.A.1.Cement	Turkish Cement Manufacturer's Association, production and EF
	2.A.2. Lime	Turkish Lime Association, Steel plants, production
	2.A.3 Glass	Producers- glass production and parameters
	2.A.4 Other process uses of carbonates	Turkish Ceramics Federation, producers and Turkstat,- production, raw material consumption
	2.B.1. Ammonia Prod.	Producers- production and fuel consumption
	2.B.2 Nitric Acid Prod.	Producers- production and technology
	2.B.5. Carbide Prod.	Producers- production and raw material
	2.B.7. Soda ash prod.	Producers- production and raw material
	2.B.8. Petrochemical and carbon black prod.	Producers- production
	2.C.2. Iron and Steel Prod.	Producers- production and other parameters
	2.C.2. Ferroalloy prod.	TurkStat, production
	2.C.3 Aluminium Prod.	Plant, production and other parameters
	2.C.5. Lead Prod.	TurkStat- production
	2.C.6. Zinc Prod.	Producers- production
	2.D.1. Lubricant Use	MENR- consumption
	2.D.2. Paraffin wax use	MENR- consumption
	2.E. Electronic industry	TurkStat, trade statistics
	2.F. Product uses as substitutes for ODS	TurkStat, trade statistics
	2.G.1. Electrical equipment	TurkStat, trade statistics

Table 1.5 Activity Data Sources for GHG Emissions Inventory (cont'd.)

Sector	Category	Activity data source
Agriculture	Agriculture – 3	TurkStat – Livestock population, Crop production data General Directorate of Meteorology - Temperature data MFAL- Inorganic N Fertilizers application data, Urea application data
Land Use, Land Use Change and Forestry	LULUCF - 4	MFWA (General Directorate of Forestry): The ENVANIS (Inventory Statistical System for Forests) Table, The annual commercial cutting and fuel wood data, The annual forest fire information (area), The annual illegal cutting and wood gathering information; MFWA- CORINE land use maps General Directorate of State Hydraulic Works: The data of dam constructions , MFAL-Static maps
Waste	Waste – 5	• TurkStat – • Waste disposal and treatment statistics • Wastewater discharge and treatment statistics • GDP, • Population and population projections, • MoEU, National Waste Management & Action Plan - waste composition data • Composting plants - amount of composted waste • Methane recovery facilities - amount of methane recovered from landfills and wastewater treatment plants

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 1990–2015 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 category analysis are given in Annex 1.

Based on the key category with and without LULUCF, the followings are determined as key source in 2015.

Table 1.6 Key Categories for GHG Emissions Inventory, 2015

Key categorıes of emıssıons and removals	Gas	Criteria used for key source identification		Key category excluding LULUCF	Key category including LULUCF
		L	T		
1.A.1 Energy Industries - Liquid Fuels	CO_2	X	X	X	X
1.A.1 Energy Industries - Solid Fuels	CO_2	X	X	X	X
1.A.1 Energy Industries - Gaseous Fuels	CO_2	X	X	X	X
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	X	X	X	X
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	X	X	X	X
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	X	X	X	X
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2		X	X	
1.A.3.b Road Transportation	CO_2	X	X	X	X
1.A.4 Other Sectors - Liquid Fuels	CO_2	X	X	X	X
1.A.4 Other Sectors - Solid Fuels	CO_2	X	X	X	X
1.A.4 Other Sectors - Solid Fuels	CH_4		X	X	X
1.A.4 Other Sectors - Gaseous Fuels	CO_2	X	X	X	X
1.A.4 Other Sectors - Biomass	CH_4		X	X	X
1.B.1 Fugitive emissions from Solid Fuels	CH_4		X	X	X
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	X	X	X	X
2.A.1 Cement Production	CO_2	X	X	X	X
2.A.2 Lime Production	CO_2	X	X	X	X
2.C.1 Iron and Steel Production	CO_2	X	X	X	X
2.C.3 Aluminium Production	PFCs		X	X	
2.F.6 Other Applications	Aggregate F-gases	X	X	X	X
2.G Other Product Manufacture and Use	Aggregate F-gases		X	X	X
3.A Enteric Fermentation	CH_4	X	X	X	X
3.B Manure Management	CH_4	X	X	X	X
3.B Manure Management	N2O	X		X	X
3.D.1 Direct N2O Emissions From Managed Soils	N2O	X	X	X	X
3.D.2 Indirect N2O Emissions From Managed Soils	N2O	X	X	X	X
4.A.1 Forest Land Remaining Forest Land	CO_2	X	X		X
4.A.2 Land Converted to Forest Land	CO_2	X	X		X
4.B.2 Land Converted to Cropland	CO_2		X		X

Table 1.6 Key Categories for GHG Emissions Inventory, 2015 (cont'd)

Key categories of emissions and removals	Gas	Criteria used for key source identification		Key category excluding LULUCF	Key category including LULUCF
		L	T		
4.C.2 Land Converted to Grassland	CO_2	X	X		X
4.D.2 Land Converted to Wetlands	CO_2		X		X
4.G Harvested Wood Products	CO_2	X	X		X
5.A Solid Waste Disposal	CH_4	X	X	X	X
5.D Wastewater Treatment and Discharge	CH_4	X	X	X	X
5.D Wastewater Treatment and Discharge	N_2O	X		X	

Note: L = Level assessment; T = Trend assessment.

Based on the results of the key category analysis, it is tried to increase the Tiers in emissions/removals estimation. However due to resource restrictions, Tier1 approaches have to be used for some key categories, such as CH_4 emissions from other sectors, solid fuels and oil and gas systems in energy sectors, CH_4 emissions from manure management, N_2O emissions from agricultural soils and wastewater treatment and discharge. Efforts to increase the tiers for all key categories is continuing.

1.6. General Uncertainty Evaluation

or calculation of uncertainty, 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).

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 with LULUCF is 9.15%, and 6.42% without LULUCF.

In Table 1.7 uncertainties are shown for the 2015. Level and trend uncertainties are estimated using Approach 1 methods. Asymmetric uncertainties are not be taken into account in Aprroach 1. The details of uncertainty analysis are given in Annex 2.

Energy and agricultural sectors are the main contributors of total uncertainty. The level uncertainties of energy and agricultural sectors are 5.55 and 6.28 respectively. In energy sector, especially other sectors has the highest uncertainty. In agricultural sector, especially manure management and agricultural soils has higher uncertainties. Those sectors are also key source categories and needs to be improved. It is tried improve AD and find out country specific EFs for especially sectors havibg higher sectors.

Table 1.7 Uncertainties for GHG Emissions Inventory

Emission, trend and uncertainty estimates	Emission kt, CO_2 eq.	Level Uncertainty %	Trend Uncertainty %
Total, without LULUCF	475 056	6.42	17.75
Total, with LULUCF	411 035	9.15	26.73
Energy	340 040	5.55	20.45
Industrial processes and product use	60 718	0.94	1.94
Agriculture	57 422	6.28	13.28
LULUCF	-64 021	3.36	10.43
Waste	16 876	1.14	2.69

1.7. General Assessment of Completeness

Completeness by source and sink categories;
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.

Completeness by geographical coverage; Geographical coverage of the inventory is complete. It includes all territories of Turkey.

A complete set of CRF tables are provided for all years and estimates are calculated in a consistent manner.

Complete list of source/sink categories reported as “NE” and “IE” is given in annex 5.

2. TRENDS IN GREENHOUSE GAS EMISSIONS

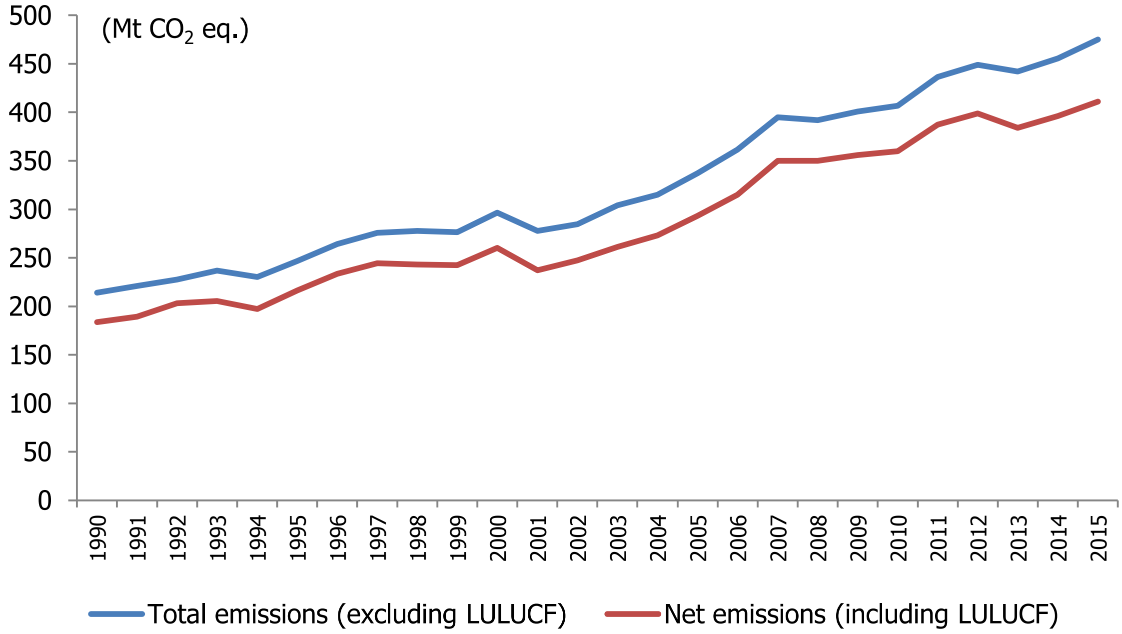
2.1. Emission Trends for Aggregated Greenhouse Gas Emissions

Total GHG emissions, excluding the LULUCF sector, were 475.1 Mt CO_2 eq. in 2015. This represents an increase of 261.1 Mt CO_2 eq. (122.0%) on total emissions in 1990 and an increase of 19.4 Mt CO_2 eq. (4.3%) in 2014.

Net GHG emissions, including the LULUCF sector, were 411.0 Mt CO_2 eq. in 2015. This represents an increase of 227.3 Mt CO_2 eq. (123.7%) on net emissions in 1990 and an increase of 14.9 Mt CO_2 eq. (3.8%) in 2014.

Figure 2.1 presents total and net GHG emissions from 1990 to 2015. The fluctuations in the emission trend are mainly due to the trends in the economic activities which can be seen through Gross Domestic Product (GDP) at market prices (constant 2010 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.

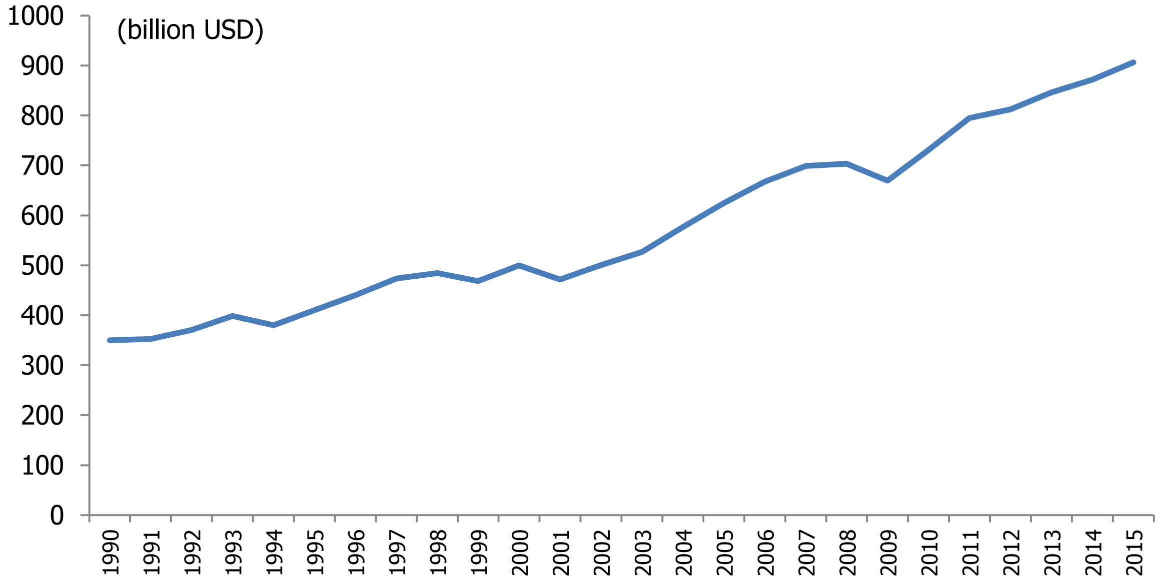
Figure 2.1 Emission trend for aggregated GHG emissions, 1990-2015



There is positive trend in the total emissions over the period 1990-2015. However, economic recession had directly caused reduction in the total GHG emissions in 1994, 1999, 2001 and 2008. In these years, total emissions are decreased 2.7%, 0.4%, 6.3% and 0.8% as compared to the previous years emissions respectively. Although there is no economic recession, total emissions are slightly decreased by 1.5% 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 2010 USD) as shown in Figure 2.2.

Figure 2.2 GDP, 1990-2015



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 1990-2015. While it was about 350 billion USD in 1990, it reached 906 billion USD with 2010 constant prices. Although economic crisis in 1994, 2001, 2009 caused 4.7%, 5.7%, 4.8% decrease in GDP, Turkish economy grew about 159% for the period 1990-2015.

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, 1990-2015

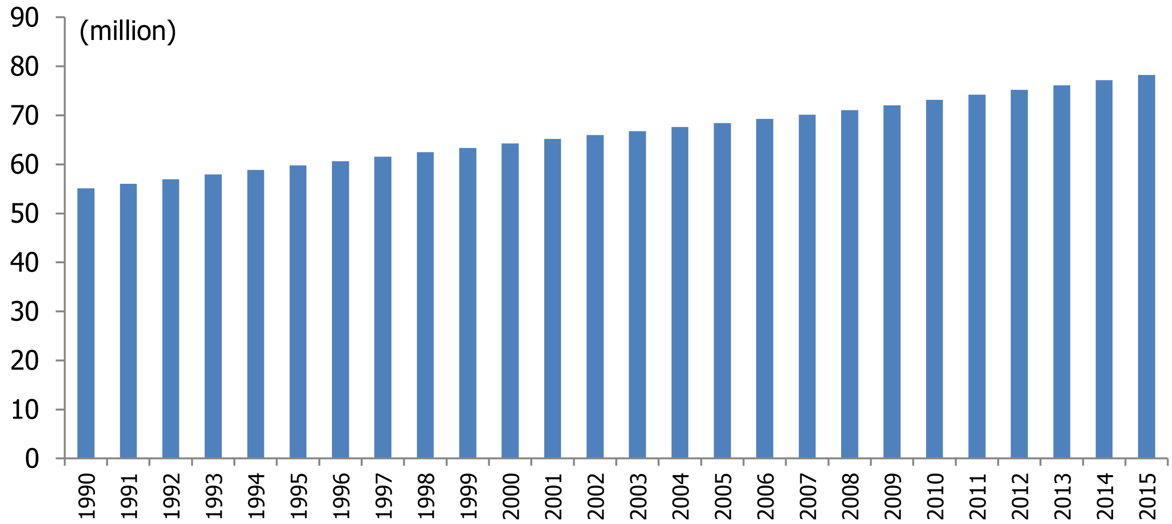


Figure 2.3 shows the mid-year population of Turkey with increase about 41.9% for the period 1990-2015. While it was 55.1 million in 1990, it reached 78.2 million in 2015. Moreover Figure 2.4 shows GHG emission per capita.

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, 1990-2015

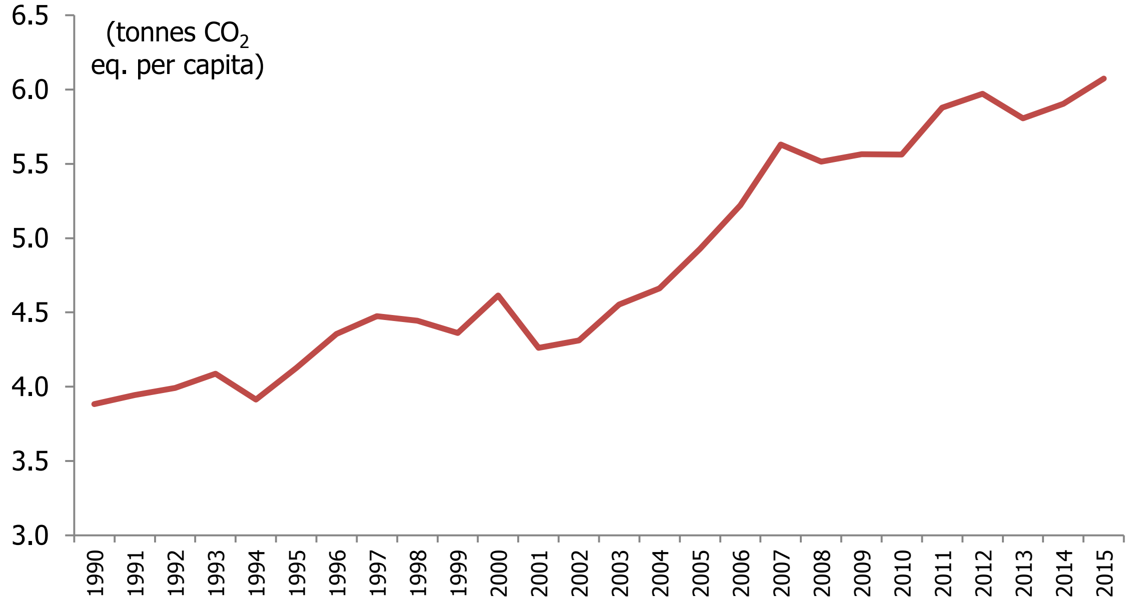


Table 2.1 gives summary data for GHG emissions for some selected years between 1990 and 2015.

Table 2.1 Aggregated GHG emissions by sectors

(Mt CO_2 eq.)

Sector	1990	1995	2000	2005	2010
Total (excluding LULUCF)	**213.97**	**246.55**	**296.47**	**337.15**	**406.81**
Energy	134.36	163.52	211.68	241.00	291.84
IPPU	23.70	27.30	27.80	35.90	50.99
Agriculture	44.82	43.35	42.50	43.34	45.78
Waste	11.09	12.38	14.49	16.92	18.20
LULUCF	-30.22	-30.16	-36.21	-43.76	-46.83
Compared to 1990 (%)	-	15.23	38.56	57.57	90.12
Sector	**2011**	**2012**	**2013**	**2014**	**2015**
Total (excluding LULUCF)	**436.35**	**448.93**	**442.17**	**455.61**	**475.06**
Energy	313.90	319.30	308.32	321.24	340.04
IPPU	55.81	57.72	60.18	60.78	60.72
Agriculture	48.15	53.77	57.20	57.23	57.42
Waste	18.50	18.15	16.47	16.36	16.88
LULUCF	-48.98	-50.20	-58.05	-59.52	-64.02
Compared to 1990 (%)	103.93	109.81	106.65	112.93	122.02

In overall 2015 emissions excluding LULUCF, the energy sector had the largest portion with 71.6%. The energy sector was followed by the IPPU with 12.8%, the agricultural activities with 12.1% and the waste with 3.6%. Total GHG emissions in 2015 increased by 4.3% compared to year 2014, and 122.0% to 1990.

2.2. Emission Trends by Gas

Total CO_2 emissions (excluding LULUCF) increased by 158.7% from 1990 to 2015. CH_4 emissions (excluding LULUCF) increased by 24.7% and N_2O emissions (excluding LULUCF) increased by 39.6%.

Total CO_2 emissions (including LULUCF) increased by 170.8% from 1990 to 2015. There are no significant changes in other GHGs by taking into account the LULUCF sector. CH_4 emissions (including LULUCF) increased by 24.7% and N_2O emissions (including LULUCF) increased by 39.5%.

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, 1990-2015

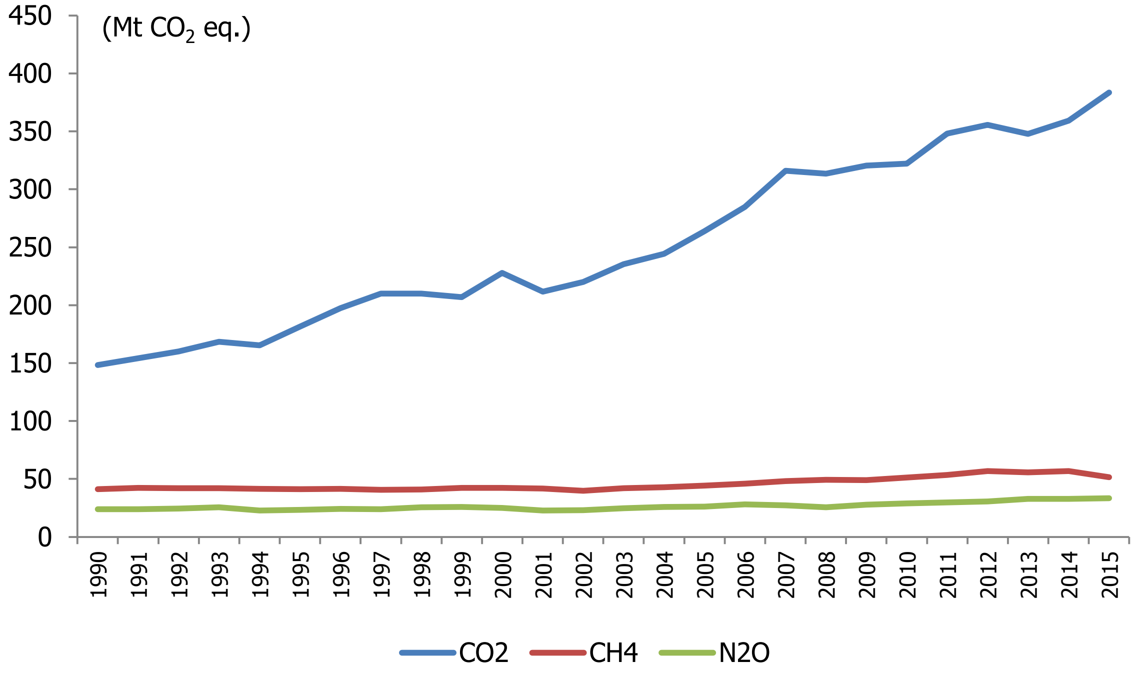


Table 2.2 gives summary data for GHG emissions by gas for some selected years between 1990 and 2015.

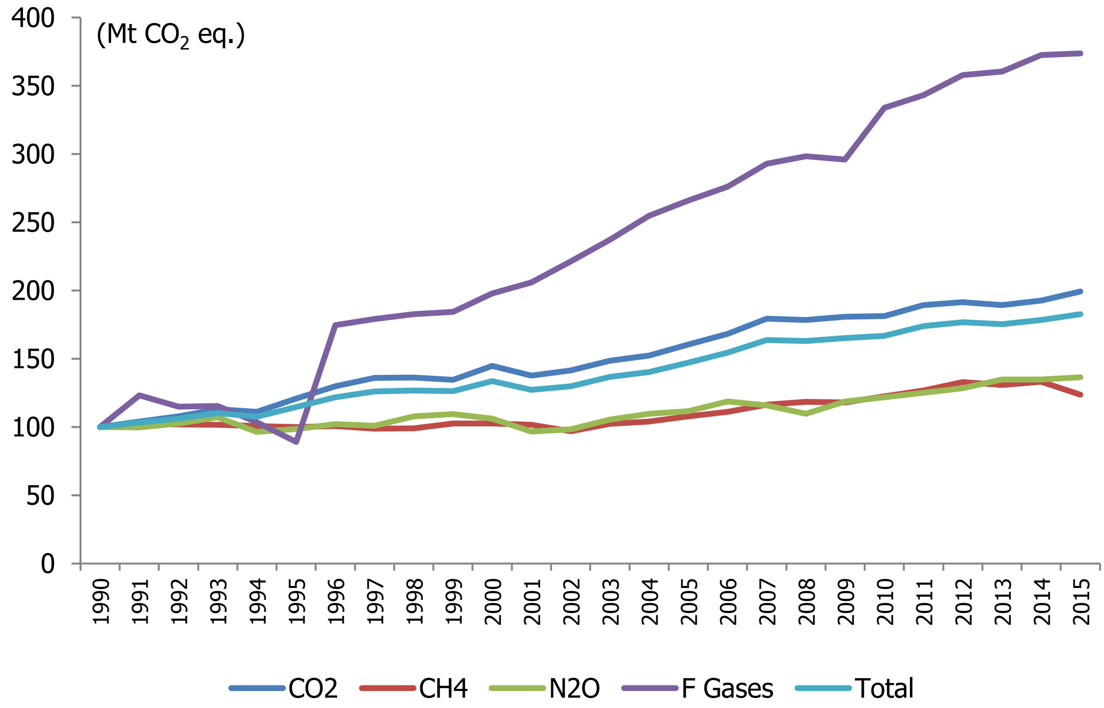
Table 2.2 Aggregated GHG emissions excluding LULUCF

(Mt CO_2 eq.)

Gas	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Total	**213.97**	**246.55**	**296.47**	**337.15**	**406.81**	**436.35**	**448.93**	**442.17**	**455.61**	**475.06**
CO_2	148.19	181.42	227.72	263.94	322.06	348.00	355.49	347.75	359.22	383.43
CH_4	41.24	41.23	42.29	44.37	51.22	53.43	56.78	55.59	56.83	51.44
N_2O	23.84	23.31	25.09	26.25	28.79	29.74	30.72	32.75	32.74	33.28
HFCs	NO	NO	0.12	1.15	3.05	3.43	4.26	4.47	4.93	4.81
PFCs	0.69	0.59	0.59	0.56	0.51	0.48	0.36	0.27	0.26	0.12
SF_6	NO	NO	0.67	0.88	1.17	1.26	1.32	1.34	1.64	1.98

Figure 2.6 shows that those all GHGs together for 1990-2015 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 80.7% of the total emission in 2015. Second one is CH_4 with 10.8%. N_2O contributes 7.0% and F gases are following with 1.5%.

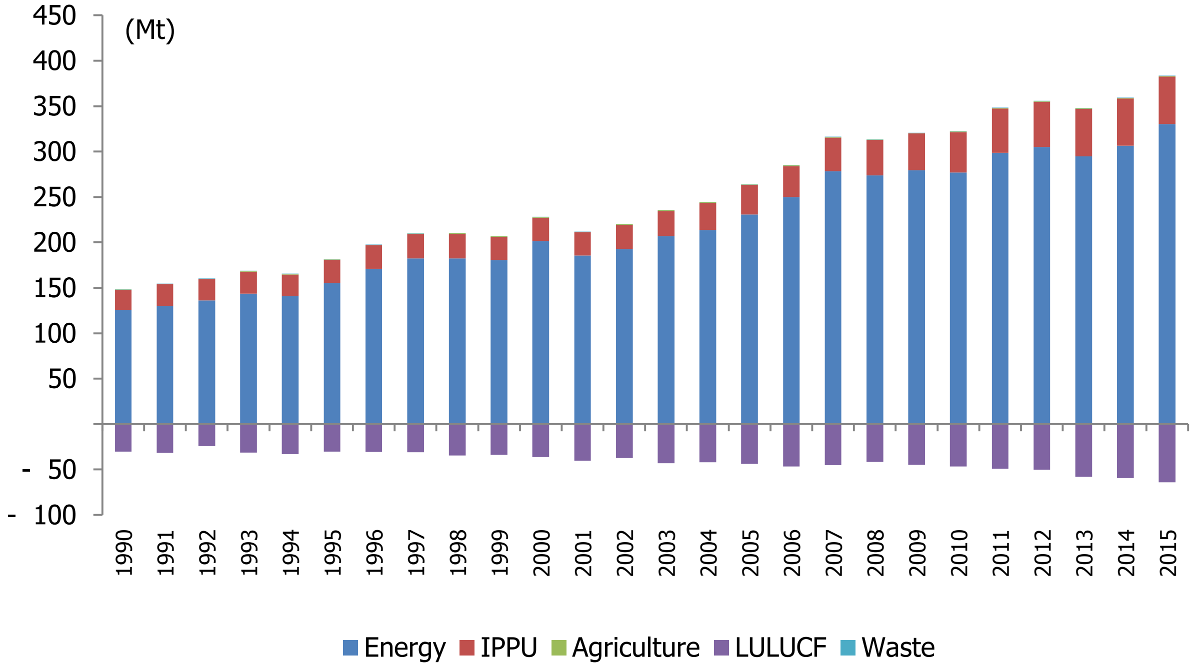
Figure 2.6 Emission trend of all GHGs, 1990-2015



Carbon Dioxide (CO_2)

In 2015, CO_2 emissions are 383.4 Mt (excluding LULUCF), 6.7% above the 2014 level and 158.7% 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 2015 excluding the LULUCF, energy sector is responsible for 86.1% of the total CO_2 emissions while IPPU is responsible for 13.6%. Agriculture and waste sectors do not cause significant amount of CO_2 emission.

Figure 2.7 CO_2 emissions by sector, 1990-2015

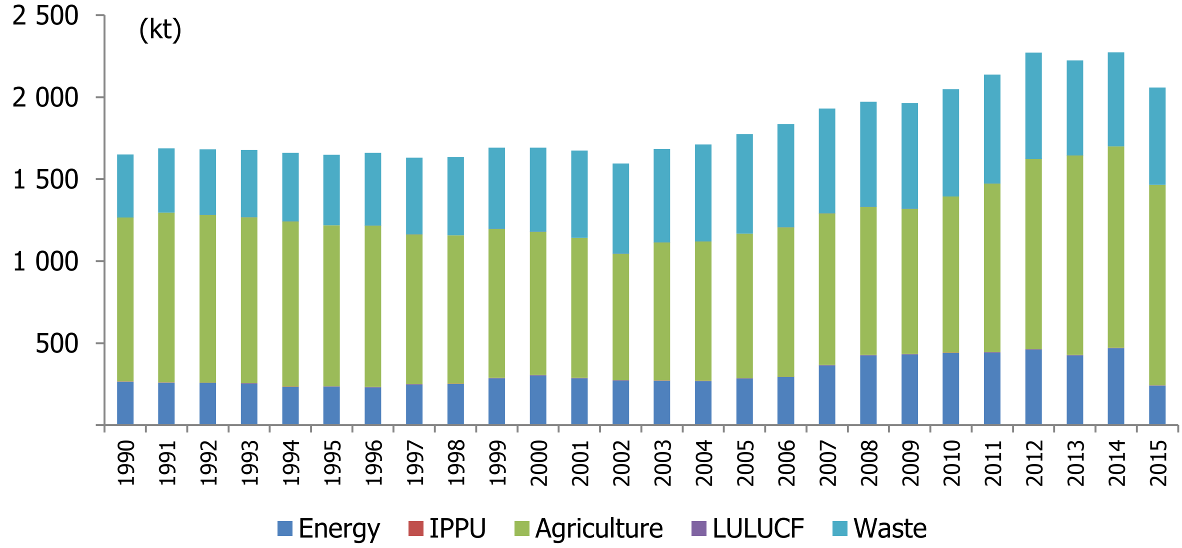


Methane (CH_4)

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 24.7% since the base year 1990 and have decreased by 9.5% compared to 2014. In 2015, CH_4 emissions were 2 057.6 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.

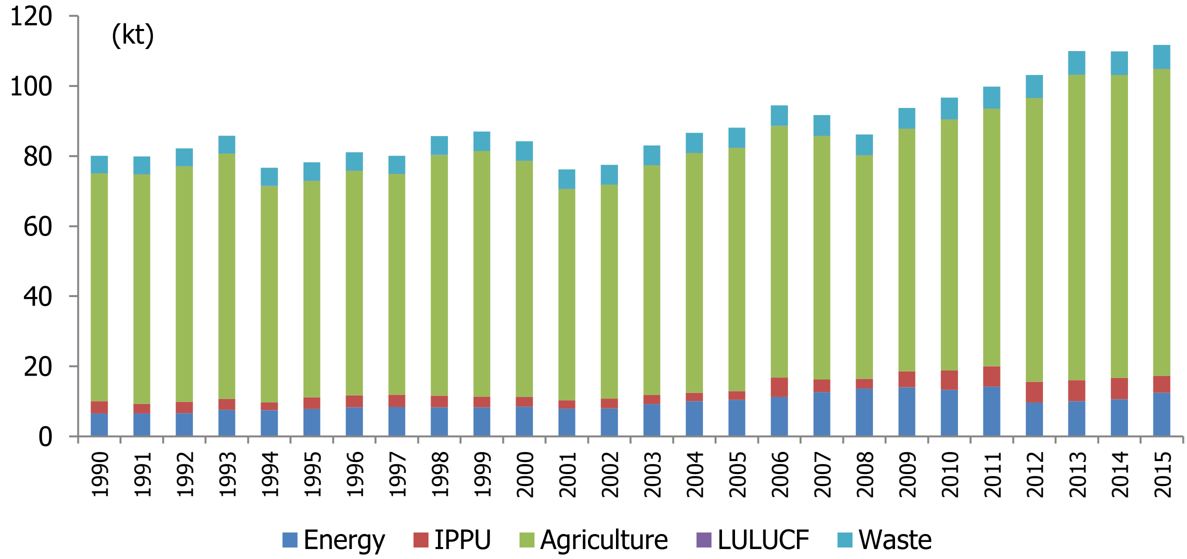
Figure 2.8 CH_4 emissions by sector 1990-2015



Nitrous Oxide (N_2O)

In 2015, N_2O emissions are 111.7 kt and it is almost the same level with 2014 level (109.9 kt) but 39.6% 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 78.4% in 2015. Energy sector is responsible for 11.2% and waste sector is responsible for 6.1% of all N_2O emissions. IPPU has a minor share for the N_2O emissions by 4.3%.

Figure 2.9 N_2O emissions by sector 1990-2015



Fluorinated Gases (HFCs, PFCs, SF_6)

The F gases are only caused by the IPPU sector. In 2015, 6 910 kt CO_2 eq. of F gases released to the atmosphere. It is seen from Table 2.3 that total F gases emissions increased by 897.5% 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.

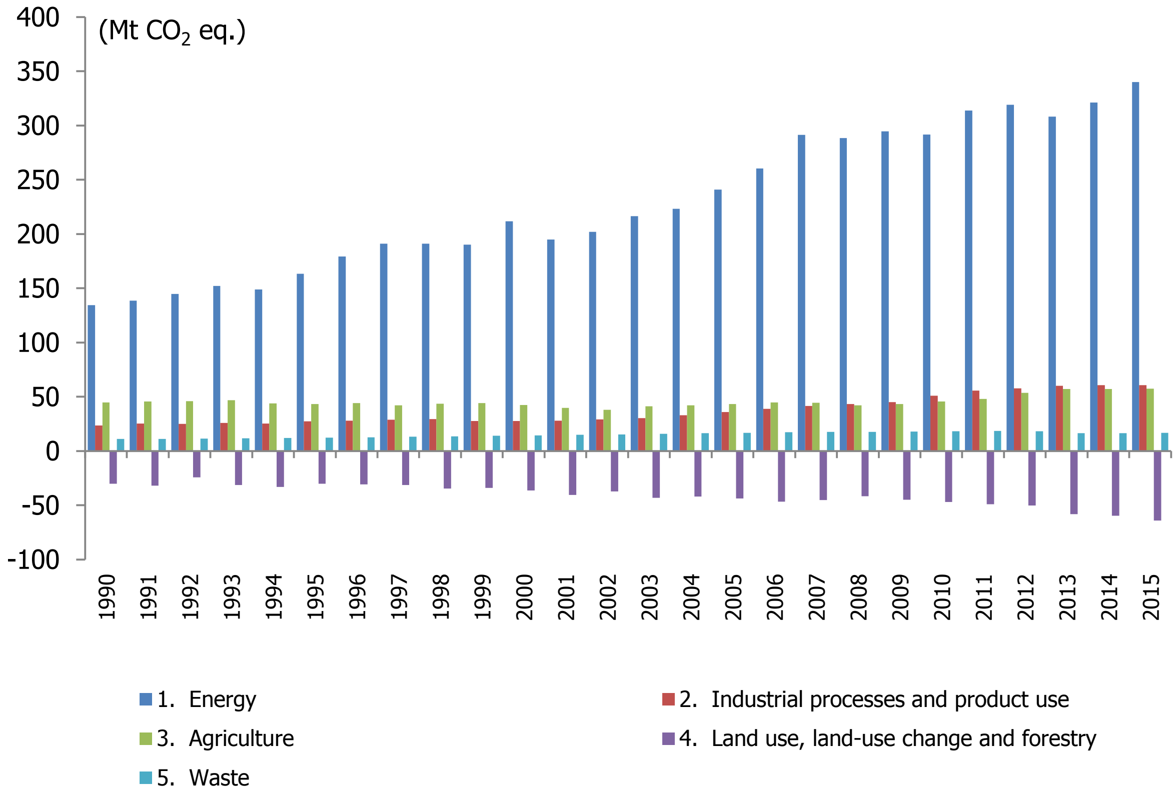
Table 2.3 Fluorinated gases emissions by sector 1990-2015

(kt CO_2 eq.)

Year	HFCs	PFCs	SF_6
1990	NO	692.77	NO
1991	NO	854.54	NO
1992	NO	781.92	NO
1993	NO	786.58	NO
1994	NO	693.65	NO
1995	NO	592.88	NO
1996	NO	597.28	503.30
1997	NO	593.33	555.75
1998	NO	593.87	595.25
1999	NO	591.07	618.99
2000	115.66	591.38	667.13
2001	232.00	592.20	658.81
2002	417.19	595.92	698.71
2003	628.80	595.33	758.55
2004	909.37	600.78	822.19
2005	1 146.88	559.97	884.09
2006	1 424.19	460.95	971.02
2007	1 713.19	574.44	1 052.90
2008	1 896.14	527.71	1 099.14
2009	2 111.28	259.26	1 064.84
2010	3 054.28	513.89	1 167.75
2011	3 432.64	480.36	1 263.10
2012	4 256.83	359.06	1 322.98
2013	4 470.24	270.59	1 344.17
2014	4 927.55	255.42	1 637.67
2015	4 805.04	120.09	1 984.90

2.3. Emission Trends by Sector

Figure 2.10 GHG emission trend by sectors, 1990-2015



1990-2015: All sectors have an increasing trend from 1990 to 2015 included IPPU (156.2%), energy (153.1%), LULUCF (111.9%), waste (52.2%) and agriculture (28.1%).

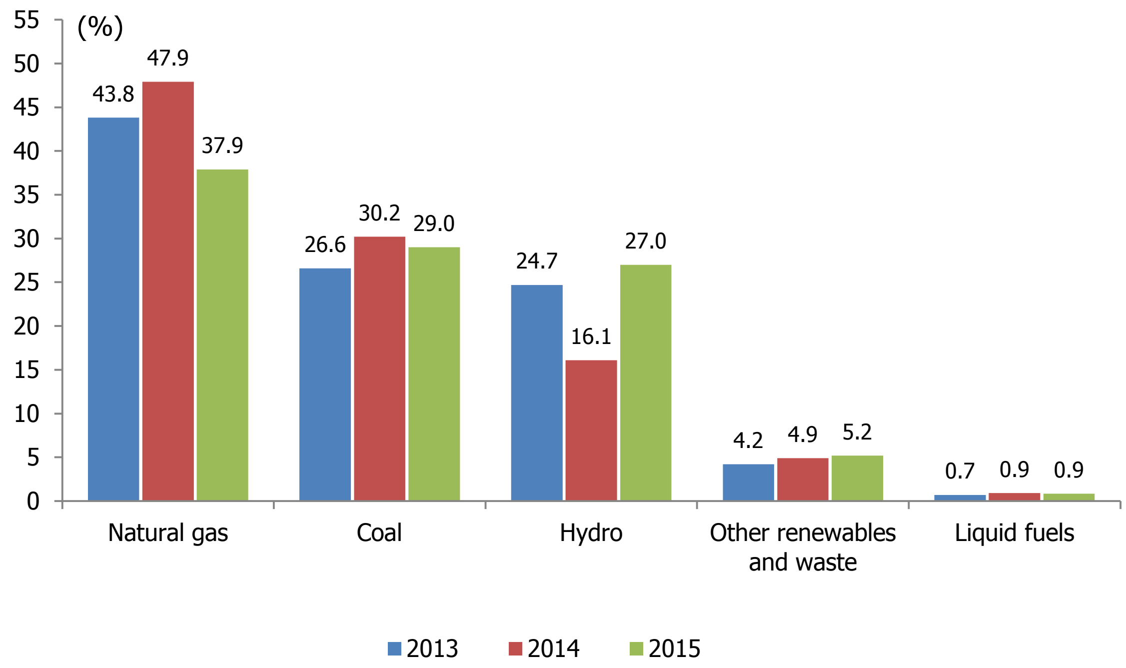
The main reasons of the increase for all sectors are population growth, a growing economy and an increase in energy demand.

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 lands, dams) and settlements.

2014-2015: There are both increasing and decreasing trends in the annual change for each sector from 2014 to 2015. The sectors having increasing trends are LULUCF (7.6%), energy (5.9%), waste (3.2%) and agriculture (0.3%). The only sector having decreasing trend is IPPU (0.1%).

The increase in energy sector is mainly originating from electricity and heat production in 2015. As shown in Figure 2.11 electricity production from natural gas is decreased so it is compensated by renewable energy sources (especially by hydraulic power generation) in 2015.

Figure 2.11 Electricity generation and shares by energy resources, 2014-2015



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 2015, 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**	**2011**	**2012**	**2013**	**2014**	**2015**
Energy	73.12	75.56	81.33	82.14	81.07	81.03	80.08	80.27	81.10	82.73
IPPU	12.90	12.62	10.68	12.24	14.16	14.41	14.47	15.67	15.34	14.77
Agriculture	24.39	20.03	16.33	14.77	12.72	12.43	13.49	14.89	14.45	13.97
Waste	6.04	5.72	5.57	5.77	5.06	4.78	4.55	4.29	4.13	4.11
LULUCF	-16.45	-13.94	-13.91	-14.91	-13.01	-12.64	-12.59	-15.11	-15.03	-15.58

Table 2.5 Contribution of sectors to the GHG emissions without LULUCF

(%)

Sectors	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Energy	62.79	66.32	71.40	71.48	71.74	71.94	71.12	69.73	70.51	71.58
IPPU	11.08	11.07	9.38	10.65	12.53	12.79	12.86	13.61	13.34	12.78
Agriculture	20.95	17.58	14.34	12.85	11.25	11.03	11.98	12.94	12.56	12.09
Waste	5.18	5.02	4.89	5.02	4.47	4.24	4.04	3.73	3.59	3.55

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 2015, emissions from the energy sector are 71.6% 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.

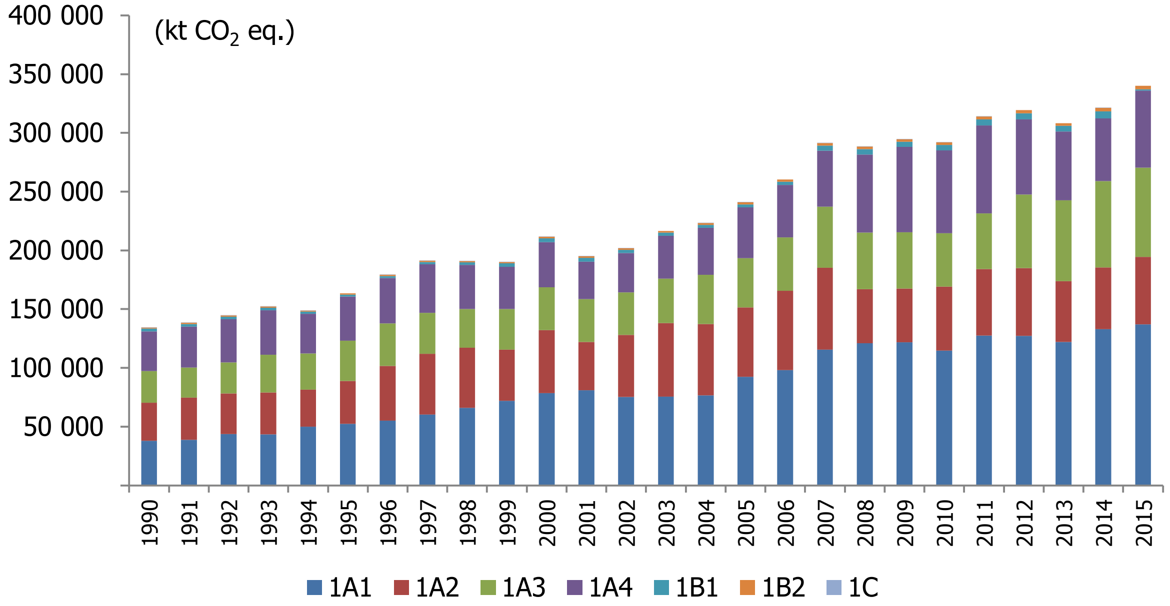
CO_2 emissions are 97.1% of the total energy sector emissions, showed an increase by 162.5% from 1990 to 2015. CH_4 emissions are just 1.8% of the total, decreased by 8.7% in comparison with the 1990. N_2O emissions, with 1.1% contribution to total emissions of energy sector, show 91.1% increase in proportion 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	2015
Total	**134 359**	**163 518**	**211 678**	**241 001**	**291 843**	**319 300**	**308 323**	**321 242**	**340 040**
Fuel combustion	131 009	160 770	206 935	236 583	285 051	311 400	301 247	312 440	335 909
Energy industries	37 986	52 520	78 568	92 421	114 870	127 230	122 067	133 105	136 970
Manufacturing industries and construction	32 381	36 431	53 669	59 019	54 435	57 702	51 777	52 295	57 636
Transport	26 969	34 113	36 465	42 041	45 392	62 525	68 865	73 559	75 789
Other sectors	33 673	37 706	38 233	43 101	70 355	63 943	58 539	53 480	65 514
Fugitive emissions from fuels	3 350	2 748	4 743	4 418	6 792	7 900	7 075	8 803	4 131
Solid fuels	2 459	1 735	3 457	2 634	4 737	5 393	4 899	5 926	1 236
Oil and natural gas	891	1 013	1 286	1 784	2 054	2 507	2 176	2 876	2 894
CO_2 transport and storage	0.13	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, 1990-2015



GHG emissions of energy sector, in CO_2 eq., show an increase by 153.1% from 1990 to 2015. Generally, an upward trend is noted from 1990-2015.

Industrial Processes and Product Use (IPPU)

Emissions from industrial processes and product use sector have a share of 12.8% of Turkey's total emissions excluding LULUCF in 2015. CO_2 emissions in year 2015, are 86.2% of total IPPU emissions. N_2O has 2.3% share in IPPU emissions and increased by 33.1%. Whereas, CH_4 has a minor impact.

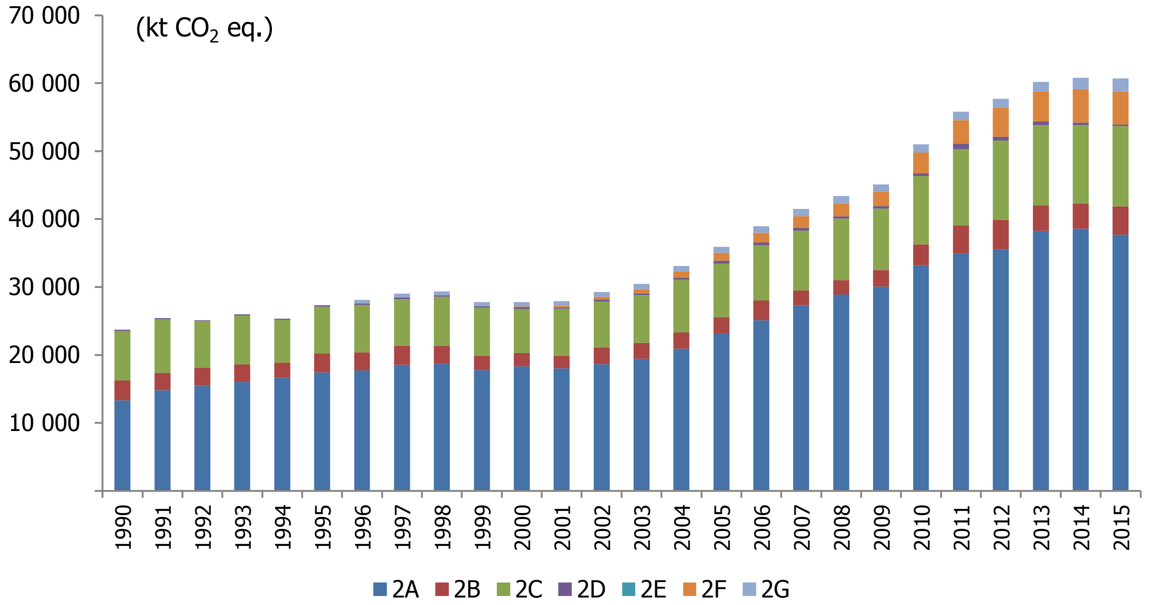
Emissions by each subsector of IPPU are tabulated in Table 2.7 for the 1990-2015 period. Figure 2.13 shows the trend for the IPPU related emissions by cumulating its subsectors.

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

(kt CO_2 eq.)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Total	**23 699**	**27 303**	**27 804**	**35 897**	**50 988**	**55 807**	**57 715**	**60 177**	**60 779**	**60 718**
Mineral industry	13 311	17 457	18 333	23 184	33 194	34 974	35 574	38 245	38 594	37 708
Chemical industry	2 933	2 777	1 968	2 397	3 068	4 087	4 302	3 824	3 672	4 174
Metal industry	7 278	6 867	6 448	7 881	10 081	11 212	11 668	11 765	11 559	11 789
Non-energy products from fuels and solvent use	177	200	272	404	423	839	592	528	388	257
Electronic industry	NO	NO	NO	NO	0.14	0.14	0.14	0.14	0.14	0.14
Product uses as ODS substitutes	NO	NO	116	1 147	3 054	3 433	4 257	4 470	4 927	4 805
Other product manufacture and use	NE,NO	NE,NO	667	884	1 168	1 263	1 323	1 344	1 638	1 985

Figure 2.13 Trend of total emissions from IPPU sector, 1990-2015



IPPU related emissions increased by 156.2% from 1990 to 2015. 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 2015, the agriculture sector accounted for 12.1% of total emissions in Turkey.

Enteric fermentation and agricultural soils dominate the trends in this sector between 1990 and 2015 as seen in Table 2.8 and they have an increase by 20.5% and 30.5% compared to 1990 respectively.

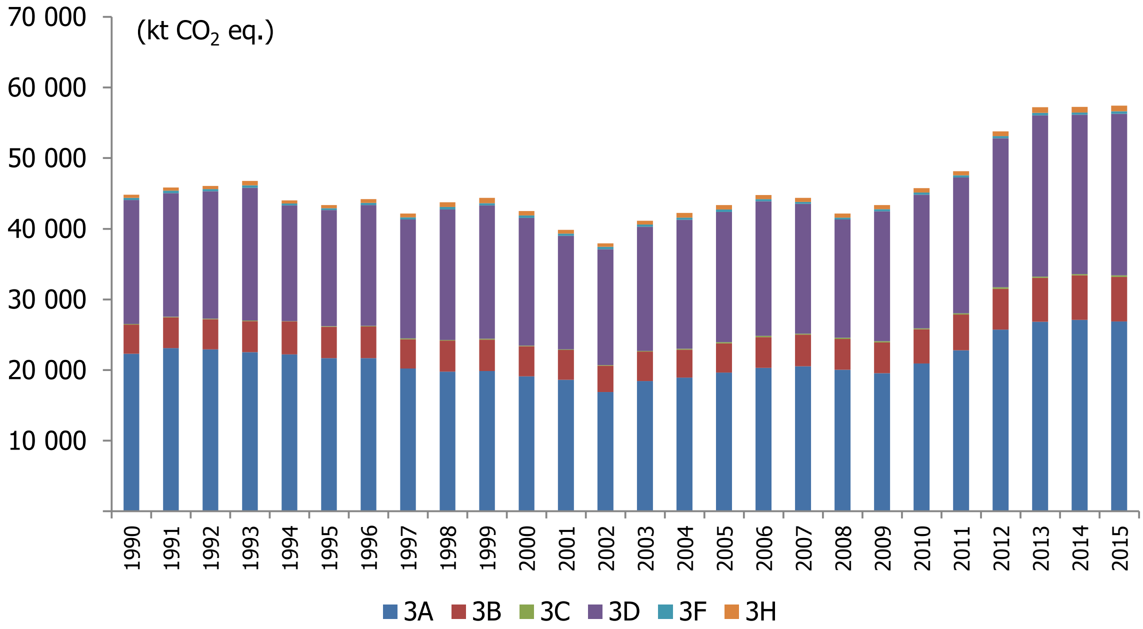
Most important portion in each gas is CH_4 with 53.1%, then comes N_2O with 45.5% share in agriculture sector emissions. CO_2 has the lowest contribution with 1.4%.

Table 2.8 Total emissions from agriculture sector by source

(kt CO_2 eq.)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Total	**44 824**	**43 351**	**42 504**	**43 335**	**45 776**	**48 145**	**53 770**	**57 198**	**57 233**	**57 422**
Enteric fermentation	22 314	21 705	19 124	19 663	20 912	22 806	25 740	26 850	27 094	26 888
Manure management	4 111	4 427	4 240	4 133	4 840	5 039	5 771	6 188	6 313	6 304
Rice cultivation	91	86	100	147	171	171	206	191	191	200
Agricultural soils	17 528	16 408	18 088	18 429	18 900	19 239	21 105	22 827	22 556	22 878
Field burning of agricultural residues	319	299	334	351	308	332	308	335	292	342
Urea application	460	426	617	613	645	558	640	807	788	811

Figure 2.14 Trend of total emissions from agriculture sector, 1990-2015



Land Use, Land Use Change and Forestry (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.

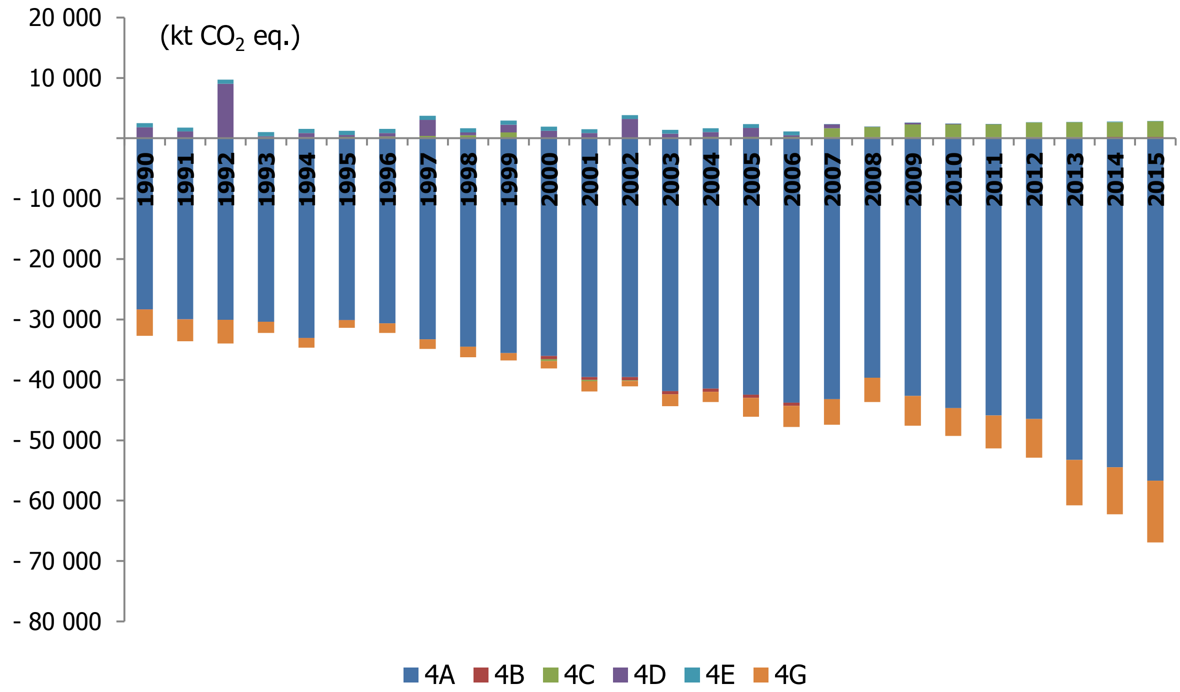
In 2015, total CO_2 eq. emissions and removals of the LULUCF sector has increased 7.6% compared to 2014. Table 2.9 reports emissions and removals from the LULUCF sector by source.

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

(kt CO_2 eq.)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Total	**-30 219**	**-30 157**	**-36 208**	**-43 758**	**-46 826**	**-48 980**	**-50 203**	**-58 053**	**-59 515**	**-64 021**
Forest land	-28 323	-30 098	-36 060	-42 447	-44 684	-45 914	-46 481	-53 261	-54 458	-56 675
Cropland	- 37	- 6	- 502	- 510	194	191	197	203	205	213
Grassland	84	228	- 304	236	2 124	2 096	2 417	2 450	2 482	2 604
Wetlands	1 742	341	1 233	1 499	61	8	NO,NE	NO,NE	NE,NO	NO,NE
Settlements	683	683	683	629	64	64	64	64	64	64
Harvested wood products	-4 368	-1 306	-1 257	-3 164	-4 585	-5 425	-6 400	-7 509	-7 809	-10 227

Figure 2.15 Trend of total emissions from the LULUCF sector, 1990-2015



LULUCF emissions or removals, in CO_2 equivalent, are variable over the reporting period 1990-2015 as seen in Figure 2.15. Generally decreases in removals were influenced by dam constructions, 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, wastewater 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 2015 are 3.6% of total GHG emissions (without LULUCF). Considering emissions by gas, the most important GHG is CH_4 which accounts for 87.9% of the total and shows a decrease of 54.6% from 1990 to 2015. N_2O levels have increased by 39.1% whereas CO_2 decreased by 98.0%; these gases account for 12.1% and 0.003%, respectively.

Table 2.10 Total emissions from the waste sector by source

(kt CO_2 eq.)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Total	**11 090**	**12 382**	**14 487**	**16 919**	**18 198**	**18 505**	**18 148**	**16 473**	**16 360**	**16 876**
Solid waste disposal	6 730	7 652	9 712	12 086	13 359	13 644	13 214	11 822	11 893	12 455
Biological treatment of solid waste	19	16	23	28	23	28	27	16	16	16
Incineration and open burning of waste	105	103	88	43	32	29	25	13	1	1
Wastewater treatment and discharge	4 236	4 611	4 663	4 762	4 785	4 803	4 882	4 623	4 450	4 404

Figure 2.16 Trend of total emissions from the waste sector, 1990-2015

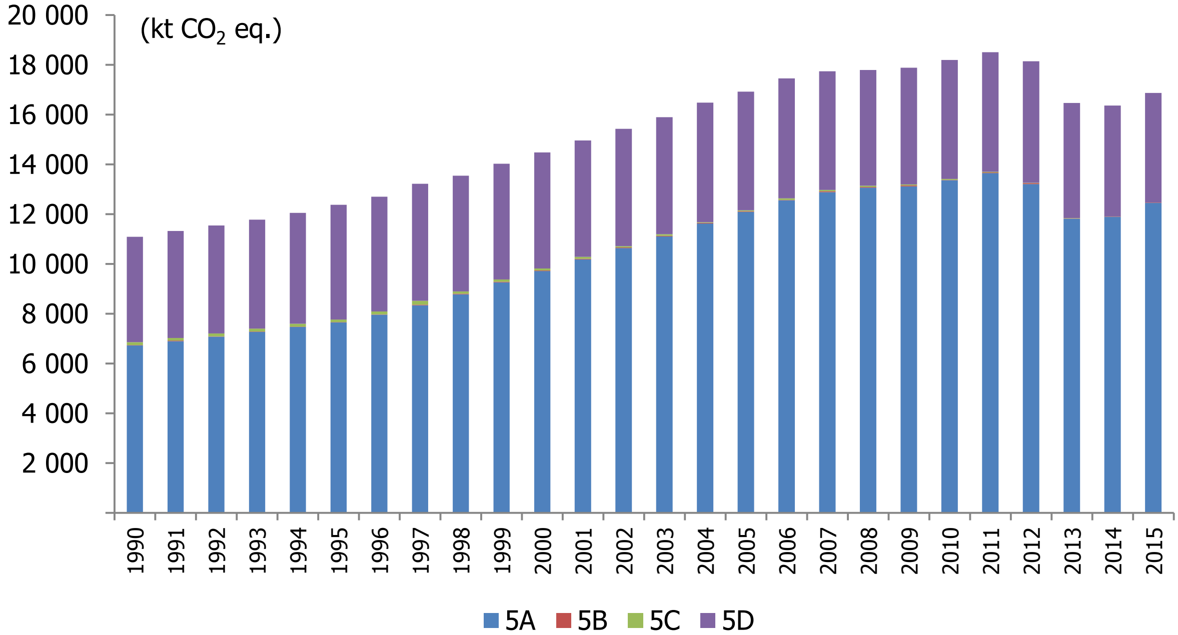


Figure 2.16 shows trends in waste sector between 1990-2015. The trend is mainly driven by solid waste disposal with 73.8% of the emissions were from, followed by 26.1% from wastewater treatment and discharge, 0.09% from biological treatment of solid waste and 0.01% from open burning of waste. Total emissions, in CO_2 equivalent, increased by 3.2% from 2014 to 2015.

2.4. Emission Trends for Indirect Greenhouse Gases

Emission trends of NO_X, CO, NMVOC and SO_2 from 1990 to 2015 are given in Table 2.11.

Table 2.11 Total emissions for indirect greenhouse gases, 1990-2015

(kt)

Gas	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
NO_X	562.0	700.0	671.6	720.1	768.5	876.4	830.5	796.7	782.8	877.7
CO	2 023.0	2 008.0	2 875.3	2 365.3	2 833.4	2 725.5	2 917.4	2 107.1	1 991.2	2 347.1
NMVOC	942.0	1 035.2	1 108.0	1 015.1	1 045.9	1 066.4	1 125.0	1 073.2	1 078.1	1 017.3
SO_2	1 747.2	1 886.5	2 238.8	2 002.5	2 558.1	2 637.5	2 713.5	1 940.7	2 145.0	1 935.3

1990-2015: All gases have an increasing trend from 1990 to 2015 included NO_X (56.2%), CO (16.0%), SO_2 (10.8%) and NMVOC (8.0%).

2014-2015: There are both increasing and decreasing trends in the annual change for each gases from 2014 to 2015. The gases having increasing trends are CO (17.9%) and NO_X (12.1%). The gases having decreasing trends are SO_2 (9.8%) and NMVOC (5.6%).

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 2015 GHG emissions (excluding LULUCF), the energy sector had the largest portion with 71.6%.

Energy sector CO_2 emissions constituted 86.1% of total CO_2 emissions in 2015. The non-CO_2 emissions from energy-related activities represented rather small portion of the total national emissions. CH_4 emissions in total CH_4 11.7% and it is 11.2% for N_2O in 2015.

Total emissions from the energy sector for 2015 were estimated to be 340 Mt CO_2 eq. (Table 3.1). Energy industries were the main contributor, accounting for 40.3% of emissions from the energy sector. It is followed by transport sector with 22.3%, other sector with 19.3% and manufacturing industries with 16.9% (Table 3.2).

Energy sector GHG emissions increased by 153.08% between 1990 and 2015. Annual emissions from 2014 to 2015 increased by 5.85% (18.8 Mt CO_2 eq.).

Table 3.1 Energy sector emissions by gas, 1990-2015

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	125 801	264	6.5	134 359
1991	130 061	259	6.5	138 480
1992	136 240	258	6.7	144 680
1993	143 594	255	7.6	152 218
1994	140 785	233	7.5	148 853
1995	155 299	235	7.8	163 518
1996	170 935	232	8.3	179 216
1997	182 511	249	8.4	191 249
1998	182 230	251	8.3	190 988
1999	180 591	286	8.3	190 217
2000	201 534	305	8.5	211 678
2001	185 467	286	7.9	194 974
2002	192 697	273	8.0	201 924
2003	207 015	271	9.3	216 559
2004	213 594	270	10.1	223 329
2005	230 776	284	10.5	241 001
2006	249 803	293	11.3	260 496
2007	278 455	365	12.7	291 365
2008	273 764	427	13.6	288 496
2009	279 576	433	14.0	294 572
2010	276 856	441	13.3	291 843
2011	298 590	443	14.2	313 897
2012	304 896	461	9.7	319 300
2013	294 679	426	10.1	308 323
2014	306 321	470	10.6	321 242
2015	330 280	241	12.5	340 040

Table 3.2 Energy sector GHG emissions, 1990-2015

(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	134 359	131 009	37 986	32 381	26 969	33 673	3 350	2 459	891	0.13
1991	138 480	135 247	38 859	35 854	25 673	34 860	3 234	2 173	1 060	0.13
1992	144 680	141 551	43 642	34 562	26 366	36 982	3 128	2 082	1 046	0.13
1993	152 218	149 119	43 300	35 875	32 143	37 801	3 098	2 101	997	0.13
1994	148 853	146 018	49 859	31 766	30 640	33 753	2 835	1 857	977	0.13
1995	163 518	160 770	52 520	36 431	34 113	37 706	2 748	1 735	1 013	0.13
1996	179 216	176 535	55 120	46 483	36 271	38 660	2 681	1 614	1 067	0.13
1997	191 249	188 288	60 309	51 772	34 690	41 517	2 960	1 808	1 152	0.13
1998	190 988	187 765	65 935	51 340	32 782	37 708	3 222	2 067	1 155	0.13
1999	190 217	185 926	72 042	43 522	34 617	35 745	4 291	3 076	1 215	0.13
2000	211 678	206 935	78 568	53 669	36 465	38 233	4 743	3 457	1 286	0.13
2001	194 974	190 377	81 029	41 110	36 455	31 784	4 596	3 305	1 291	0.13
2002	201 924	197 692	75 379	52 716	36 234	33 363	4 232	2 899	1 333	0.13
2003	216 559	212 446	75 571	62 509	37 825	36 541	4 113	2 613	1 500	0.13
2004	223 329	219 313	76 650	60 576	42 048	40 039	4 016	2 476	1 540	0.13
2005	241 001	236 583	92 421	59 019	42 041	43 101	4 418	2 634	1 784	0.13
2006	260 496	255 843	98 020	67 756	45 424	44 642	4 653	2 715	1 938	0.13
2007	291 365	284 975	115 691	69 565	52 099	47 620	6 390	4 194	2 196	0.13
2008	288 496	281 693	120 926	45 977	48 166	66 623	6 802	4 537	2 265	0.13
2009	294 572	288 036	121 751	45 718	47 907	72 660	6 537	4 488	2 049	0.13
2010	291 843	285 051	114 870	54 435	45 392	70 355	6 792	4 737	2 054	0.13
2011	313 897	306 398	127 614	56 596	47 386	74 803	7 498	5 117	2 381	0.13
2012	319 300	311 400	127 230	57 702	62 525	63 943	7 900	5 393	2 507	0.13
2013	308 323	301 247	122 067	51 777	68 865	58 539	7 075	4 899	2 176	0.13
2014	321 242	312 440	133 105	52 295	73 559	53 480	8 803	5 926	2 876	0.13
2015	340 040	335 909	136 970	57 636	75 789	65 514	4 131	1 236	2 894	0.13

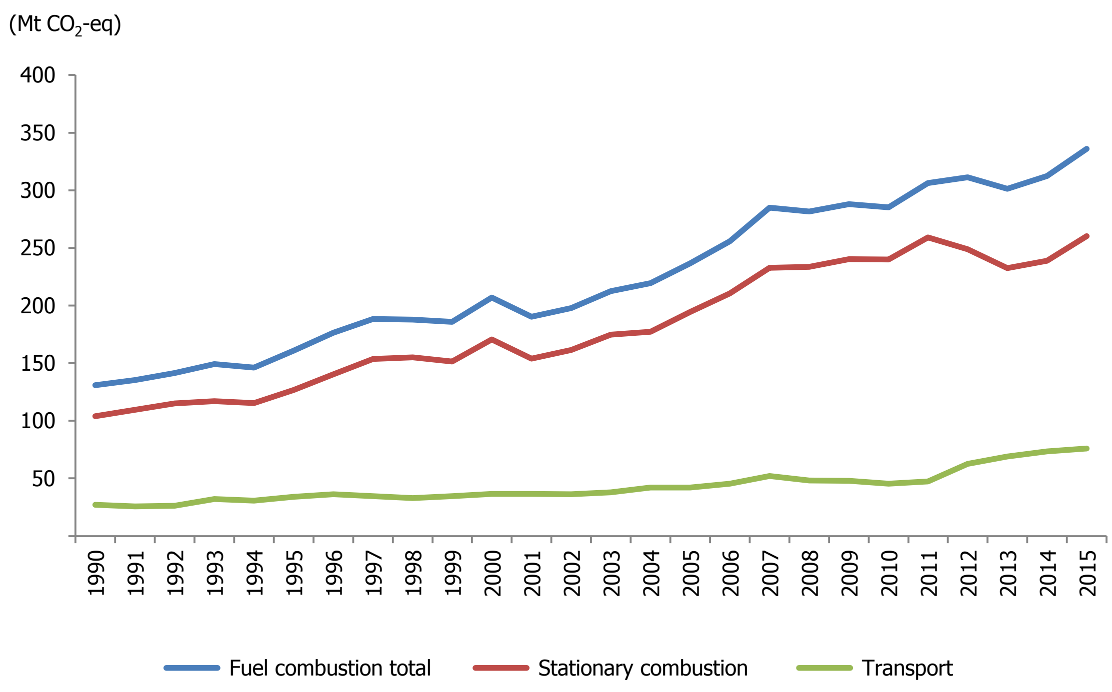
Energy sector GHG emissions mainly are coming from stationary combustion. Total emissions from stationary combustion are 260.1 Mt CO_2 eq. in 2015, equal to 54.8% of total national GHG emissions (excluding LULUCF).

The energy industries subsector includes fuel combustion in public electricity and heat production, petroleum refining, and manufacture of solid fuels. Public electricity and heat production (1.A.1.a) contributed 129.6 Mt CO_2 eq. which is 49.8% of stationary combustion in 2015. The manufacturing industries and construction subsector (1.A.2) emissions were 57.6 Mt CO_2 eq. in 2015 while it was 65.5 Mt CO_2 eq. from other sectors (1.A.4).

GHG emissions from stationary combustion increased by 150% (156.1 Mt CO_2 eq.) between 1990 and 2015, and increased by 8.9% (21.2 Mt CO_2 eq.) between 2014 and 2015.

Although GHG emissions of Turkey demonstrated an increasing trend between 1990 and 2015, 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, 1990-2015



In 2015, transport contributed 75.8 Mt CO_2 eq., which is 16% of total GHG emissions (excluding LULUCF). The major source of transport emissions in Turkey is road transportation. It accounts for 91.4% of transport emissions. It is followed by domestic aviation while other sources are far smaller: domestic aviation with 5.5% and domestic navigation with 1.5%. Pipeline transport contribution was 0.9% and railway contribution was 0.6%.

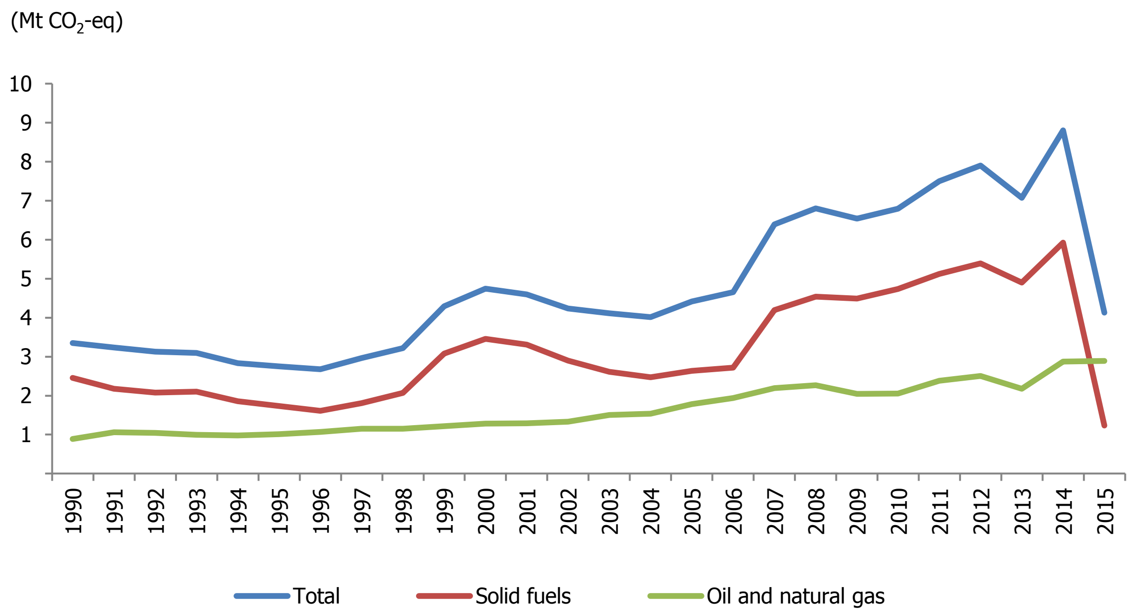
Fuel used in international aviation and marine bunkers is reported separately from the national total. In 2015, international bunker GHG emissions were 13.9 Mt CO_2 eq.

Emissions from transport sector increased 181% in 2015 compared to 1990. In the same period increase in road transportation emissions was 179.7%, in domestic aviation it was 355.7% and in domestic navigation it was 125.5%. Emissions from railway transport decreased by 33.4% between 1990 and 2015.

Total fugitive emissions for 2015 were 4.1 Mt CO_2 eq., representing 0.9% of total GHG emissions (excluding LULUCF). Oil and natural gas systems contributed 70.1%, solid fuels account for the remaining 29.9% of fugitive emissions.

Although overall fugitive emissions increased 23.3% between 1990 and 2015, it decreased by 53% from 2014 to 2015. From 1990 to 2015, fugitive emissions from oil and natural gas systems increased by 224.8%. Emissions from solid fuels decreased by 49.7% in the same period.

Figure 3.2 Fugitive emissions, 1990-2015



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

GHG sources and sink categories	CO_2		CH_4		N_2O	
	Method applied	**Emission factor**	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**
1. Energy	T1,T2,T3	CS,D,PS	T1,T2,T3	D,PS	T1,T2,T3	D,PS
A. Fuel combustion	T1,T2,T3	CS,D,PS	T1,T2,T3	D,PS	T1,T2,T3	D,PS
1. Energy industries	T2,T3	CS,D,PS	T2,T3	D,PS	T2,T3	D,PS
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 and plant 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 public electricity and heat production 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. Technology specific CH4 and N_2O emission factors from 2006 IPCC guidelines are used for 1A1a category for 2003-2015 period and 2006 IPCC guidelines default CH4 and N_2O EFs are used for 1990-2002 period since combustion technology data is available from 2003 onward for this category.

For petroleum refining sector (1A1b), fuel consumption data, NCVs and carbon content of fuels are compiled directly from the refineries. In the same way for manufacture of solid fuels (1A1c) categories, plant specific AD and plant specific carbon content are used in the emission estimation. 2006 IPCC guidelines default EFs are used for CH4 and N_2O 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. 2006 IPCC guidelines default EFs are used for CH4 and N_2O emission estimation.

Transportation sector consists of road transportation, domestic aviation, railways, domestic navigation and pipeline transportation. Data availability in road transportation, navigation sector and railways allows mostly T1 methodology in the emission 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 77% of total road transportation, and 22.8% from LPG and gasoline. T2 methodology was used for the calculation of emissions from domestic aviation. Also T2 methodology was used for the calculation of CO_2 emissions from pipeline transportation. 2006 IPCC guidelines default EFs are used for CH4 and N_2O emission estimation.

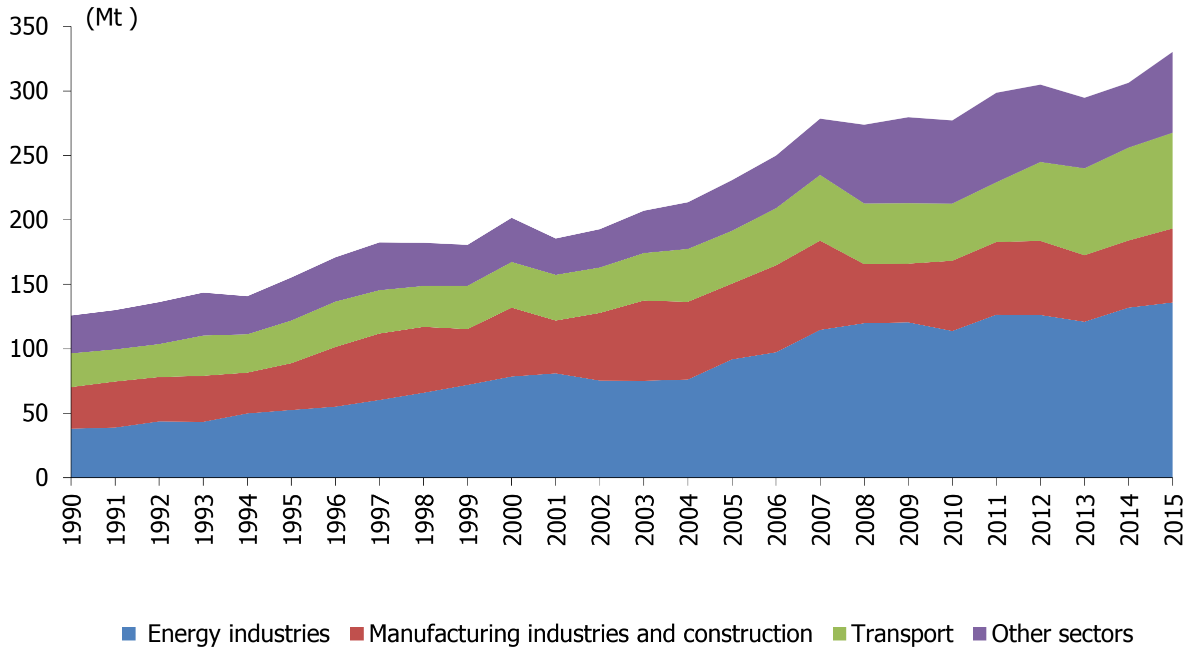
CO_2, CH_4 and N_2O emissions from fuel combustion were calculated for the period 1990-2015.

Table 3.4 Emissions from fuel combustion, 1990-2015

(kt)

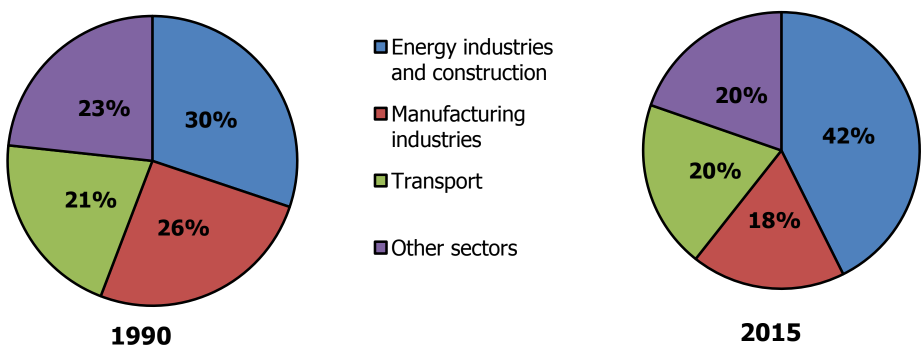
Year	CO_2	CH_4	N_2O	CO_2-eq
1990	125 581	139	6.5	131 009
1991	129 798	140	6.5	135 247
1992	135 986	143	6.7	141 551
1993	143 363	140	7.6	149 119
1994	140 566	129	7.5	146 018
1995	155 090	134	7.8	160 770
1996	170 727	133	8.3	176 535
1997	182 304	139	8.4	188 288
1998	182 036	130	8.3	187 765
1999	180 413	122	8.3	185 926
2000	201 366	122	8.5	206 935
2001	185 312	108	7.9	190 377
2002	192 549	110	8.0	197 692
2003	206 870	113	9.3	212 446
2004	213 453	115	10.1	219 313
2005	230 634	113	10.5	236 583
2006	249 668	113	11.3	255 843
2007	278 322	115	12.7	284 975
2008	273 629	160	13.6	281 693
2009	279 438	177	14.0	288 036
2010	276 700	175	13.3	285 051
2011	298 440	149	14.2	306 398
2012	304 752	151	9.7	311 400
2013	294 534	149	10.1	301 247
2014	306 175	124	10.6	312 440
2015	330 125	82	12.5	335 909

Figure 3.3 CO_2 emissions from fuel combustion, 1990-2015



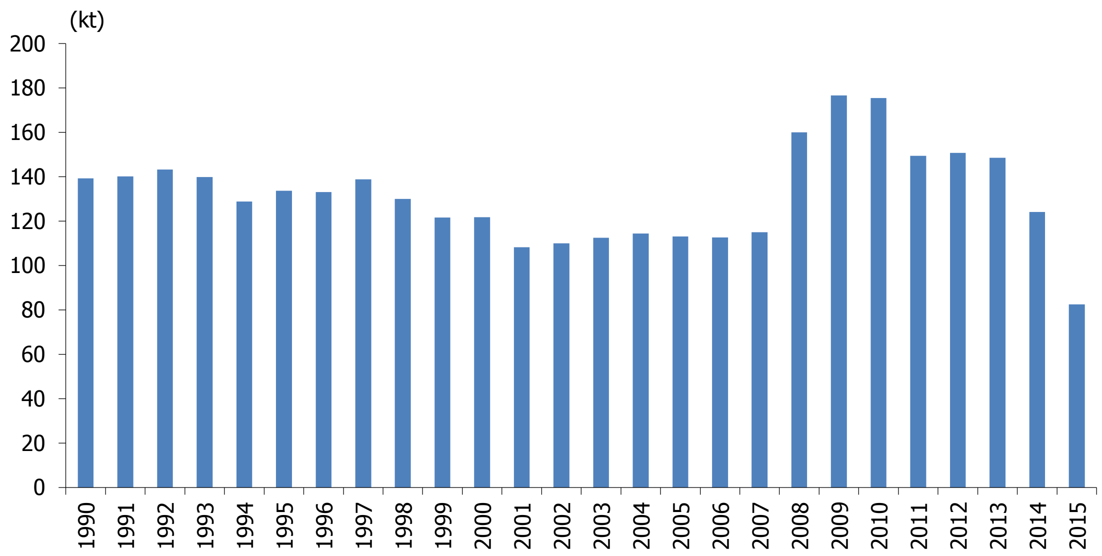
Energy industry has the highest share in total CO_2 emission from fuel combustion in 2015. It is followed by transport, other sectors, and manufacturing industries and construction (Figure 3.4).

Figure 3.4 CO_2 emissions from fuel combustion by sectors, 1990 and 2015



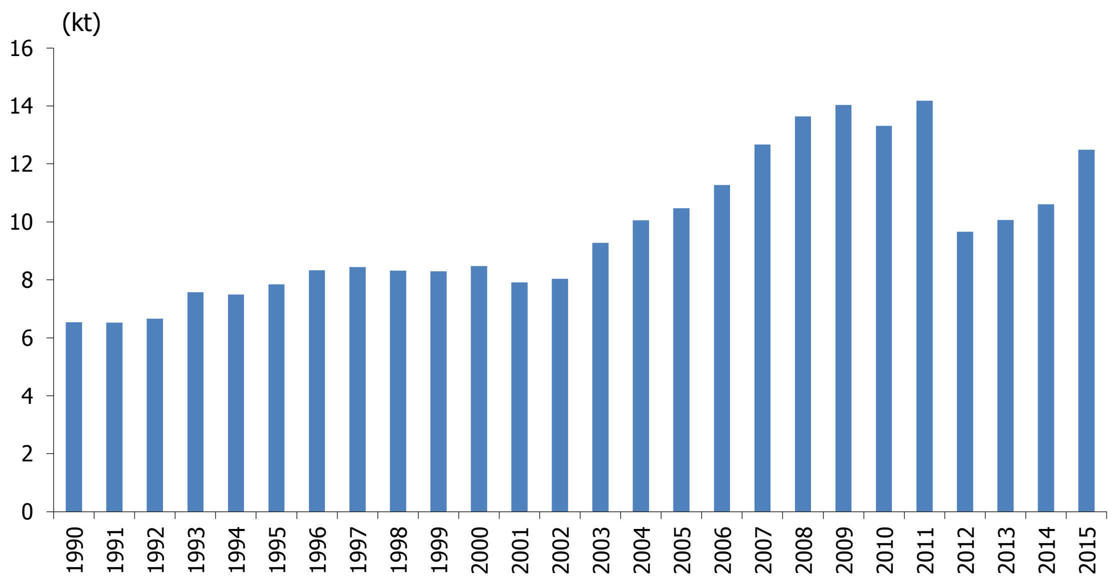
Trends in CH_4 emission from fuel combustion is given in Figure 3.5.

Figure 3.5 CH_4 emissions from fuel combustion, 1990-2015



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

Figure 3.6 N_2O emissions from fuel combustion, 1990-2015



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, carbide 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, process emissions from carbide production and process emissions from ammonia-production which are included in category 2. B. 5 and 2.B.1 respectively 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	2015
Crude Oil	TJ/kt	43.06	43.17	43.65	43.56	43.67	43.67	43.54	43.82	45.25	43.96
Gasoline	TJ/kt	44.80	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	44.59
Other Kerosene	TJ/kt	43.75	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	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	40.19
LPG	TJ/kt	47.31	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	45.01
Bitumen	TJ/kt	40.19	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	40.19
Petroleum Coke	TJ/kt	31.82	32.27	32.24	32.24	31.55	31.36	31.72	32.84	31.86	32.84
Refinery Feedstocks	TJ/kt	43.00	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	40.19
Coking Coal	TJ/kt	31.43	28.92	26.79	26.98	25.35	26.60	27.04	26.29	26.91	30.90
Other Bit. Coal	TJ/kt	31.43	28.92	26.79	26.98	25.35	26.60	27.04	26.29	26.91	26.85
Sub-bit. Coal	TJ/kt	18.00	18.00	18.00	18.00	18.41	19.54	22.72	22.72	20.41	20.22
Lignite	TJ/kt	8.91	8.47	8.14	6.90	9.30	9.30	9.44	10.00	9.91	8.58
Coke Oven/Gas Coke	TJ/kt	28.57	28.57	28.57	28.62	28.58	28.48	28.64	28.77	28.76	28.70
Coal Tar	TJ/kt	38.09	38.09	38.09	38.09	38.09	38.09	38.09	38.09	38.25	37.92
Natural Gas (Dry)	TJ/MSm^3	34.35	34.35	34.35	34.35	34.56	34.56	34.57	34.54	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, 1990-2015

(kt)

Year	Reference approach: Liquid fuels (excluding international bunkers)	Reference approach: Solid fuels (excluding international bunkers)	Reference approach: Gaseous fuels	Reference approach: Other fossil fuels	Reference approach: Total	Sectoral approach: Liquid fuels (excluding international bunkers)	Sectoral approach: Solid fuels (excluding international bunkers)	Sectoral approach: Gaseous fuels	Sectoral approach: Other fossil fuels	Sectoral approach: Total
1990	64 246	60 306	5 626	NO	130 178	60 697	58 169	6 715	NO,IE	125 581
1991	61 341	65 612	7 179	NO	134 132	59 333	62 201	8 264	NO,IE	129 798
1992	66 999	68 250	7 998	NO	143 247	63 895	63 056	9 034	NO,IE	135 986
1993	76 759	62 488	8 982	NO	148 229	73 978	59 313	10 072	NO,IE	143 363
1994	75 328	63 768	9 724	NO	148 819	71 576	58 406	10 583	NO,IE	140 566
1995	80 868	66 286	12 518	1	159 672	79 020	62 446	13 623	1	155 090
1996	86 758	76 270	14 824	5	177 858	83 063	71 745	15 914	5	170 727
1997	86 414	86 347	18 530	9	191 299	82 832	79 588	19 874	9	182 304
1998	81 187	89 592	19 750	12	190 540	78 511	82 864	20 650	12	182 036
1999	81 874	80 950	24 486	17	187 328	79 710	74 843	25 843	17	180 413
2000	89 297	91 974	28 726	42	210 040	83 313	87 701	30 310	42	201 366
2001	85 014	75 480	31 114	4	191 612	79 318	73 269	32 721	4	185 312
2002	86 258	78 690	33 126	39	198 113	81 325	76 376	34 809	39	192 549
2003	87 052	84 646	40 406	11	212 115	82 835	81 160	42 864	11	206 870
2004	88 045	84 680	42 344	37	215 106	86 506	82 771	44 139	37	213 453
2005	83 199	87 077	52 179	75	222 530	84 517	91 646	54 395	75	230 634
2006	81 402	102 200	60 848	48	244 499	83 069	102 718	63 832	48	249 668
2007	82 363	115 247	71 783	136	269 528	87 511	116 179	74 497	136	278 322
2008	82 603	118 186	71 069	175	272 033	86 276	115 452	71 727	175	273 629
2009	69 058	119 911	69 264	299	258 532	84 746	122 413	71 980	299	279 438
2010	73 810	125 363	73 753	441	273 367	80 245	122 200	73 813	441	276 700
2011	81 465	132 769	82 899	545	297 677	82 668	126 584	88 643	545	298 440
2012	85 731	141 989	86 327	803	314 850	88 076	128 246	87 627	803	304 752
2013	92 501	117 287	87 413	1 166	298 367	93 336	112 125	87 907	1 166	294 534
2014	98 364	132 047	93 401	1 238	325 050	97 163	114 594	93 180	1 238	306 175
2015	110 901	123 005	90 005	1 812	325 723	107 823	125 490	95 000	1 812	330 125

Figure 3.7 CO_2 emissions, 1990-2015

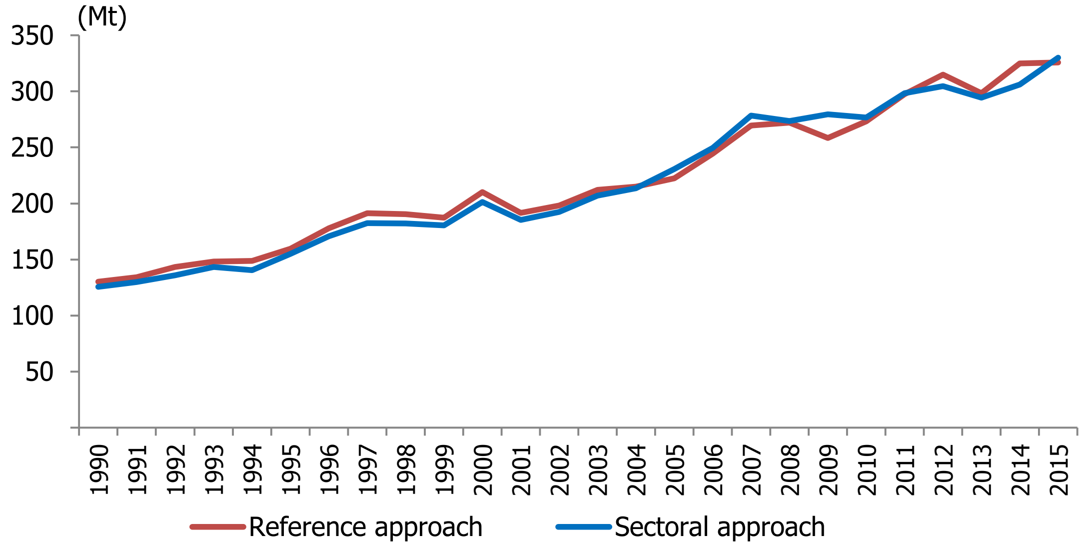


Table 3.7 Comparison of CO_2 from fuel combustion

(%)

Year	Liquid fuels	Solid fuels	Gaseous	Other	Total
1990	5.8	3.7	-16.2	NO,IE	3.7
1991	3.4	5.5	-13.1	NO,IE	3.3
1992	4.9	8.2	-11.5	NO,IE	5.3
1993	3.8	5.4	-10.8	NO,IE	3.4
1994	5.2	9.2	-8.1	NO,IE	5.9
1995	2.3	6.1	-8.1	0.0	3.0
1996	4.4	6.3	-6.8	0.0	4.2
1997	4.3	8.5	-6.8	0.0	4.9
1998	3.4	8.1	-4.4	0.0	4.7
1999	2.7	8.2	-5.3	0.0	3.8
2000	7.2	4.9	-5.2	0.0	4.3
2001	7.2	3.0	-4.9	0.0	3.4
2002	6.1	3.0	-4.8	0.0	2.9
2003	5.1	4.3	-5.7	0.6	2.5
2004	1.8	2.3	-4.1	0.0	0.8
2005	-1.6	-5.0	-4.1	0.0	-3.5
2006	-2.0	-0.5	-4.7	0.0	-2.1
2007	-5.9	-0.8	-3.6	0.0	-3.2
2008	-4.3	2.4	-0.9	0.0	-0.6
2009	-18.5	-2.0	-3.8	0.0	-7.5
2010	-8.0	2.6	-0.1	0.0	-1.2
2011	-1.5	4.9	-6.5	0.0	-0.3
2012	-2.7	10.7	-1.5	0.0	3.3
2013	-0.9	4.6	-0.6	0.0	1.3
2014	1.2	15.2	0.2	0.0	6.2
2015	2.9	-2.0	-5.3	0.0	-1.3

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 and heat 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. Especially for solid fuels and more specifically the Turkish lignite NCVs causing such differences. Since the Turkish lignite is poor quality fuel, its NCV is generally too low from the that of literature lignite. In plant level data especially NCV of lignite changes in wide range (from 1000-6000 kg/kcal). However in national balance tables an average NCV value (~2200 kcal/kg). Based on the quality of lignite used in a specific year, consumption in TJ differs from the national energy balance data. This causes differences in emissions.

Big differences (more than 5%) have been highlighted especially in 1992, 1994, 2009, and 2014. The differences are mainly related to solid fuels for 1992, 1994 and 2014 but liquid fuels for 2009. No obvious reasons for those differences have been found and still being investigated.

Recalculation:

During the latest review of Turkey’s 2015 and 2016 inventory submission, The ERT noted that the stock change data comparison between the CRF tables and IEA data for almost all solid fuels have been of opposite signs for many years and to work to understand the reasons for the differences in the reported data for stock changes for liquid and solid fuels between the CRF tables and IEA data and to recalculate emission estimates as necessary in order to improve the accuracy and comparability of the estimates.

Based on the ERT recommendation, the reason for the difference in sign was investigated and realized that the sign of stock change in national energy balance table and IEA data set used differently. So all the signs are corrected and CO_2 emissions in reference approach is recalculated for 1990-2014 periods.

There is also recalculation due to the revision of country specific carbon content of liquid, solid and gaseous fuels.

3.2.2. International bunker fuels

In consistent with the UNFCCC reporting guidelines, CO_2, CH_4 and N_2O emissions from international bunker fuels are calculated and reported separately.

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, and N_2O from international aviation between 1990 and 2015.

GHG emissions from international aviation have an increasing trend in consistent with the growth in international aviation sector. CO_2 emissions were 11 Mt in 2015 while it was 0.6 Mt in 1990. In 2015, CH_4 and N_2O emissions were 78 tonnes and 310 tonnes respectively.

Emissions from international aviation are calculated using the T1 methodology given in the 2006 IPCC guidelines. The following equation is used.

$$Emissions = fuel\ consumption * EF$$

According to the 2006 IPCC Guidelines, the tier 1 method should only be used for aircraft using aviation gasoline, not larger aircraft using jet kerosene however use of a higher tier method is not possible in Turkey because aircraft operational use data are not available.

Energy balance tables were used for AD. To estimate emissions, Turkey applies the default emission factors from the 2006 IPCC Guidelines as follows: CO_2 (71,500 kg/TJ), CH_4 (0.5 kg/TJ) and N_2O (2 kg/TJ).

Figure 3.8 GHG emissions from international aviation, 1990-2015

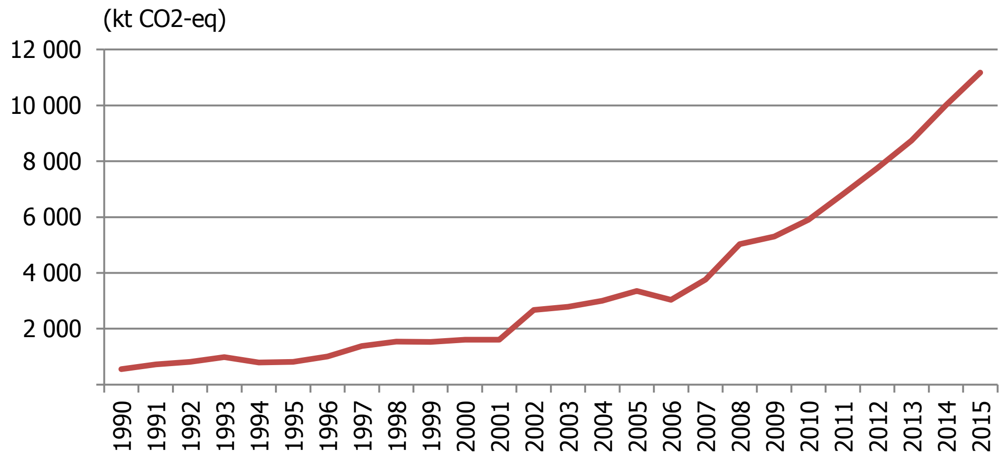


Table 3.8 Emissions and fuel for international aviation, 1990-2015

Year	CO2 (kt)	CH4 (kt)	N2O (kt)	CO2 eq (kt)	Aviation bunkers (TJ)
1990	552	0.004	0.02	556	7 718
1991	716	0.005	0.02	722	10 011
1992	804	0.006	0.02	811	11 246
1993	977	0.007	0.03	986	13 671
1994	788	0.006	0.02	795	11 025
1995	807	0.006	0.02	814	11 290
1996	1 003	0.007	0.03	1 011	14 024
1997	1 368	0.010	0.04	1 380	19 139
1998	1 523	0.011	0.04	1 536	21 300
1999	1 514	0.011	0.04	1 526	21 168
2000	1 599	0.011	0.04	1 612	22 359
2001	1 592	0.011	0.04	1 606	22 271
2002	2 649	0.019	0.07	2 671	37 044
2003	2 762	0.019	0.08	2 786	38 632
2004	2 977	0.021	0.08	3 002	41 630
2005	3 330	0.023	0.09	3 358	46 570
2006	3 014	0.021	0.08	3 040	42 160
2007	3 731	0.026	0.10	3 762	52 177
2008	4 991	0.035	0.14	5 034	69 810
2009	5 255	0.037	0.15	5 299	73 493
2010	5 858	0.041	0.16	5 908	81 937
2011	6 769	0.047	0.19	6 827	94 671
2012	7 684	0.054	0.21	7 750	107 473
2013	8 661	0.061	0.24	8 734	121 129
2014	9 922	0.069	0.28	10 007	138 775
2015	11 085	0.078	0.31	11 180	155 037

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 2015.

GHG emissions from international navigation have an increasing trend corresponding to the growth in the international navigation sector. CO_2 emissions were 2.7 Mt in 2015 while it was 0.4 Mt in 1990. In 2015, CH_4 and N_2O emissions were 248 tonnes and 71 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. The following equation is used. Activity data is taken from national energy balance tables.

$$missions = \sum Fuel\ consumed_{ab} * \quad F_{ab}$$

Where:

a = fuel type (residual fuel oil and gas diesel oil)

b = water-borne navigation type (the type of vessel b is ignored at Tier 1)

Energy balance tables were used for AD. Country specific carbon content is used for CO_2 emission estimation. To estimate CH_4 and N_2O emissions, Turkey applies the default emission factors from the 2006 IPCC Guidelines as follows: CH_4 (7 kg/TJ) and N_2O (2 kg/TJ).

Figure 3.9 GHG emissions from international navigation, 1990-2015

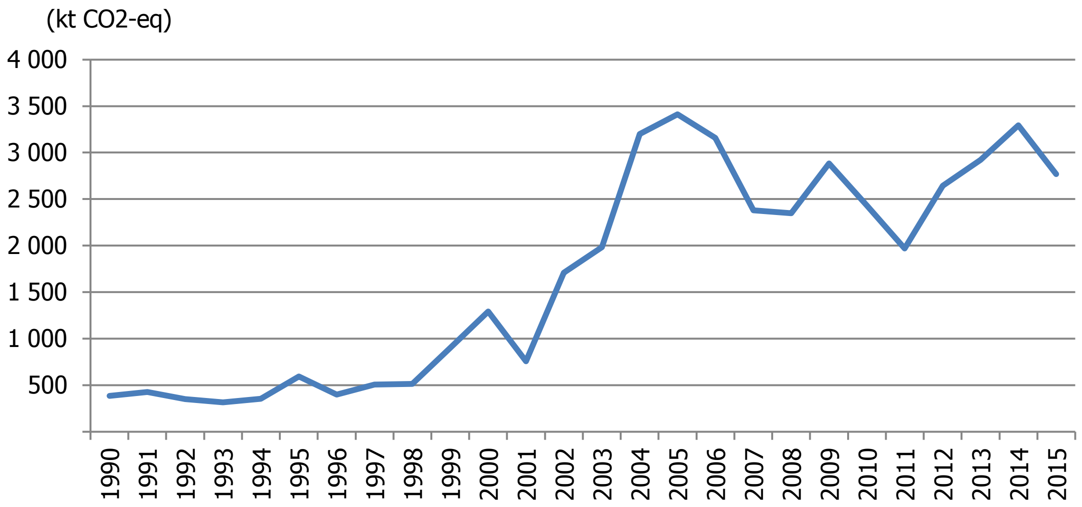


Table 3.9 Emissions and fuel for international navigation, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Navigation bunkers (TJ)
1990	379	0.035	0.01	383	5 035
1991	423	0.039	0.01	428	5 622
1992	347	0.032	0.01	351	4 626
1993	313	0.029	0.01	316	4 148
1994	351	0.033	0.01	354	4 656
1995	587	0.055	0.02	593	7 819
1996	395	0.037	0.01	399	5 248
1997	502	0.047	0.01	507	6 658
1998	509	0.047	0.01	514	6 689
1999	894	0.083	0.02	903	11 810
2000	1279	0.118	0.03	1 292	16 861
2001	749	0.069	0.02	756	9 848
2002	1690	0.156	0.04	1 707	22 334
2003	1964	0.183	0.05	1 984	26 127
2004	3168	0.294	0.08	3 200	41 988
2005	3376	0.312	0.09	3 411	44 586
2006	3127	0.287	0.08	3 159	41 059
2007	2355	0.212	0.06	2 379	30 323
2008	2325	0.211	0.06	2 348	30 114
2009	2854	0.257	0.07	2 882	36 737
2010	2407	0.217	0.06	2 431	31 058
2011	1951	0.176	0.05	1 971	25 160
2012	2618	0.237	0.07	2 645	33 786
2013	2892	0.261	0.07	2 921	37 316
2014	3260	0.294	0.08	3 292	41 958
2015	2742	0.248	0.07	2 769	35 358

Recalculations:

There is recalculations for the entire time series of international navigation since country-specific carbon content of residual fuel oil and gas diesel oil were revised based on new data. Overall, for 2014, The difference in 2014 emissions between latest submission and the previous submission is 0.64 kt CO_2-eq (-0.02 %) due to these recalculations.

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 (coke oven gas) 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.

Coke used as a reductant in the carbide production is reported under 2.B.5

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. Naphtha is given as feedstock in the national energy balance tables. Fuels used for non energy purposes are lubricants, bitumen, solvents etc. but they were not given separately in the national energy balance tables till 2015. They were 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 Oil questionnaire were used as AD. Only Naphtha was used from national energy balance tables.

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

Emissions from lubricants and paraffin-wax use are included under 2.D-non-energy products from fuels and solvent use category. However, bitumen is used for road paving or asphalt roofing purposes and carbon stored in the products not released. Refinery feedstock is used in the refining industry and is transformed into one or more components and/or finished products. Naphtha is used for input material for petrochemical industry. Both refinery feedstock and naphtha are used input material for production processes, so they are not combusted. Those products are normally not considered as carbon emissions sources. Therefore no emissions from those fuels are estimated under IPPU 2.D category. So notation key "NA" is used in table 1A(d) for emissions from those fuels.

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 40.8% in 2015 while it was 29% in 1990. The source category 1.A.1 is a key category in terms of emission level and emission trend of CO_2 from liquid, solid and gaseous fuels in 2015.

Table 3.10 GHG emissions from energy industries, 1990-2015

Year	CO_2	CH_4	N_2O	CO_2 eq.	TJ
1990	37 861	0.5	0.4	37 986	402 617
1991	38 729	0.5	0.4	38 859	418 963
1992	43 493	0.5	0.5	43 642	465 111
1993	43 154	0.5	0.4	43 300	467 361
1994	49 688	0.6	0.5	49 859	534 498
1995	52 348	0.6	0.5	52 520	560 579
1996	54 934	0.7	0.6	55 120	596 374
1997	60 107	0.7	0.6	60 309	662 871
1998	65 715	0.8	0.7	65 935	729 241
1999	71 815	0.9	0.7	72 042	816 390
2000	78 325	1.0	0.7	78 568	921 163
2001	80 781	1.1	0.7	81 029	959 216
2002	75 162	1.0	0.6	75 379	911 634
2003	75 026	1.0	1.7	75 571	942 932
2004	75 991	1.0	2.1	76 650	948 178
2005	91 625	1.2	2.6	92 421	1120 229
2006	97 128	1.3	2.9	98 020	1186 918
2007	114 515	1.6	3.8	115 691	1405 142
2008	119 689	1.6	4.0	120 926	1478 763
2009	120 360	1.8	4.5	121 751	1490 650
2010	113 634	1.7	4.0	114 870	1421 098
2011	126 305	1.9	4.2	127 614	1558 140
2012	126 036	1.9	3.8	127 230	1596 620
2013	120 811	1.8	4.1	122 067	1534 608
2014	131 759	2.0	4.4	133 105	1718 922
2015	135 767	2.0	3.9	136 970	1716 039

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, T3 approaches. Plant-specific NCVs were used to calculate heat values that led to emissions. Plant level fuel consumption and NCVs of fuels are received from Turkish Electricity Transmission Company (TEİAŞ-authority for Turkish electricity transmission). Carbon contents of fuels are calculated by using fuel analysis reports and oxidation rates are 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) are 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. Activity data of CH_4 and N_2O emissions from CRF category 1A1a, have been estimated by using plant specific fuel consumption and NCVs For the years 2000-2015 technology information of power plants were obtained. According to type of technology, using 2006 IPCC Guidelines for National Greenhouse Gas Inventories, emission factors were chosen in order for CH_4 and N_2O to be estimated with Tier 3.

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 T2, T3 approaches 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 NCVs and IPCC default EFs .

Recalculation:

In light of the recommendations addressed by ERT in annual review process and in order for the international data to be convenient and comparable with that of General Energy Balance Sheets, it is decided to disaggregate GHG emissions of 1.A.1.a sector under electricity and combined heat production nodes, using the same data source, TEİAŞ. Since disaggregated data was available for the years 2000-2015, aforementioned breakdown applied for those years. Also CO_2 EFs for 1.A.1a category were revised through whole time series taking into account the additional fuel analysis reports obtained recently. Data gaps of carbon contents through whole time series were thereby reduced.
Activity data of autoproducers for electricity production and sold heat were also included under 1.A.1.a category. Formerly whole activity data of autoproducers had been accounted under the industry branch they operate. In this submission, however, only activity data of unsold heat, namely the heat used for plants' industrial purposes was accounted under the related industry branch.
Also CH_4 and N_2O EFs for 1.A.1.a category were revised and technology specific EFs from 2006 IPCC guidelines are used for the years 2003-2015 since information technology classification was available only for those years.

In this regard, for 1.A1.a category whole time series was revised.

Also, there is a recalculation in 1.A.1.c category due to the carbon mass balance studies performed in the integrated iron and steel production facilities.

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

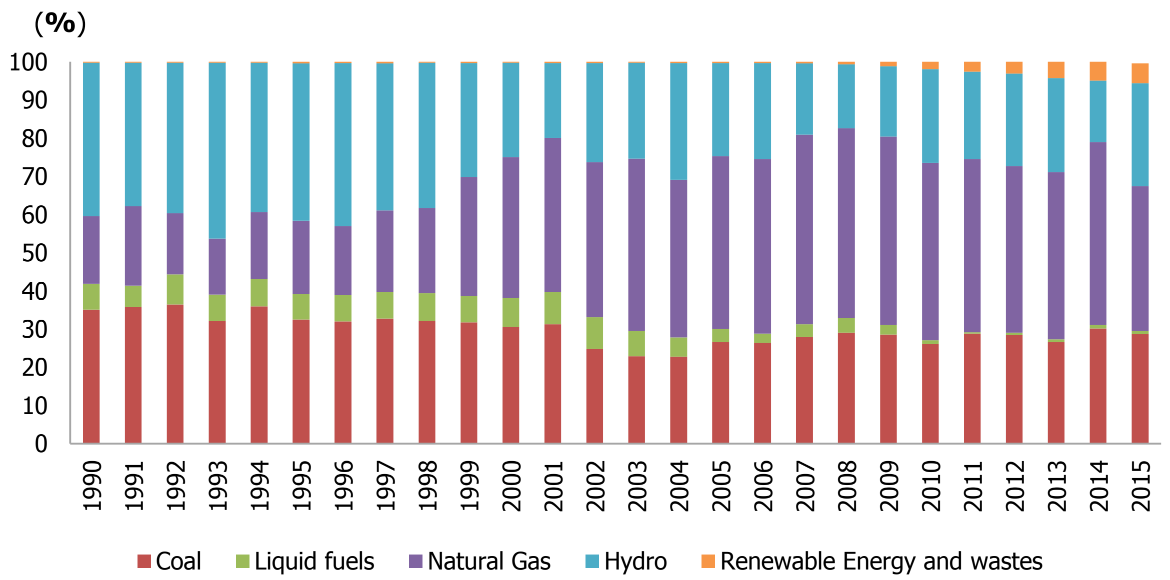
Source Category Description:

Public electricity and heat production category includes electricity and heat production of all electricity generation installations in operation including autoproducers. Autoproducers are the facilities that produce electricity that they use for their own purposes. Their AD for electricity production and sold heat are taken under 1.A.1.a. Unsold heat, namely the heat they use for industry purpose, on the other hand, is 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 plant specific AD are gathered from TEİAŞ.

In 2015, electricity production kept its major role in GHG emissions. Total installed capacity reached to 73.147 GW with 5% increase from the previous year and more than 4.5 times higher than 1990 values. The total net electricity consumption has increased in 2015 compared to the previous year. In the year 2015, net consumption was 265.725 TWh meanwhile in 2014 this figure realized as 257.22 TWh. Above mentioned installed capacities and consumption amounts belong to electricity production companies and autoproducers as well. In 2015, natural gas had a very high share of 37.9% in all electricity production, which was followed by other bituminous coal (16.7%), Turkey lignite (12%) hydro and geothermal (27%), other renewable (5.2%), oil (0.85%) and sub-bituminous coal (0.4%). From 2014 to 2015, Electricity production from hydropower plants increased by 65%. Amount of electricity production from Turkey lignite has decreased from 36.61 TWh to 31.34 TWh, whereas this change was from 38.6 TWh to 43.75 TWh for other bituminous coal. Electricity production from natural gas has decreased as well, from 120.5 TWh to 99.22 TWh.

In 2015 electricity production from fossil fueled thermal power plants has accounted for 179.367 TWh of a total of 261.784 TWh production whilst in 2014 electricity production from fossil fueled thermal power plants had accounted for 200.4 TWh of a total of 251.9 TWh production. Fossil fueled thermal share in electricity production dropped from 80% in 2014 to 68.5% in 2015.

Figure 3.10 Energy mix of category 1.A.1.a, 1990-2015



There was an accelerated increase in wind installed capacity from 3629.7 MW in 2014 to 4503 MW in the year 2015. 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 2015 solar power plants installed capacity raised to 249 MW. 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 22.7% compared to the previous year, reaching to 370 MWs of installed power, generating 1758 GWh of power in 2015.

In 2015, Turkey's Total Primary Energy Supply (TPES) was 5412150.76 TJ, a 4.6% increase compared to 2014. Oil had a share of 1642816.58 TJ while hard coal and gas accounted for 934744.968 TJ and 1660108.07 TJ respectively.

Figure 3.11 Electricity generation and shares by energy resources, 2014-2015

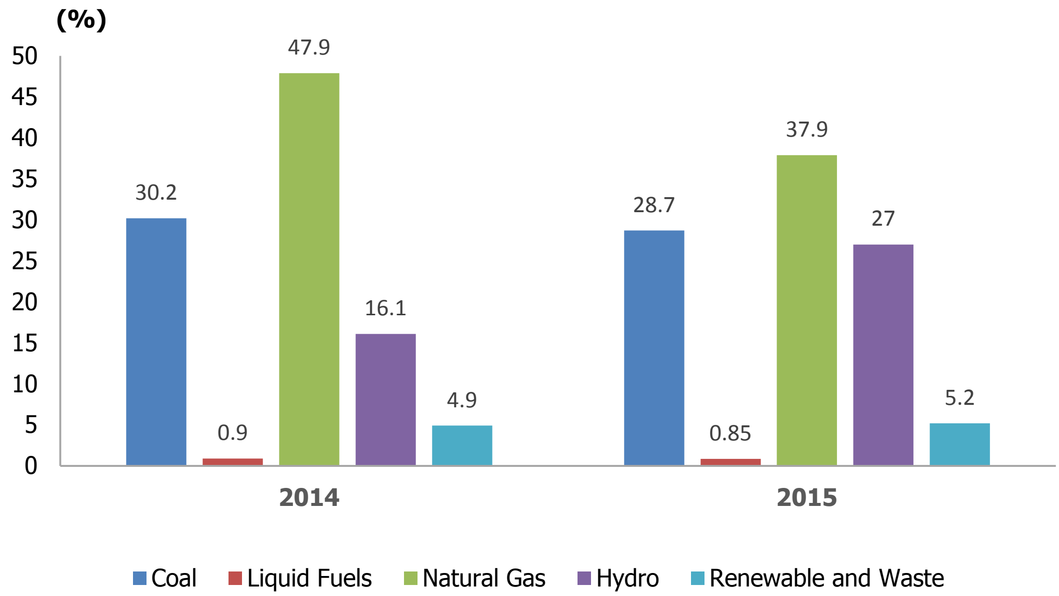
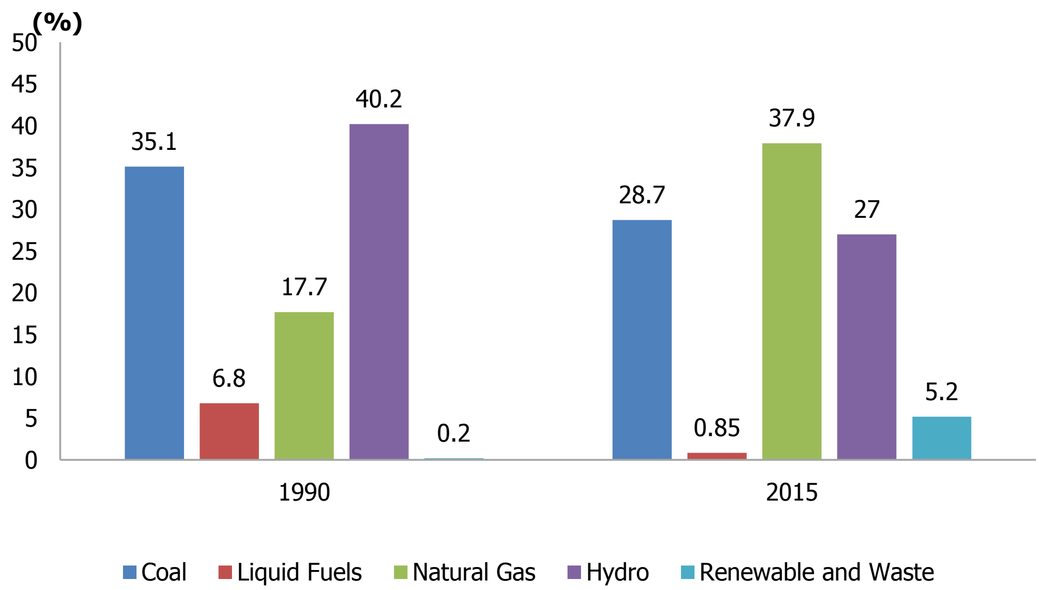


Figure 3.12 Electricity generation and shares by energy resources, 1990 and 2015



Primary energy (domestic) production 1303350.84 TJ in 2015 and provided 25% of overall energy supply. The share of import in TPES increased to 86.8% from previous years' 82.6%.

The production of solid fossil fuels, excluding animal & yard waste, has decreased to 535656.2 TJ in 2015 from 684918.6 TJ in 2014. The main domestic energy source remains as Turkey lignite with a production decreased by about 10% from 62.57 Mt in 2014 to 56.12 Mt in 2015.

Public electricity and heat production category is one of the main emission sources in Turkey. The share of GHG emissions from public electricity and heat production in total fuel combustion was 38.6% in 2015 while it was 25.1% in 1990.

Table 3.11 Emissions from category 1A1a, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2eq. (kt)	TJ
1990	32 823	0.3	0.4	32 938	346 707
1991	34 429	0.4	0.4	34 550	362 934
1992	39 047	0.4	0.4	39 186	408 249
1993	38 255	0.4	0.4	38 390	403 148
1994	44 562	0.5	0.5	44 721	466 134
1995	45 860	0.5	0.5	46 020	490 230
1996	49 744	0.5	0.5	49 919	529 408
1997	54 810	0.6	0.6	55 000	590 895
1998	60 336	0.7	0.6	60 544	656 466
1999	65 778	0.8	0.7	65 993	749 301
2000	73 413	0.9	0.7	73 645	854 300
2001	75 474	0.9	0.7	75 709	888 392
2002	69 522	0.8	0.6	69 726	834 375
2003	69 174	0.9	1.7	69 705	862 965
2004	70 023	0.9	2.1	70 668	866 064
2005	84 814	1.1	2.5	85 597	1036 864
2006	90 365	1.2	2.9	91 244	1103 265
2007	107 814	1.4	3.8	108 978	1323 995
2008	112 967	1.5	4.0	114 192	1389 232
2009	114 279	1.6	4.5	115 659	1413 335
2010	108 331	1.6	4.0	109 559	1344 379
2011	119 496	1.8	4.2	120 797	1478 115
2012	120 568	1.8	3.8	121 754	1512 807
2013	115 524	1.7	4.0	116 772	1451 358
2014	126 155	1.8	4.3	127 494	1624 731
2015	128 429	1.8	3.9	129 622	1591 475

Methodological Issues:

Activity Data

In light of recommendations directed by expert review team and TurkStat, it is decided to use the same data source with Transformation part of General Energy Balance Sheets for 1.A.1.a sector. Therefore rather than sending questionnaires to power plants, plant specific activity data for the whole time series is obtained from Turkish Electricity Transmission Company (TEİAŞ) in a compiled form. After the completion of data obtaining, 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 Turkish Electricity Transmission Company (TEİAŞ).

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 obtained from Turkish Electricity Transmission Company (TEİAŞ). 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.

Average NCVs are given in the Table 3.12.

Table 3.12 Average NCVs of fuels used in category 1A1a

(TJ/kt)

Fuel Type	Weighted average	Default
Sub-Bituminous Coal	13.92	18.90
Natural gas	54.04	48.00
Residual Fuel Oil	40.21	40.40
Other bituminous coal	25.06	25.80
Turkey Lignite	7.18	11.90
Diesel Oil	43.75	43.00

The multipliers of EF, namely carbon content and oxidation rates were calculated through fuel analysis and ash-slag or stack gas analysis reports. For Turkey lignite and other bituminous 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 the 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 for carbon contents. To fill 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.

CO_2 EFs used for source category 1.A.1.a were listed in Table 3.13 for whole time series on fuel basis.

For CH_4 and N_2O emissions starting from the year 2000, plant specific technology classification information were obtained from Turkish Electricity Transmission Company (TEİAŞ). Using *Table 2.6: Utility Source Emission Factors*from Stationary Combustion Chapter of Guideline, Tier 3 EFs for CH_4 and N_2O were chosen.

EFs for CH_4 and N_2O were listed in Table 3.14 for whole time series on fuel basis.

Table 3.13 CO_2 emission factors used for source category 1A1a

(t/TJ)

Year	Turkey Lignite	Sub-Bituminous Coal	Other Bituminous Coal	Natural Gas	Residual Fuel Oil	Diesel Oil	LPG	Biogas	Industrial Waste	Wood-wood waste	Coke Oven Gas	Black Liquor	Blast Furnace Gas	Petroleum Coke	Oxygen Steel Furnace Gas	Coal Tar	Refinery Gas
1990	114.16	93.37	NO	58.23	76.97	72.28	63.07	NO	NO	NO	107.07	95.33	259.60	97.53	181.87	80.67	57.57
1991	114.01	101.38	NO	58.23	76.97	72.28	63.07	NO	NO	NO	107.07	95.33	259.60	97.53	181.87	80.67	57.57
1992	113.85	101.35	NO	58.23	76.97	72.28	63.07	NO	NO	NO	107.07	95.33	259.60	97.53	181.87	80.67	57.57
1993	113.70	100.54	NO	58.23	76.97	72.28	63.07	NO	NO	NO	107.07	95.33	259.60	97.53	181.87	80.67	57.57
1994	113.54	99.12	NO	58.23	76.97	72.28	63.07	NO	NO	NO	107.07	95.33	259.60	97.53	181.87	80.67	57.57
1995	113.39	102.17	NO	58.23	76.97	72.28	63.07	NO	NO	NO	107.07	95.33	259.60	97.53	181.87	80.67	57.57
1996	113.23	102.50	NO	58.23	76.97	72.28	63.07	NO	NO	NO	107.07	95.33	259.60	97.53	181.87	80.67	57.57
1997	113.08	103.34	NO	58.23	76.97	72.28	63.07	NO	NO	NO	107.07	95.33	259.60	97.53	181.87	80.67	57.57
1998	112.92	102.81	NO	58.23	76.97	72.28	63.07	NO	NO	NO	107.07	95.33	259.60	97.53	181.87	80.67	57.57
1999	112.77	93.39	NO	58.23	76.97	72.28	63.07	NO	NO	NO	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2000	110.05	95.52	88.62	58.23	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2001	110.58	99.28	88.62	58.23	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2002	111.30	96.27	88.62	58.23	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2003	112.00	100.90	79.88	58.23	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2004	112.72	90.34	84.02	58.23	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2005	113.50	94.23	85.24	58.23	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2006	114.18	88.71	90.07	58.23	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2007	113.62	88.52	91.17	58.23	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2008	112.51	93.35	83.29	58.23	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2009	111.39	96.03	90.35	58.23	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2010	110.26	98.56	90.01	58.23	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2011	109.48	95.10	89.11	58.23	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2012	109.29	96.65	88.89	58.23	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2013	109.09	96.18	93.57	58.23	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2014	107.63	93.15	87.70	58.23	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57
2015	107.63	92.38	92.64	58.66	76.97	72.28	63.07	54.63	143.00	111.83	107.07	95.33	259.60	97.53	181.87	80.67	57.57

Table 3.14 CH_4 and N_2O emission factors used for source category 1A1a

(kg/TJ)

Fuel Types	CH_4	N_2O
Liquid Fuels		
Fuel Oil		
Steam	0.8	0.3
Internal Combustion	0.8	0.3
Combined Heat	0.8	0.3
Liquid Fuels		
Diesel Oil, Naphtha		
Steam	0.9	0.4
Internal Combustion	0.9	0.4
Combined Heat	0.9	0.4
Solid Fuels		
Turkey Lignite and Sub-Bituminous and Other Bituminous Coal		
Dry bottom, wall fired	0.7	0.5
Fluidised Bed	1	61
Lignite (other type of technology)	0.7	1.4
Sub-Bituminous and Coking Coal	0.7	1.4
Natural Gas		
Boiler	4	1
Gas Engine	4	1
Gas Turbine	4	1
Internal Combustion	4	1
Combined Heat	1	3
Other Fuels		
Coke Oven Gas	1	0.1
Blast Furnace Gas	1	0.1
Oxygen Steel Furnace Gas	1	0.1
Coal Tar	1	1.5
LPG	1	0.1
Refinery Gas	1	0.1
Petroleum Coke	3	0.6
Other Petroleum Products	3	0.6
Black Liquor	3	2
Industrial Waste	30	4
Biomass		
Biogas	1	1
Wood waste	11	7

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 in 2015 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.

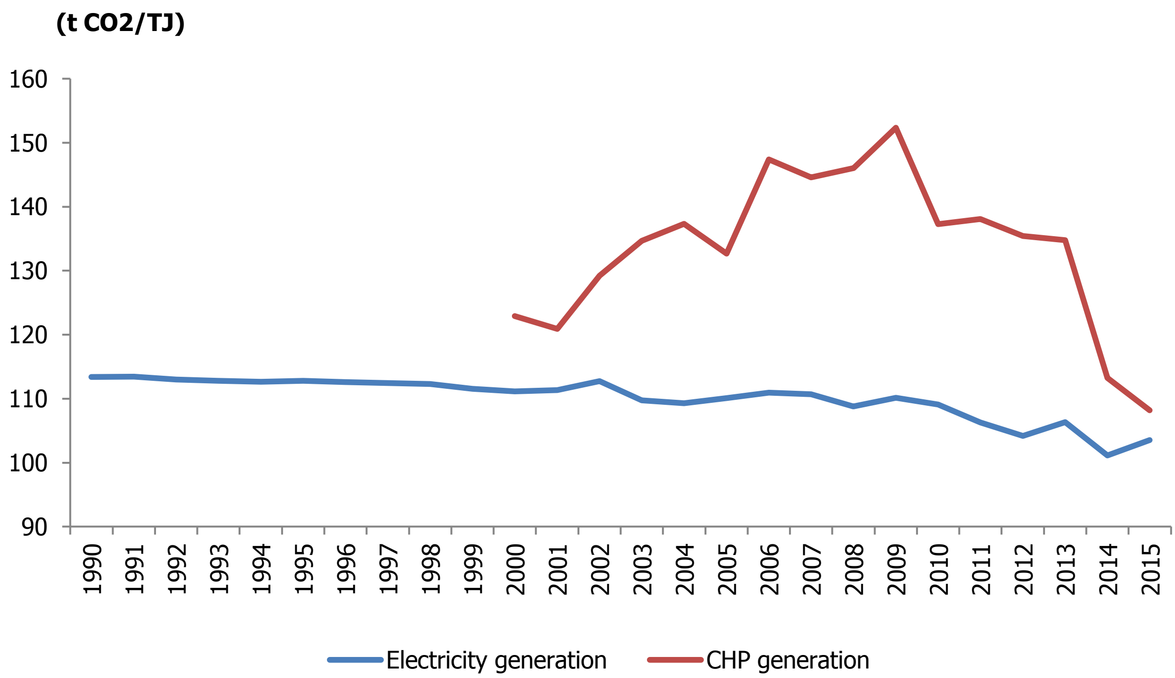
Carbon Capture and Storage in 1.A.1.a, if applicable

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

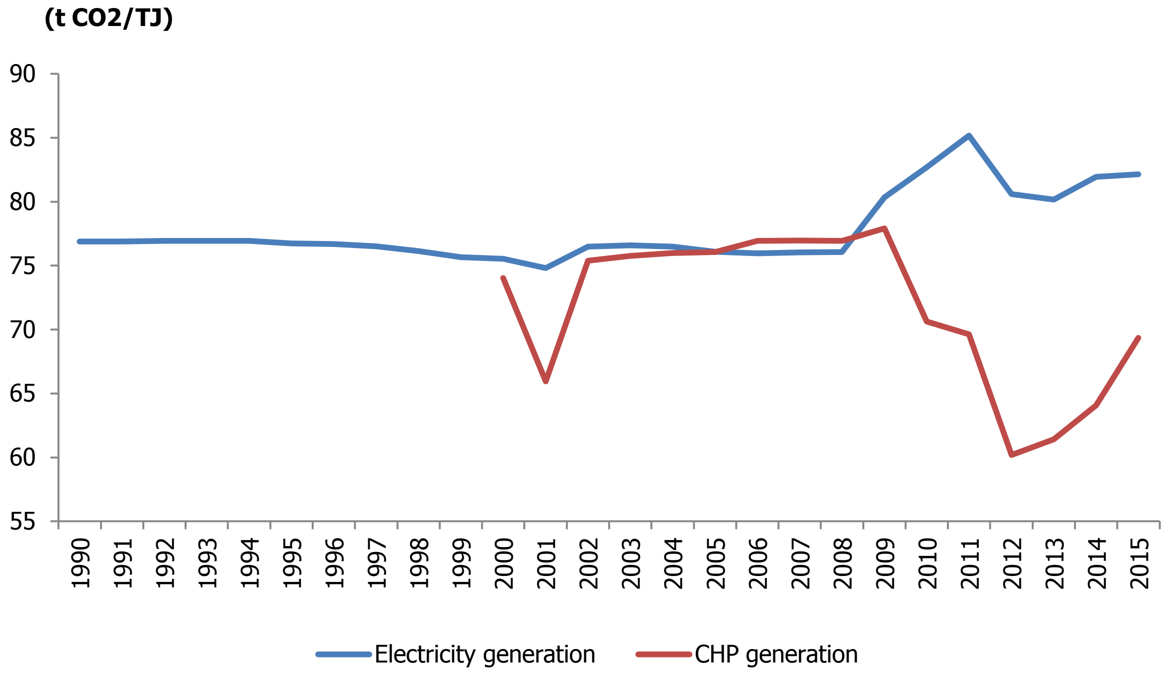
IEFs were examined in the following graphs to see time series consistency for solid, liquid, gaseous fuels and biomass respectively.

Figure 3.13 CO_2 IEFs of solid fuels used for category 1A1a, 1990-2015



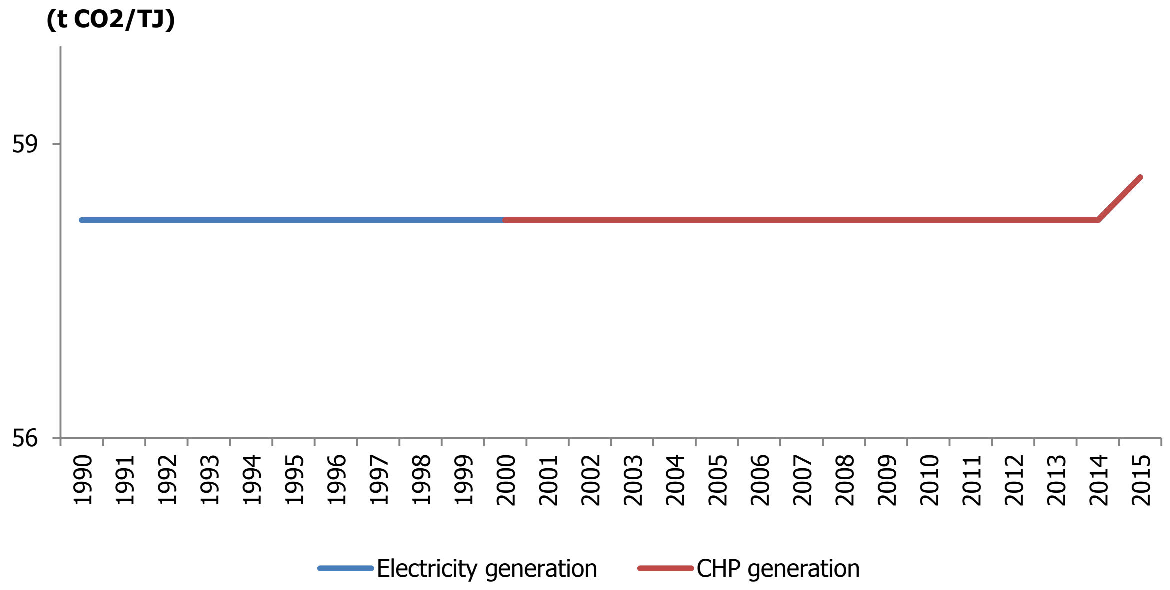
IEFs of CO_2 ranges from 101 to 152 t/TJ. It is mainly because of local Turkey lignite and its share in solid fuels. Different from literature lignite of statistics manual, Turkey's lignite has a very low NCV, about one fifth of that of literature. Also its share in the solid fuels affects the overall IEF causing a dramatic rise and fall like its trend through the years 2001-2014 for 1.A.1.a.i.

Figure 3.14 CO_2 IEFs of liquid fuels used for category 1A1a, 1990-2015



Fuel mix change is the main reason for the increase in 1.A.1.a.i between the years 2008-2011 and the decrease in 1.A.1.a.ii between the years 2010-2012. Petroleum coke share causes a rise in 2011 in 1.A.1.a.i subsector. Declines in the trend are mainly owing to the share of refinery gas in the related year.

Figure 3.15 CO_2 IEFs of gaseous fuels used for category 1A1a,1990-2015



IEFs of gaseous fuels do not change considerably over time.

Figure 3.16 CH_4 IEFs of biomass used for category 1A1a,1990-2015

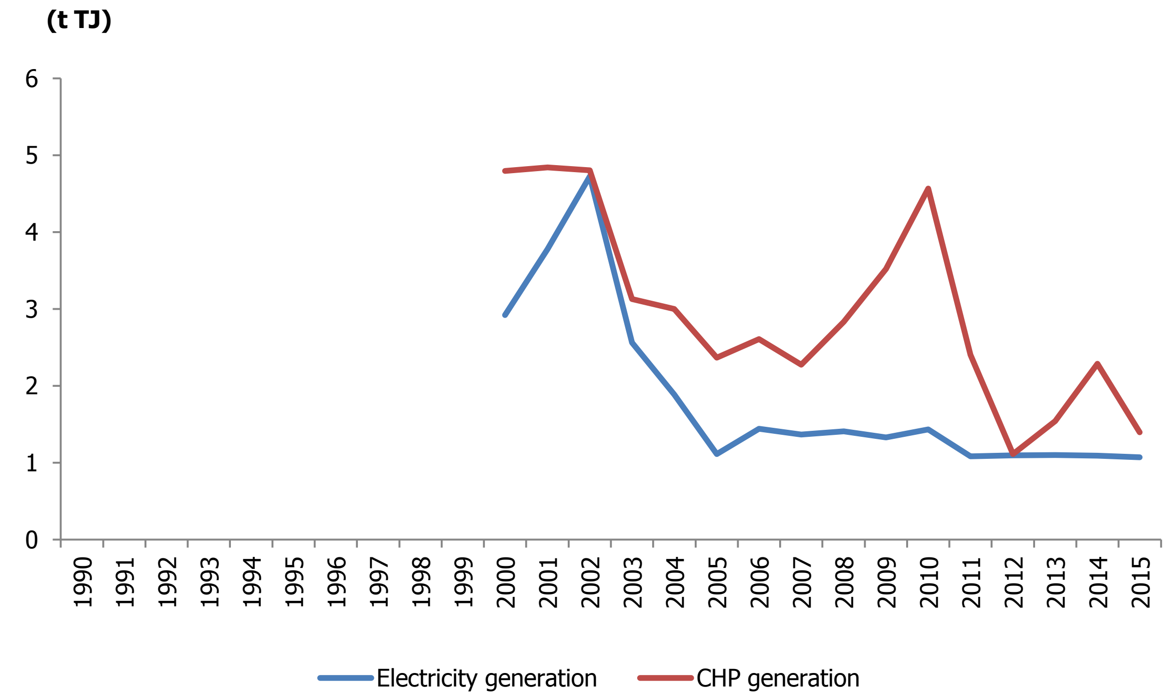
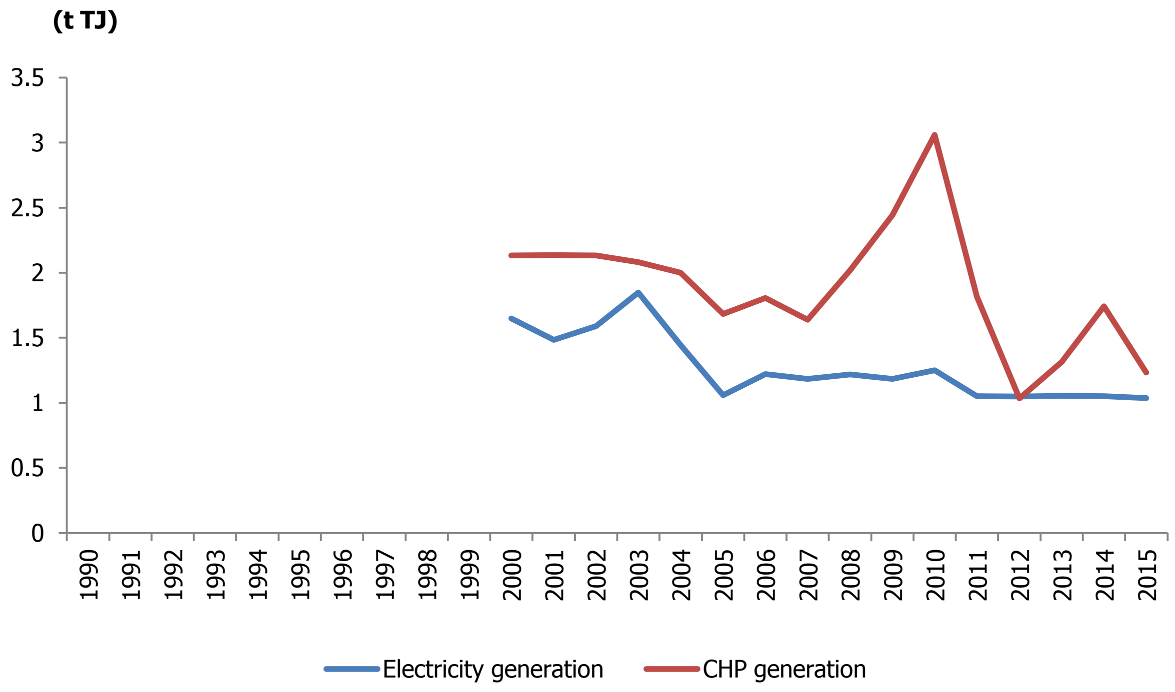


Figure 3.17 N_2O IEFs of biomass used for category 1A1a,1990-2015



Fluctuations in IEFs, especially declines are mainly owing to the increasing share of biogas. Rises in the trend, however, due to share of black liquor.

"Other Fossil Fuels" node is used for industrial wastes data reporting that consist of clinic and hazardous wastes.

Emission estimation with T2, T3 approach using plant specific data are compared with the T1 emission estimation using fuel data from national energy balance tables. Comparison with with T1 emission estimation results is given in Table 3.15.

Table 3.15 Comparison of GHG emissions from 1A1a category , 1990-2015

Year	GHG emissions with plant specific data		GHG emissions with national energy balance data		Difference	
	GHG Emission (kt CO_2-eq)	Fuel consumption (TJ)	GHG Emission (kt CO_2-eq)	Fuel consumption (TJ)	GHG emission (kt CO_2-eq)	Fuel consumption (TJ)
1990	32 938	346 707	30 378	351 828	2 559	-5 120
1991	34 550	362 934	33 096	379 309	1 454	-16 375
1992	39 186	408 249	38 193	434 584	993	-26 336
1993	38 390	403 148	36 323	416 312	2 067	-13 164
1994	44 721	466 134	42 715	486 320	2 006	-20 186
1995	46 020	490 230	43 860	509 410	2 160	-19 180
1996	49 919	529 408	47 439	548 709	2 479	-19 302
1997	55 000	590 895	53 331	621 001	1 669	-30 105
1998	60 544	656 466	58 896	692 187	1 647	-35 721
1999	65 993	749 301	64 154	776 586	1 840	-27 286
2000	73 645	854 300	71 387	890 309	2 258	-36 009
2001	75 709	888 392	73 602	928 611	2 107	-40 219
2002	69 726	834 375	67 634	877 230	2 091	-42 855
2003	69 705	862 965	67 573	893 679	2 132	-30 714
2004	70 668	866 064	69 047	913 224	1 622	-47 160
2005	85 597	1036 864	75 931	1014 006	9 666	22 857
2006	91 244	1103 265	80 594	1058 967	10 650	44 298
2007	108 978	1323 995	94 898	1246 920	14 080	77 076
2008	114 192	1389 232	105 364	1406 932	8 828	-17 700
2009	115 659	1413 335	101 768	1359 211	13 892	54 124
2010	109 559	1344 379	99 673	1328 530	9 886	15 849
2011	120 797	1478 115	115 867	1501 870	4 930	-23 755
2012	121 754	1512 807	118 661	1547 598	3 093	-34 791
2013	116 772	1451 358	114 540	1504 131	2 233	-52 773
2014	127 494	1624 731	139 771	1796 820	-12 277	-172 089
2015	129 622	1591 475	127 757	1479 522	1 865	111 953

The differences between T1 (national energy balance data) and T2, T3 (plant specipic data) results are mainly related to the solid fuels, especially NCVs of Turkish lignite. Since the Turkish lignite is poor quality fuel, its NCV is generally too low from the that of literature lignite. In plant level data especially NCV of lignite changes in wide range (from 1000-6000 kg/kcal). However in national balance tables an average NCV value (~2200 kcal/kg). Based on the quality of lignite used in a specific year, consumption in TJ differs from the national energy balance data. This cause differences in emissions. For example in 2005, 42% of lignite consumed in 1A1a category has NCVs less than 1500 kcal/kg, 58% has NCVs in 1700-6000 while in national balance table NCV is used as 1400 kcal/kg for 2005.

Therefore lignite consumption in CRF (plant specific data) is 13% higher than national balance figures. On the other hand in 2014, 70% of lignite consumption in plant specific data has NCV less than 2000, while in national balance average NCV for lignite is used as 2100 kcal/kg. That result in 29% decrease in lignite consumption in TJ (Table 3.16).

Table 3.16 Comparison of solid fuel consumption, 1990-2015

Year	Plant specific data				National Energy balance data			
	Hard coal consumption		Lignite consumption		Hard coal consumption		Lignite consumption	
	(kt)	(TJ)	(kt)	(TJ)	(kt)	(TJ)	(kt)	(TJ)
1990	474	7 761	29 884	205 169	474	9 184	29 884	208 339
1991	782	10 611	32 293	217 563	782	14 830	32 293	235 307
1992	1 339	17 428	35 318	240 051	1 339	25 498	35 318	257 780
1993	1 298	17 027	31 917	230 652	1 298	24 744	31 917	238 005
1994	1 441	18 977	39 701	277 193	1 441	27 465	39 701	288 765
1995	1 246	15 866	39 815	275 859	1 246	23 781	39 815	286 412
1996	1 476	18 792	42 441	302 290	1 476	28 176	42 441	311 529
1997	1 828	22 942	45 694	324 707	1 828	34 990	45 694	343 141
1998	1 884	23 778	52 115	353 093	1 885	35 942	52 115	373 748
1999	1 729	23 943	53 780	359 678	1 729	33 259	53 780	386 669
2000	1 942	30 130	52 539	371 196	2 034	32 951	53 312	385 302
2001	2 167	35 209	52 883	372 593	2 274	38 381	53 435	383 515
2002	1 945	32 979	41 883	307 731	2 051	36 149	42 576	318 522
2003	3 614	75 116	34 167	246 969	3 706	78 431	35 556	264 737
2004	4 471	99 803	32 994	242 008	4 565	105 047	33 777	256 911
2005	5 174	108 533	47 414	324 826	5 259	111 092	48 319	286 826
2006	5 476	119 784	49 709	337 847	5 477	119 857	49 709	338 137
2007	5 913	131 324	60 536	408 777	5 912	131 338	60 536	409 096
2008	6 197	137 584	65 685	441 791	6 197	137 677	65 685	453 076
2009	6 361	140 943	62 894	424 612	6 361	142 715	62 894	432 739
2010	6 935	154 215	55 437	389 958	7 582	149 650	55 436	388 874
2011	10 116	230 759	60 271	423 208	10 116	261 414	60 271	450 720
2012	11 760	287 433	54 584	378 208	11 854	289 795	55 742	419 643
2013	11 707	279 108	45 919	327 977	11 777	289 696	47 120	384 702
2014	13 826	332 019	51 967	363 512	14 044	362 210	57 411	511 985
2015	16 126	389 644	48 820	350 379	16 127	389 939	48 820	350 312

Uncertainties and Time-Series Consistency:

AD have been compiled from all public electricity and heat production facilities by Turkish Electricity Transmission Company (TEİAŞ). via survey. As a result of the change made in activity data source, there was no bias in total electricity production that was published in Activity Report of TEİAŞ. On the other hand, compared to General Energy Balance Sheets AD of 1.A.1.a category had some bias in amount of fuel used. Uncertainties were determined by experts of MENR as 6% for liquid (resulting from incomparable "other oil products"), 1% for solid, 3% for gaseous fuels. For industrial waste and biomass, the sum of two was able to be compared with the "bioenergy and wastes" cell of General Energy Balance Sheets, and the bias was determined as 0.91%.

CO_2 emission factors uncertainties:

Solid fuels: Turkey lignite, other bituminuous coal, sub-bituminous coal, coal tar, coke oven gas, blast furnace gas and oxygen steel furnace gas have been used as solid fuels in 1.A.1.a category and combined uncertainty for solid fuels was calculated as 3.35%.

Liquid fuels: Residual fuel oil, diesel oil, naphta, LPG, petroleum coke, refinery gas and other oil products have been used as liquid fuels in 1.A.1.a category and combined uncertainty for liquid fuels was calculated as 4.12%.

Gaseous Fuels: Natural gas has been used as gaseous fuels in 1.A.1.a category and uncertainty for gaseous fuels was calculated as 1.12%.

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 fuels' uncertainties were combined using weighted average according to generated heat amount. So, the combined uncertainty for biomass is 9.57%. For industrial waste (mainly composed of hazardous and clinic waste) default EFs were 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 was considered as 25% and that for N_2O was considered as 75% by making use of the table in 2006 IPCC Guideline on page 2.40 (choosing The Netherlands as an example with PS and D EFs).

Recalculation:

In light of the recommendations addressed by ERT in annual review process and in order for the international data to be convenient and comparable with that of General Energy Balance Sheets, it is decided to disaggregate GHG emissions of 1.A.1.a sector under electricity and combined heat production nodes, using the same data source, TEİAŞ. Since disaggregated data was available for the years 2000-2015, aforementioned breakdown applied for those years. Also CO_2 EFs for 1.A.1a category were revised through whole time series taking into account the additional fuel analysis reports obtained recently. Data gaps of carbon contents through whole time series were thereby reduced.

Activity data of autoproducers for electricity production and sold heat were also included under 1.A.1.a category. Formerly whole activity data of autoproducers had been accounted under the industry branch they operate. Also CH_4 and N_2O EFs for 1.A.1.a category were revised and technology specific EFs from 2006 IPCC guidelines are used for the years 2003-2015 since information technology classification was available only for those years.

In this regard, for 1.A1.a category whole time series was recalculated.

Planned Improvement:

There is no planned improvement in this category.

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. The share of GHG emissions as CO_2 eq. from petroleum refining in total fuel combustion was 1.8% in 2015 while it was 2.5% in 1990.

Table 3.17 Emissions from petroleum refining, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ	Share in fuel combustion sector %
1990	3 228	0.11	0.02	3 237	44 089	2.5
1991	3 118	0.11	0.02	3 126	42 699	2.3
1992	3 304	0.11	0.02	3 313	45 990	2.3
1993	3 825	0.12	0.02	3 835	53 507	2.6
1994	4 159	0.14	0.03	4 170	58 174	2.9
1995	4 305	0.14	0.03	4 317	60 275	2.7
1996	4 197	0.14	0.03	4 208	58 284	2.4
1997	4 352	0.14	0.03	4 363	61 166	2.3
1998	4 433	0.15	0.03	4 445	61 641	2.4
1999	4 119	0.14	0.03	4 130	56 968	2.2
2000	4 066	0.14	0.03	4 077	56 104	2.0
2001	4 449	0.15	0.03	4 461	61 562	2.3
2002	4 838	0.16	0.03	4 851	67 823	2.5
2003	4 938	0.16	0.03	4 951	69 429	2.3
2004	5 019	0.16	0.03	5 032	71 039	2.3
2005	4 994	0.15	0.03	5 006	72 393	2.1
2006	4 990	0.15	0.03	5 002	72 973	2.0
2007	4 969	0.15	0.03	4 981	72 918	1.7
2008	5 076	0.15	0.03	5 088	76 621	1.8
2009	4 385	0.13	0.02	4 395	65 876	1.5
2010	4 246	0.11	0.02	4 254	67 634	1.5
2011	4 336	0.10	0.01	4 343	70 772	1.4
2012	4 431	0.10	0.01	4 438	71 719	1.4
2013	4 189	0.10	0.01	4 195	69 431	1.4
2014	4 506	0.10	0.01	4 512	79 770	1.4
2015	6 204	0.14	0.02	6 214	109 000	1.8

The increase since 2014 is 1.7 Mt CO_2 eq. (37.7% of increase) which is in parallel to the increase in oil refining (37.2% increase).

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. 2006 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 2006IPCC 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.

IEFs are checked. CO_2 IEFs for liguid fuels ranges from 57.61to 73.22 based on the share of refinery gas and residual fuel oil/diesel oil used in a specific year. CO_2 IEFs for liguid fuels ranges between 53.94 and 55.4. In the same way CH_4 and N_2O IEFs varies based on the share of fuels used.

Recalculation:

There is no recalculation in this category.

Planned Improvement:

Determination of AD and EF uncertainty values in cooperation with refineries authorities will be continued.

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. The share of GHG emissions as CO_2 eq. from manufacture of solid fuels category in total fuel combustion was 0.3% in 2015 while it was 1.4% in 1990.

Table 3.18 Emissions from category 1A1c, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ	Share in fuel combustion sector %
1990	1 810	0.01	0.001	1 811	11 820	1.4
1991	1 182	0.01	0.001	1 183	13 330	0.9
1992	1 142	0.01	0.001	1 143	10 872	0.8
1993	1 075	0.01	0.001	1 075	10 706	0.7
1994	967	0.01	0.001	968	10 190	0.7
1995	2 183	0.01	0.001	2 184	10 073	1.4
1996	993	0.01	0.001	994	8 682	0.6
1997	945	0.01	0.001	946	10 810	0.5
1998	946	0.01	0.001	947	11 134	0.5
1999	1 918	0.01	0.001	1 919	10 122	1.0
2000	846	0.01	0.001	846	10 759	0.4
2001	859	0.01	0.001	859	9 262	0.5
2002	802	0.01	0.001	803	9 437	0.4
2003	914	0.01	0.001	914	10 538	0.4
2004	949	0.01	0.001	950	11 075	0.4
2005	1 817	0.01	0.001	1 818	10 972	0.8
2006	1 773	0.01	0.001	1 774	10 680	0.7
2007	1 732	0.01	0.001	1 733	8 229	0.6
2008	1 646	0.01	0.001	1 646	12 910	0.6
2009	1 696	0.01	0.001	1 697	11 439	0.6
2010	1 056	0.01	0.001	1 057	9 084	0.4
2011	2 473	0.01	0.001	2 473	9 253	0.8
2012	1 038	0.01	0.001	1 038	12 094	0.3
2013	1 099	0.01	0.001	1 099	13 819	0.4
2014	1 098	0.01	0.001	1 099	14 420	0.4
2015	1 134	0.02	0.002	1 134	15 563	0.3

Compared to 2014, there is 35.4 kt CO_2 eq. (3.2% 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 (10.7%) and blast furnace gas consumption (4.9%).

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 heating of coke ovens. 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 2006 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 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

All coke production facilities were covered in the inventory. AD uncertainty for solid 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 2006 IPCC default values.

IEFs are checked. CO_2 IEFs for lsolid fuels ranges from 72.83 to 267.76 based on the share of coke oven gas and blast furnace gas used in a specific year. In the same way CH_4 and N_2O IEFs varies based on the share of fuels used.

Recalculation:

A carbon balance studies in integrated iron and steel production plants has been performed in cooperation with the experts from the plants. Site visits to two (out of 3) of the integrated iron and steel production plants were organized and AD and EFs (which are provided by the facilities itself) used for GHG emission were examined together with plant authorities and definitions of fuels and allocation of emissions were studied to reach the common understanting on the issues. Discussion showed that there were some mistakes in amount of fuels, NCVs, density of the derived gas provided previously by the companies. Generally there was some confusion problem with data provided by the companies whether it is mass or volumetric basis, it led to the incorrect carbon content calculation of coke oven gas and blast furnace gas (they were out of 2006 IPCC default values previously). All the missunderstandins and inconsistencies were clarified in communication with the companies. Also it is realized that all integrated iron and steel companies have their on energy balance tables showing all energy inputs and outputs for each processes in the facilities. After clarifying GHG inventory related issues, ADs, NCVs, carbon contents of fuels and other input/output materials were revised by the companies based on the reached consensus.

There is a recalculation in the category 1A1c for 1990-2014 periods with the revised plant specific data.

Planned Improvement:

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

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. Untill, 2015 sectoral breakdown of national energy balance tables are not fully in line with CRF categories. In the national energy balance tables, pulp, paper and print sector were presented separately from 2011 onward. It was presented under "other industries (1.A.2.g)" category before 2011. Food processing category included only sugar industry for 1990-2010 periods. From 2011 onward all food processing industries were covered but beverages and tobacco industry were still included under "other industries (1.A.2.g)" category. However, starting from 2015, national energy balance tables are detailed and provided energy consumption for all economical activities so GHG emissions are allocated in line with CRF category.

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.

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.

Although 2006 IPCC guidelines recommends that the autoproducers is considered under the economical branch in which they are operated, in our national energy balance tables all electricity production and heat production (for selling purposes) of autoproducers are included under electricity and heat production sector. The data for this sector are provided by TEİAŞ (electricity tansmission authority of Turkey). Since, based on the New Electricity Market Law No. 6446 auto producers became main electricity producers, and in order for the use of consistent data sets in the GHG inventory, it is decided to allocate all emissions from autoproducers under CRF category 1A1a. Therefore GHG emissions from stationary combustion sectors (including CRF category 1.A.2) are recalculated for 1990-2014 periods.

Table 3.19 Fuel combustion emissions from manufacturing industry, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2-eq (kt)	TJ	Share in fuel combustion sector %
1990	32 225	2.1	0.3	32 381	360 882	24.7
1991	35 683	2.4	0.4	35 854	397 406	26.5
1992	34 407	2.1	0.3	34 562	396 434	24.4
1993	35 722	2.1	0.3	35 875	419 167	24.1
1994	31 632	1.8	0.3	31 766	372 884	21.8
1995	36 280	2.0	0.3	36 431	433 535	22.7
1996	46 275	2.9	0.5	46 483	531 990	26.3
1997	51 539	3.2	0.5	51 772	591 172	27.5
1998	51 093	3.4	0.5	51 340	575 826	27.3
1999	43 315	2.8	0.5	43 522	510 662	23.4
2000	53 391	3.9	0.6	53 669	613 574	25.9
2001	40 925	2.6	0.4	41 110	486 060	21.6
2002	52 460	3.6	0.6	52 716	615 531	26.7
2003	62 216	4.1	0.6	62 509	730 599	29.4
2004	60 278	4.2	0.6	60 576	739 298	27.6
2005	58 747	3.8	0.6	59 019	726 992	24.9
2006	67 420	4.8	0.7	67 756	850 864	26.5
2007	69 211	5.1	0.8	69 565	876 231	24.4
2008	45 792	2.6	0.4	45 977	582 177	16.3
2009	45 526	2.7	0.4	45 718	557 686	15.9
2010	54 217	3.1	0.5	54 435	680 074	19.1
2011	56 379	3.1	0.5	56 596	736 307	18.5
2012	57 489	3.0	0.5	57 702	746 603	18.5
2013	51 579	2.8	0.4	51 777	658 084	17.2
2014	52 088	3.0	0.4	52 295	671 114	16.7
2015	57 411	3.2	0.5	57 636	745 938	17.2

GHG emissions from manufacturing industries and construction is 57.6 Mt CO_2 eq. in 2015 which is 17.2% of total fuel combustion and 12.1% of total national emissions (excluding *LULUCF*), where as GHG emissions from 1.A.2 was 32.2 Mt CO_2 eq. which is 24.7% of total fuel combustion and 15.1% of total national emissions (excluding LULUCF) in 1990. Emissions increased by 5.32 Mt CO2 eq. (10.2%) from 2014 to 2015 (Table 3.19).

Table 3.20 GHG emissions from manufacturing industry , 1990-2015

(kt CO2-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	32 381	1 942	1 087	4 893	IE	2 911	8 222	13 326
1991	35 854	2 118	1 019	4 457	IE	2 873	9 379	16 008
1992	34 562	2 327	1 070	4 925	IE	2 341	8 173	15 725
1993	35 875	2 332	981	4 814	IE	2 154	8 138	17 455
1994	31 766	2 133	1 309	4 246	IE	1 573	9 516	12 989
1995	36 431	2 032	1 758	4 961	IE	1 686	8 797	17 196
1996	46 483	2 181	1 360	4 880	IE	2 213	10 400	25 449
1997	51 772	2 084	1 249	4 944	IE	2 189	9 503	31 804
1998	51 340	1 973	1 165	4 086	IE	2 648	8 440	33 028
1999	43 522	1 739	1 700	3 592	IE	2 561	10 227	23 704
2000	53 669	1 833	2 018	3 857	IE	2 143	9 262	34 556
2001	41 110	1 730	2 033	5 146	IE	3 982	8 853	19 367
2002	52 716	1 604	2 197	4 689	IE	3 909	8 917	31 400
2003	62 509	1 705	1 964	4 447	IE	2 705	10 157	41 532
2004	60 576	1 428	2 234	6 939	IE	2 352	13 226	34 398
2005	59 019	1 134	2 261	5 620	IE	2 128	14 888	32 989
2006	67 756	834	2 591	4 842	IE	2 038	14 913	42 538
2007	69 565	696	9 111	2 226	IE	1 416	13 737	42 378
2008	45 977	2 086	241	933	IE	1 357	19 431	21 929
2009	45 718	1 870	1 063	1 451	IE	435	16 682	24 218
2010	54 435	2 921	1 327	3 307	IE	402	17 951	28 527
2011	56 596	3 238	366	3 084	763	1 146	23 850	24 148
2012	57 702	2 522	1 431	4 364	706	2 214	25 729	20 736
2013	51 777	3 161	889	3 820	730	2 211	23 473	17 492
2014	52 295	3 187	998	3 254	887	2 911	26 218	14 841
2015	57 636	3 246	1 207	6 157	966	4 374	30 706	10 979

Non-metallic minerals and chemicals and other industries are the main contributors for GHG emissions in 1.A.2 category. The share of non-metalic minerals is 53.3% and that of other industries is -19% in 2015. It is followed by chemicals with 10.7%, food processing, beverages and tobacco with 7.6% and iron and steel with 5.6%.

Table 3.21 Contribution of subsectors of manufacturing industries and construction, 2014-2015

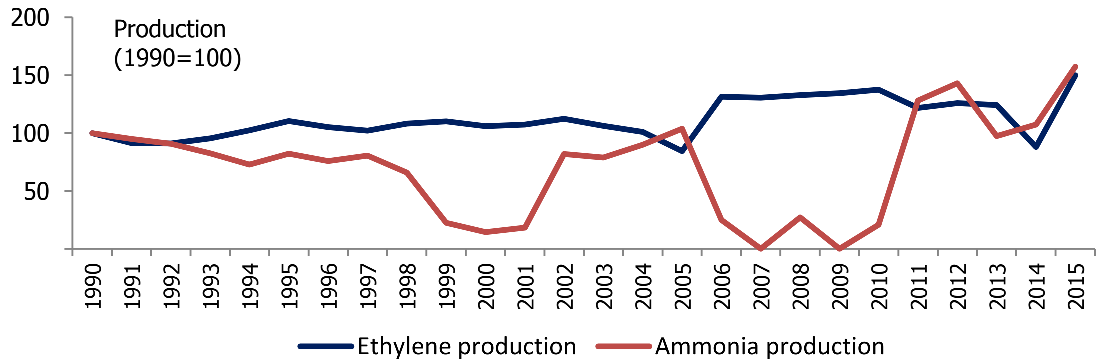
	Emission (kt CO_2 eq.)		Changes from 2014 to 2015		Share in manufacturing industry (%)	
	2014	2015	(kt CO_2-eq)	%	2014	2015
1.A.2 Total	52 295	57 636	5 340	10.2	100.0	100.0
Iron and steel	3 187	3 246	60	1.9	6.1	5.6
Non-ferrous metals	998	1 207	209	21.0	1.9	2.1
Chemicals	3 254	6 157	2 903	89.2	6.2	10.7
Pulp, paper and print	887	966	79	8.9	1.7	1.7
Food processing, beverages and tobacco	2 911	4 374	1 463	50.3	5.6	7.6
Non-metallic minerals	26 218	30 706	4 489	17.1	50.1	53.3
Other industries	14 841	10 979	-3 862	-26.0	28.4	19.0

Reallocation of GHG emissions from autoproducers which are operated under CRF category 1.A.2 to CRF category 1.A.1.a is the main reason in change in emission over time. However, the changes from 2014 to 2015 are due to the reallocation of some sub-sectors allocated under 1A2g in the previous years to the appropriate categories based on the improvement in the 2015 national energy balance tables. Beverages and tobacco and print is separated from 1.A.2.g and allocated under 1.A.2.e and 1.A.2.d respectively.

The changes in GHG emissions from 1.A.2 between 2014 and 2015 are mainly related to the increase of GHG emissions in non metallic minerals, chemicals, and food processing, beverages and tobacco and decrease of GHG emissions in other industries category.

In chemicals industry, petrochemical industry and ammonia production are the most energy consuming sectors so the main GHG emission contributors. The production of ethylene increased 70.1% and ammonia production increased 46.5% between 2014 and 2015. The increase in GHG emissions (89.2%) is mainly related to the increase in the chemicals production in this sector.

Figure 3.18 Ethylene and ammonias production, 1990-2015



The increase in total emissions from food processing, beverages and tobacco subcategory is 50.3% from 2014 to 2015. The main reason of this increase is the reallocation of beverages and tobacco under 1A1e. Beverages and tobacco is allocated under 1A2g in the previous years.

Manufacturing industry and construction category is a key category in terms of emission level and emission trend of CO_2 emissons from liquid, solid and gaseous fuels in 2015. It is also a key category interms of emission level of CO_2 from other fossil fuels.

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.

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 data and NCVs were used in the GHG estimation. But, 2006 IPCC default EFs were used for CO_2, CH_4 and N_2O emission estimation.

Country specific CO2 EFs are used for emission estimation. Country specific CO2 EFs determined from fuel analysis reports. The carbon content and oxidation rates were calculated through fuel analysis and ash-slag or stack gas analysis reports. For Turkey lignite and other bituminous 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 the related fuel.

Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 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 1990-2014 period.

CO_2 emissions from biomass were estimated by using 2006 IPCC default emissions factors.

CH_4 and N_2O emissions from all sub categories of CRF category 1A2, have been estimated by using 2006 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 except 1A2a.

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. Also country specific carbon content of fuels is checked with IPCC default values to ensure they are in the range. Reasonability of IEFs are compared with the previous annual submission and with the 2006 IPCC Guidelines. Also time series consistency of the IEF is checked and any large changes are explained in NIR.

Recalculation:

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 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 were recalculated for 1990-2014 period.

Also there is a recalculation for 1990-2014 periods in GHG emissions due to reallocation of emissions from autoproducers as explained above (under Source Category Description). There is a recalculation for 1.A.2.a category based on the carbon mass balance studies performed in integrated iron and steel production facilities.

The impact of recalculation is mainly related to reallocation of autopruducers under 1A1a. Since 1990-2008 periods autoproducers were not properly categorized in the appropriate branches of 1A2, all of them had been included under 1A2g category for 1990-2008 periods. Therefore 1A2g category is only affected category by reallocation of autoproducers for that period. After 2009 the effects of reallocation of autoproducers could be seen especially in 1A2a, 1A2c, and 1A2e categories. There is

17.8 Mt CO_2-eq decrease (25.4% decrease) in 2014 total GHG emissions from 1A2 category as compared to previous submission. 1A2a is responsible from 61.5% of the that decrease in 1A2 category.

Table 3.22 Difference in GHG emissions from 1A2 category between 2017 and 2016 submissions,

(kt CO2-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	-2 760	83	- 13	- 55	NO,IE	3	63	-2 842
1991	-2 019	81	- 13	- 61	NO,IE	1	436	-2 465
1992	-2 744	72	- 13	- 71	NO,IE	- 4	384	-3 112
1993	-3 415	77	- 11	- 73	NO,IE	- 4	232	-3 636
1994	-3 418	88	- 15	- 66	NO,IE	- 4	290	-3 711
1995	-3 567	119	- 10	- 66	NO,IE	- 5	318	-3 922
1996	-2 734	111	- 7	- 63	NO,IE	- 2	395	-3 167
1997	-2 648	124	5	- 64	NO,IE	10	506	-3 229
1998	-4 082	117	8	- 46	NO,IE	19	345	-4 526
1999	-6 671	120	- 21	- 53	NO,IE	- 3	60	-6 774
2000	-13 773	171	- 17	- 55	NO,IE	6	107	-13 985
2001	-14 771	158	- 10	- 69	NO,IE	- 16	172	-15 006
2002	-16 270	131	- 11	- 50	NO,IE	- 26	103	-16 417
2003	-15 084	277	- 7	- 68	NO,IE	- 3	297	-15 581
2004	-18 524	308	- 34	- 109	NO,IE	- 20	- 125	-18 543
2005	-23 161	311	- 26	- 83	NO,IE	- 6	71	-23 429
2006	-22 256	308	- 47	- 74	NO,IE	- 19	- 255	-22 169
2007	-22 950	274	- 146	- 32	NO,IE	- 2	- 302	-22 742
2008	-14 198	248	- 3	- 11	NO,IE	- 19	- 20	-14 394
2009	-5 144	-2 165	- 12	- 215	NO,IE	- 1	145	-2 897
2010	-8 432	-5 319	- 52	- 888	NO,IE	- 226	84	-1 551
2011	-3 034	90	- 75	- 674	- 510	- 280	- 285	-1 300
2012	-9 089	-5 070	- 124	- 780	- 455	- 621	- 113	-1 925
2013	-10 045	-7 087	- 138	- 579	- 498	- 845	- 61	- 837
2014	-17 790	-10 945	- 314	-1 537	- 800	-2 117	- 730	-1 348

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

Source Category Description:

The source categories covers sinter production, blast furnaces for pig iron production, and basic oxygen furnaces, electric arc furnace mills. There is no direct reduced iron (DRI) production in Turkey.

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

The share of GHG emissions as CO_2 eq. from 1.A.2.a in total manufacturing industry fuel combustion was 5.6% in 2015 while it was 6% in 1990.

Table 3.23 Fuel combustion emissions from iron and steel industry, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2-eq (kt)	TJ	Share in 1.A.2 (%)
1990	1 936	0.07	0.014	1 942	26 301	6.0
1991	2 112	0.08	0.015	2 118	29 211	5.9
1992	2 320	0.09	0.017	2 327	32 056	6.7
1993	2 324	0.09	0.018	2 332	31 542	6.5
1994	2 126	0.08	0.016	2 133	29 061	6.7
1995	2 026	0.08	0.015	2 032	28 090	5.6
1996	2 174	0.08	0.016	2 181	29 947	4.7
1997	2 077	0.08	0.015	2 084	28 812	4.0
1998	1 967	0.07	0.015	1 973	27 203	3.8
1999	1 733	0.07	0.013	1 739	24 102	4.0
2000	1 827	0.07	0.013	1 833	25 650	3.4
2001	1 724	0.06	0.012	1 730	24 236	4.2
2002	1 600	0.06	0.012	1 604	22 379	3.0
2003	1 700	0.06	0.012	1 705	23 765	2.7
2004	1 424	0.05	0.009	1 428	20 350	2.4
2005	1 131	0.04	0.007	1 134	16 668	1.9
2006	832	0.03	0.005	834	12 733	1.2
2007	694	0.02	0.004	696	10 876	1.0
2008	2 083	0.04	0.005	2 086	36 519	4.5
2009	1 868	0.03	0.004	1 870	33 754	4.1
2010	2 915	0.08	0.012	2 921	48 365	5.4
2011	3 235	0.06	0.006	3 238	58 304	5.7
2012	2 520	0.05	0.005	2 522	45 468	4.4
2013	3 158	0.06	0.006	3 161	56 847	6.1
2014	3 184	0.06	0.006	3 187	57 294	6.1
2015	3 243	0.06	0.006	3 246	58 293	5.6

The increase in total emissions from iron and steel subcategory from 2014 to 2015 is 1305 kt CO_2 eq. (1.87% of increase).

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.

Country specific CO_2 EFs are used for emission estimation. Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from 1.A.2.a category were recalculated for 1990-2014 period.

CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs.

A carbon mass balance study was carried out for integrated iron and steel production facilities. There are three integrated iron and steel plants in Turkey and plant specific data are gathered from those plants. Turkish inventory team had a site visit to two of the three integrated steel plants and organized a meeting with the experts from the third integrated iron and steel plant. Through the site visits and the meeting, processes and data reporting issues are discussed in order to identify potential inconsistencies and reporting errors. Plant specific AD and EFs used for GHG emission estimation were examined together with plant authorities and definitions of fuels and allocation of emissions were studied to reach the common understanting on the issues. Discussion showed that there were some mistakes in amount of fuels, NCVs, density of the derived gas provided previously by the companies. Generally there was some confusion problem with data provided by the companies whether it is mass or volumetric basis, it led to the incorrect carbon content calculation of coke oven gas and blast furnace gas (they were out of 2006 IPCC default values previously). All the missunderstandins and inconsistencies were clarified in communication with the companies. Also it is realized that all integrated iron and steel companies have their on energy balance tables showing all energy inputs and outputs for each processes in the facilities. After clarifying GHG inventory related issues, ADs, NCVs, carbon contents of fuels and other input/output materials were revised by the companies based on the reached consensus.

All emission sources were identified together with experts from integrated facilities and emissions are allocated under appropriate CRF categories. Allocation is made in the following way;

- Fuels used for electricity generation in auto-producer is considered under Energy-1.A.1.a public electricity and heat production category (based on the reallocation of autoproducers as explained above under source category description of section 3.2.5).
- Fuel used for the heating of coke ovens (for coke production) is considered under Energy-1.A.1.c (manufacture of solid fuels) category,
- Fuel used for rolling mills and other miscellaneous combustion source is considered under Energy-1.A.2.a iron and steel industry category
- All carbonaceous fuels (including coke as reducing agent) used in blast furnaces and sinter production are considered under IPPU-2.C.1 iron &steel production,

Uncertainties and Time-Series Consistency:

Plant specific AD is used for integrated iron and steel production facilities. The AD for EAFs is taken from the national energy balance tables. Uncertainties in the AD were determined by experts of MENR and TurkStat. AD uncertainties were determined as 10 % 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 1.A.2.a 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.

A carbon mass balance study was carried out for integrated iron and steel production facilities. Each integrated iron and stell production facility has their own energy balance table showing all energy inputs and outputs for each processes in the facilities. For verification purpose, bottom up emission estimation which is emissions from each processes within the facilities (allocated under 1.A.1.a, 1.A1.c, 1.A.2.a, and 2.C.1 categories) is compared with overall carbon mass balance of the facilities which is difference between Carbon from all carbonaceous input materials (coking coal, injection coal, other input fuels, lime, dolomite) and Carbon from all carbon containing outputs (coke, iron and steel). The comparison for 2015 result is given in the below.

Emissions calculated by overall carbon mass balance = 22137 kt
Aggregated emissions from each CRF category = 21 958 kt

Emissions from the bottom up approach is 99% of emissions from overall carbon mass balance. Although it shows good quality CO_2 emission estimation in the overall integrated iron and steel facilities, the percentage varying 92% to 107% in the facility level, still need to be improved.

CO_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC guidelines but are changing based on fuel mix used in the sector. CO_2 IEF for liquid fuels, ranges from 65.02-76.92 based on share of fuels used. Residual fuel oil was 99% of total liquid fuels in 1990 resulting in highest IEF but share of LPG is the higest (80%) in 2012 resulting in the lowest IEF. CO_2 IEF for solid fuels, ranges from 42.64-65 based on share of coke oven gas and blust furnace gas used. CO_2 IEF for gaseous fuels, ranges from 55.75-56.36.

Recalculations:

There is a recalculation for 1990-2014 periods in GHG emissions due to reallocation of emissions from autoproducers as explained above (under Source Category Description). Also there is a recalculation for 1.A.2.a category based on the carbon mass balance studies performed in integrated iron and steel production facilities.

There is 10.9 Mt CO_2-eq decrease (77.4% decrease) in 2014 total GHG emissions from 1A2a category as compared to previous submission.

Planned Improvement:

Work on the improvement of carbon mass 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:

The share of GHG emissions as CO_2 eq. from 1.A.2.b in total manufacturing industry fuel combustion was 2.1% in 2015 while it was 3.4% in 1990.

Table 3.24 Fuel combustion emissions from non-ferrous metals, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2-eq (kt)	TJ	Share in 1.A.2 category (%)
1990	1 083	0.05	0.009	1 087	13 172	3.4
1991	1 015	0.05	0.009	1 019	12 437	2.8
1992	1 066	0.05	0.010	1 070	12 967	3.1
1993	978	0.05	0.009	981	11 835	2.7
1994	1 304	0.06	0.012	1 309	15 677	4.1
1995	1 752	0.08	0.014	1 758	22 277	4.8
1996	1 355	0.06	0.010	1 360	18 256	2.9
1997	1 244	0.06	0.011	1 249	15 841	2.4
1998	1 160	0.06	0.011	1 165	13 998	2.3
1999	1 695	0.07	0.012	1 700	23 789	3.9
2000	2 010	0.10	0.016	2 018	26 751	3.8
2001	2 026	0.10	0.016	2 033	26 815	4.9
2002	2 189	0.11	0.017	2 197	29 611	4.2
2003	1 958	0.08	0.013	1 964	27 983	3.1
2004	2 228	0.09	0.014	2 234	32 947	3.7
2005	2 255	0.08	0.013	2 261	33 724	3.8
2006	2 584	0.09	0.014	2 591	39 815	3.8
2007	9 098	0.22	0.025	9 111	157 450	13.1
2008	241	0.00	0.000	241	4 258	0.5
2009	1 061	0.03	0.003	1 063	17 689	2.3
2010	1 325	0.04	0.005	1 327	21 535	2.4
2011	365	0.01	0.001	366	6 166	0.6
2012	1 428	0.05	0.006	1 431	22 645	2.5
2013	887	0.03	0.004	889	14 631	1.7
2014	996	0.02	0.002	998	17 371	1.9
2015	1 205	0.03	0.004	1 207	20 103	2.1

The increase in total emissions of 1.A.2.b category from 2014 to 2015 is 209.5 kt CO2 eq. (21% of increase).

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.

Country specific CO_2 EFs are used for emission estimation. Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from 1.A.2.b category were recalculated for 1990-2014 period.

CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs. GHG emissions from biomass were 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. CO_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC guidelines but are changing based on fuel mix used in the sector. CO_2 IEF for liquid fuels, ranges from 72.2-93.96 based on the share of fuels used. Petroleum coke used in 2009, 2010 results in highest IEF. CO_2 IEF for solid fuels, ranges from 92.88.112.57 based on share of Turkish lignite used. CO_2 IEF for gaseous fuels, ranges from 55.75-56.36.

Recalculation:

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 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 1990-2014 period.

There is also a recalculation for 1990-2014 periods in GHG emissions due to reallocation of emissions from autoproducers as explained above (under Source Category Description).

There is 314 kt CO_2-eq decrease (23.9% decrease) in 2014 total GHG emissions from 1A2b category as compared to previous submission.

Planned Improvement:

There is no planned improvement for this category.

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

Source Category Description:

The source category includes manufacture of chemicals, fertilizer and basic pharmaceutical products. The share of GHG emissions as CO_2 eq. from 1.A.2.c in total manufacturing industry was 10.7% in 2015 while it was 15.1% in 1990.

Table 3.25 Fuel combustion emissions from chemicals, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2-eq (kt)	TJ	Share in 1.A.2 category (%)
1990	4 875	0.24	0.040	4 893	62 696	15.1
1991	4 444	0.18	0.031	4 457	61 825	12.4
1992	4 912	0.18	0.031	4 925	70 470	14.3
1993	4 802	0.17	0.028	4 814	70 397	13.4
1994	4 234	0.15	0.026	4 246	61 011	13.4
1995	4 947	0.17	0.030	4 961	71 444	13.6
1996	4 867	0.17	0.029	4 880	70 610	10.5
1997	4 932	0.17	0.028	4 944	72 806	9.6
1998	4 074	0.16	0.028	4 086	56 182	8.0
1999	3 581	0.14	0.025	3 592	49 420	8.3
2000	3 845	0.15	0.027	3 857	53 253	7.2
2001	5 131	0.20	0.036	5 146	70 465	12.5
2002	4 676	0.17	0.029	4 689	68 018	8.9
2003	4 436	0.14	0.025	4 447	65 218	7.1
2004	6 920	0.24	0.044	6 939	98 773	11.5
2005	5 607	0.17	0.029	5 620	84 915	9.5
2006	4 831	0.15	0.025	4 842	72 868	7.1
2007	2 223	0.05	0.005	2 226	38 692	3.2
2008	932	0.02	0.002	933	16 215	2.0
2009	1 446	0.07	0.010	1 451	20 410	3.2
2010	3 294	0.17	0.028	3 307	43 631	6.1
2011	3 077	0.11	0.015	3 084	48 501	5.4
2012	4 355	0.13	0.018	4 364	70 794	7.6
2013	3 808	0.18	0.025	3 820	55 937	7.4
2014	3 245	0.14	0.019	3 254	49 679	6.2
2015	6 142	0.23	0.031	6 157	98 913	10.7

The increase in total emissions of 1.A.2.c category from 2014 to 2015 is 2903 kt CO2 eq. (89.2% of increase). The petrochemical industry and ammonia production is main emission contributor of this sector. Production increased considerably in those sectors (as explained above under section 3.2.5). The increase in GHG emission of this category is related to the increase in production of main contributing sectors.

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.

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 data and NCVs were used in the GHG estimation.

Country specific CO_2 EFs are used for emission estimation. Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from 1.A.2.c category were recalculated for 1990-2014 period.

GHG emissions from waste incineration were estimated by using 2006 IPCC default EFs.

CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD was 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 petrochemical facility, 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. Also country specific carbon content of fuels is checked with IPCC default values to ensure they are in the range. Reasonability of IEFs is compared with the previous annual submission and with the 2006 IPCC Guidelines.

Also time series consistency of the IEF is checked.mCO2, CH4 and N2O IEFs for all fuels are in the range of 2006 IPCC guidelines but are changing based on fuel mix used in the sector. CO2 IEF for liquid fuels, ranges from 64.15-76.97 based on share of residual fuel oil, and LPG used. IEF for solid fuels, ranges from 96.24-114.18 based on share of Turkish lignite used. CO2 IEF for gaseous fuels, ranges from 55.75-56.36.

Recalculation:

Country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 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 1.A.2.c were recalculated for 1990-2014 period.

There is also a recalculation for 1990-2014 periods in GHG emissions due to reallocation of emissions from autoproducers as explained above (under Source Category Description).

There is 1537 kt CO_2-eq decrease (32.1% decrease) in 2014 total GHG emissions from 1A2c category as compared to previous submission. Mainly reallocation of autoproducers is responsible from that decrease.

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 and paper 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. In 2015 national energy balance, print sector is also covered under 1.A.2.d which is included under 1.A.2.g previously. The share of GHG emissions as CO_2 eq. from 1.A.2.d in total manufacturing industry fuel combustion was 1.7% in 2015 while it was 1.3% in 2011.

Table 3.26 Fuel combustion emissions from pulp, paper and print, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2-eq (kt)	TJ	Share in 1.A.2 category (%)
1990	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
1991	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
1992	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
1993	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
1994	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
1995	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
1996	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
1997	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
1998	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
1999	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
2000	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
2001	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
2002	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
2003	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
2004	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
2005	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
2006	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
2007	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
2008	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
2009	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
2010	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
2011	758	0.07	0.010	763	12 223	1.3
2012	703	0.04	0.005	706	9 561	1.2
2013	728	0.03	0.005	730	10 671	1.4
2014	884	0.05	0.007	887	12 263	1.7
2015	962	0.06	0.008	966	12 946	1.7

The increase in total emissions of 1.A.2.d category from 2014 to 2015 is 79.2 kt CO2 eq. (8.9% of increase).

Methodological Issues:

GHG emissions from 1.A.2.d 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 CO_2 EFs are used for emission estimation. Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from 1.A.2.d category were recalculated for 1990-2014 period.

CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs.

GHG emissions from biomass were 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.

CO_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC guidelines but are changing based on fuel mix used in the sector. CO_2 IEF for liquid fuels, ranges from 70.08-73.07 based on share of residual fuel oil/gas diesel oil, and LPG used. IEF for solid fuels, ranges from 103.56-109.16 based on share of Turkish lignite used. CO_2 IEF for gaseous fuels, ranges from 56.05-56.36.

Recalculation:

Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO2 emissions from 1.A.2.d category were recalculated for 1990-2014 period.

There is also a recalculation for 1990-2014 periods in GHG emissions due to reallocation of emissions from autoproducers as explained above (under Source Category Description).

There is 800 kt CO_2-eq decrease (47.4% decrease) in 2014 total GHG emissions from 1A2d category as compared to previous submission.

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:

In the national energy balance tables, the fuel consumption for food processing sector was separated in 2011. For 1990-2010 period only sugar industry, 2011-2014 period all food processing industry were covered under this category but fuel consumption for beverages and tobacco industry cannot be separated and was considered under the section other industries (1.A.2.g). In 2015 national energy balance table, the beverages and tobacco industry are also included under 1.A.2.e category.

The share of GHG emissions as CO_2 eq. from 1.A.2.e in total 1.A.2 GHG emissions was 7.6% in 2015 while it was 9% in 1990.

Table 3.27 Fuel combustion emissions from 1A2e category, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2-eq (kt)	TJ	Share in 1.A.2 category (%)
1990	2 894	0.24	0.037	2 911	27 656	9.0
1991	2 857	0.23	0.036	2 873	26 900	8.0
1992	2 328	0.19	0.029	2 341	22 193	6.8
1993	2 142	0.17	0.026	2 154	20 603	6.0
1994	1 565	0.12	0.019	1 573	15 214	5.0
1995	1 677	0.13	0.020	1 686	16 883	4.6
1996	2 202	0.16	0.025	2 213	22 803	4.8
1997	2 178	0.16	0.025	2 189	22 410	4.2
1998	2 633	0.21	0.033	2 648	25 684	5.2
1999	2 546	0.21	0.032	2 561	25 070	5.9
2000	2 130	0.19	0.028	2 143	20 644	4.0
2001	3 963	0.26	0.042	3 982	44 738	9.7
2002	3 891	0.24	0.040	3 909	44 355	7.4
2003	2 692	0.19	0.030	2 705	29 133	4.3
2004	2 340	0.16	0.025	2 352	26 399	3.9
2005	2 117	0.16	0.024	2 128	22 493	3.6
2006	2 028	0.14	0.022	2 038	22 788	3.0
2007	1 409	0.10	0.016	1 416	14 805	2.0
2008	1 352	0.07	0.012	1 357	17 585	3.0
2009	433	0.03	0.005	435	4 405	1.0
2010	400	0.03	0.004	402	4 756	0.7
2011	1 140	0.08	0.013	1 146	13 002	2.0
2012	2 208	0.09	0.012	2 214	34 215	3.8
2013	2 206	0.08	0.011	2 211	34 213	4.3
2014	2 901	0.14	0.020	2 911	41 763	5.6
2015	4 356	0.26	0.037	4 374	58 490	7.6

Total GHG emission in 1.A.2.e category increased 1463 kt CO_2 eq. (50.3% of increase) from 2014 to 2015. The increase is mainly related to inclusion of beverages and tobacco sectors in this category in 2015.

Methodological Issues:

GHG emissions from 1.A.2.e 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 CO_2 EFs are used for emission estimation. Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from 1.A.2.e category were recalculated for 1990-2014 period.

CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been 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.

CO_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC guidelines but are changing based on fuel mix used in the sector. CO_2 IEF for liquid fuels, ranges from 71.8-78.76 based on share of residual fuel oil used. IEF for solid fuels, ranges from 103.41-113.57 based on share of Turkish lignite used. CO_2 IEF for gaseous fuels, ranges from 55.75-56.36.

Recalculation:

Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and

lignite was determined. So based on revised EFs, CO2 emissions from 1.A.2.e category were recalculated for 1990-2014 period.

There is also a recalculation for 1990-2014 periods in GHG emissions due to reallocation of emissions from autoproducers as explained above (under Source Category Description).

There is 2117 kt CO_2-eq decrease (42.1% decrease) in 2014 total GHG emissions from 1A2e category as compared to previous submission. It is mainly related to the reallocation of autoproducers.

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. 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.

In Turkey, some cement plants have waste incineration licence which is given by MoEU. They use waste as alternative fuels and also raw material. Wastes co-incinerated by license are: waste plastics, used tires, waste oils, industrial sludge, tank bottom sludge and sewage sludge, etc. Waste incineration has been carried out since 2004 in cement industry. Waste incineration emissions from cement industry for the period 2004-2015 were covered under this category.

1.A.2.f category is energy intensive sector. The share of GHG emissions as CO_2 eq. from 1.A.2.f in total manufacturing industry GHG emission was 53.3% in 2015 while it was 25.4% in 1990.

Table 3.28 Fuel combustion emissions from non-metallic minerals, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2-eq (kt)	TJ	Share in 1.A.2 category (%)
1990	8 177	0.63	0.100	8 222	85 402	25.4
1991	9 328	0.72	0.112	9 379	96 889	26.2
1992	8 130	0.60	0.093	8 173	84 132	23.6
1993	8 101	0.52	0.082	8 138	84 467	22.7
1994	9 468	0.67	0.106	9 516	95 257	30.0
1995	8 753	0.61	0.097	8 797	86 753	24.1
1996	10 350	0.69	0.111	10 400	102 887	22.4
1997	9 453	0.70	0.109	9 503	93 117	18.4
1998	8 398	0.58	0.092	8 440	82 676	16.4
1999	10 175	0.71	0.113	10 227	106 169	23.5
2000	9 217	0.63	0.100	9 262	94 764	17.3
2001	8 810	0.58	0.093	8 853	88 686	21.5
2002	8 875	0.57	0.093	8 917	90 367	16.9
2003	10 107	0.69	0.110	10 157	100 845	16.2
2004	13 159	0.92	0.147	13 226	136 780	21.8
2005	14 816	0.99	0.158	14 888	153 000	25.2
2006	14 836	1.06	0.169	14 913	156 495	22.0
2007	13 660	1.09	0.170	13 737	143 789	19.7
2008	19 329	1.42	0.225	19 431	200 392	42.3
2009	16 597	1.18	0.187	16 682	167 143	36.5
2010	17 854	1.35	0.212	17 951	177 760	33.0
2011	23 731	1.68	0.259	23 850	256 359	42.1
2012	25 604	1.77	0.274	25 729	274 543	44.6
2013	23 355	1.67	0.258	23 473	247 118	45.3
2014	26 093	1.74	0.272	26 218	287 757	50.1
2015	30 560	2.05	0.320	30 706	339 827	53.3

The increase in total GHG emission of 1.A.2.f category is 4489 kt CO_2 eq. (17.1% of increase) from 2014 to 2015.

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.

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 data and NCVs were used in the GHG estimation.

Country specific CO_2 EFs are used for emission estimation. Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO2 emissions from 1.A.2.f category were recalculated for 1990-2014 period.

GHG emissions from waste incineration and biomass were estimated by using 2006 IPCC default EFs.

CH4 and N2O emissions from liquid, solid and gaseous fuels have been 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 25.5% solid fuels, 27.8% for liquid fuels, and 29.2% for gaseous fuels.

For other fossil fuels and biomass, it was considered 2% as indicated in table 2.15 of 2006 IPCC guideline Vol.2. Since AD for waste and sewage sludge incineration data have been taken directly from the cement producers 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.

CO_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC guidelines but are changing based on fuel mix used in the sector. CO_2 IEF for liquid fuels, ranges from 83.41-97.06 based on share of petroleum coke used. Especially considerable amount of petroleum coke is used in cement production. IEF for solid fuels, ranges from 95.02-106.65 based on share of Turkish lignite used. CO_2 IEF for gaseous fuels, ranges from 55.75-56.36. CO_2 IEF for other fossil fuels ranges from 73.33-141.39 based on the share of industrial waste and waste oil used.

Recalculation:

Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and

lignite was determined. So based on revised EFs, CO2 emissions from 1.A.2.e category were recalculated for 1990-2014 period.

There is also a recalculation for 1990-2014 periods in GHG emissions due to reallocation of emissions from autoproducers as explained above (under Source Category Description).

There is 730 kt CO_2-eq decrease (2.7% decrease) in 2014 total GHG emissions from 1A2f category as compared to previous submission.

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 category. Based on the improvements in the sectoral breakdown of national energy balance the coverage of this category varies over times. As explained under section 3.2.5.4 and 3.2.5.5 some of the categories are included under 1.A.2.g category until 2011. In 2015 national energy balance tables provide complete sectoral breakdown of all economical activities, the coverage of this category is in line with CRF categorization.

The share of GHG emissions as CO_2 eq. from 1.A.2.g in total manufacturing industry fuel combustion was 19% in 2015 while it was 41.2% in 1990.

Table 3.29 Fuel combustion emissions from other industries, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2-eq (kt)	TJ	Share in 1.A.2 category (%)
1990	13 261	0.91	0.145	13 326	145 655	41.2
1991	15 929	1.10	0.175	16 008	170 144	44.6
1992	15 652	1.01	0.163	15 725	174 615	45.5
1993	17 376	1.08	0.175	17 455	200 323	48.7
1994	12 935	0.72	0.119	12 989	156 665	40.9
1995	17 125	0.97	0.158	17 196	208 087	47.2
1996	25 327	1.70	0.268	25 449	287 487	54.7
1997	31 656	2.05	0.324	31 804	358 187	61.4
1998	32 861	2.36	0.365	33 028	370 083	64.3
1999	23 585	1.65	0.259	23 704	282 112	54.5
2000	34 361	2.76	0.422	34 556	392 513	64.4
2001	19 271	1.37	0.207	19 367	231 120	47.1
2002	31 230	2.41	0.368	31 400	360 801	59.6
2003	41 324	2.95	0.450	41 532	483 655	66.4
2004	34 208	2.73	0.409	34 398	424 050	56.8
2005	32 821	2.39	0.362	32 989	416 191	55.9
2006	42 309	3.29	0.492	42 538	546 165	62.8
2007	42 127	3.58	0.542	42 378	510 618	60.9
2008	21 856	1.08	0.156	21 929	307 209	47.7
2009	24 122	1.38	0.206	24 218	314 285	53.0
2010	28 429	1.43	0.212	28 527	384 027	52.4
2011	24 072	1.09	0.165	24 148	341 752	42.7
2012	20 671	0.92	0.140	20 736	289 378	35.9
2013	17 438	0.74	0.119	17 492	238 667	33.8
2014	14 785	0.80	0.121	14 841	204 986	28.4
2015	10 942	0.53	0.078	10 979	157 367	19.0

Total GHG emission in 1.A.2.g category decreased 3862 kt CO_2 eq. (26% of decrease) from 2014 to 2015. The main reason for decreasing emissions in this sector is mainly related to the separation of beverages, tobacco and print industries from this category and allocation of them into their appropriate categories.

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.

Country specific CO_2 EFs are used for emission estimation. Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from 1.A.2.g category were recalculated for 1990-2014 period.

CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been 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.

CO_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC guidelines but are changing based on fuel mix used in the sector. CO_2 IEF for liquid fuels, ranges from 70.95-84.84 based on share of petroleum coke used. IEF for solid fuels, ranges from 91.88-112.08 based on share of Turkish lignite used. CO_2 IEF for gaseous fuels, ranges from 55.75-56.36.

Recalculation:

Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO2 emissions from 1.A.2.e category were recalculated for 1990-2014 period.

There is also a recalculation for 1990-2014 periods in GHG emissions due to reallocation of emissions from autoproducers as explained above (under Source Category Description).

There is 1348 kt CO_2-eq decrease (8.3% decrease) in 2014 total GHG emissions from 1A2g category as compared to previous submission.

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 the sub-categories listed below:

- Domestic Aviation (1.A.3.a)
- Road Transportation (1.A.3.b)
- Railways (1.A.3.c)
- Domestic water-borne Navigation (1.A.3.d)
- Pipeline (other transportation) (1.A.3.e.i)

Emissions from this category were 181% higher in 2015 than in 1990 (Figure 3.17), and on average emissions increased by more than 7.5% annually.

In 2015 transport sector contributed to 75.8 Mt CO_2 eq. emissions. GHG emissions (in CO_2 eq) from transport sector as a share of total fuel combustion was 22.6% in 2015 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 91.4% of transport emissions in 2015. Contribution of domestic aviation is 5.5%, domestic water-borne navigation is 1.5%, and railways are 0.6% in 2015. The share of pipeline transportation is 0.9%.

Figure 3.19 GHG emissions for transportation sector, 1990-2015

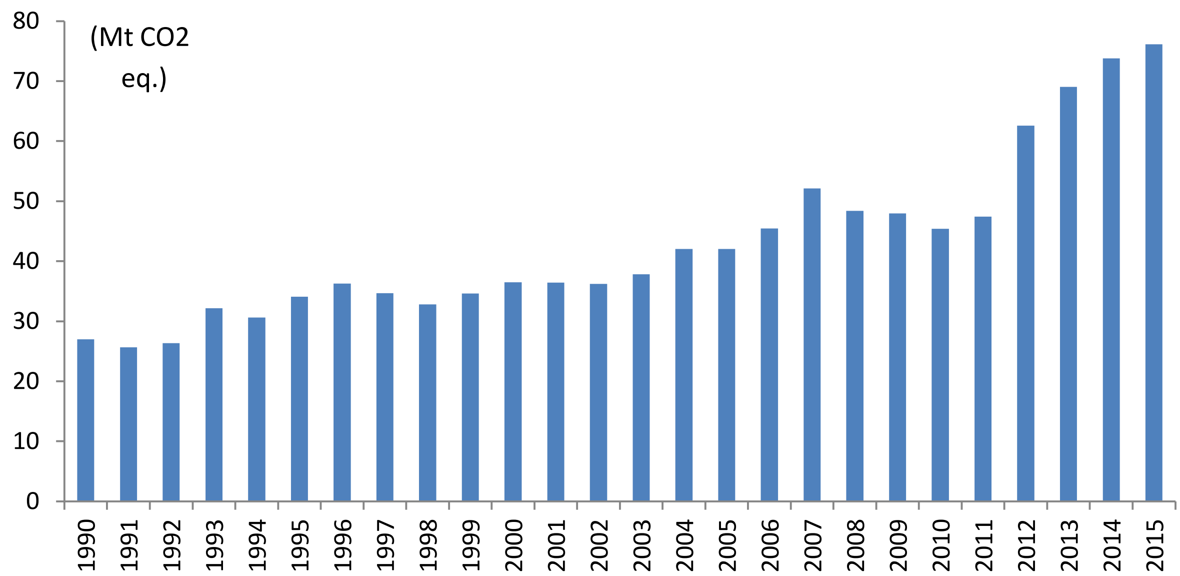


Table 3.30 GHG emissions from transport sector, 1990-2015

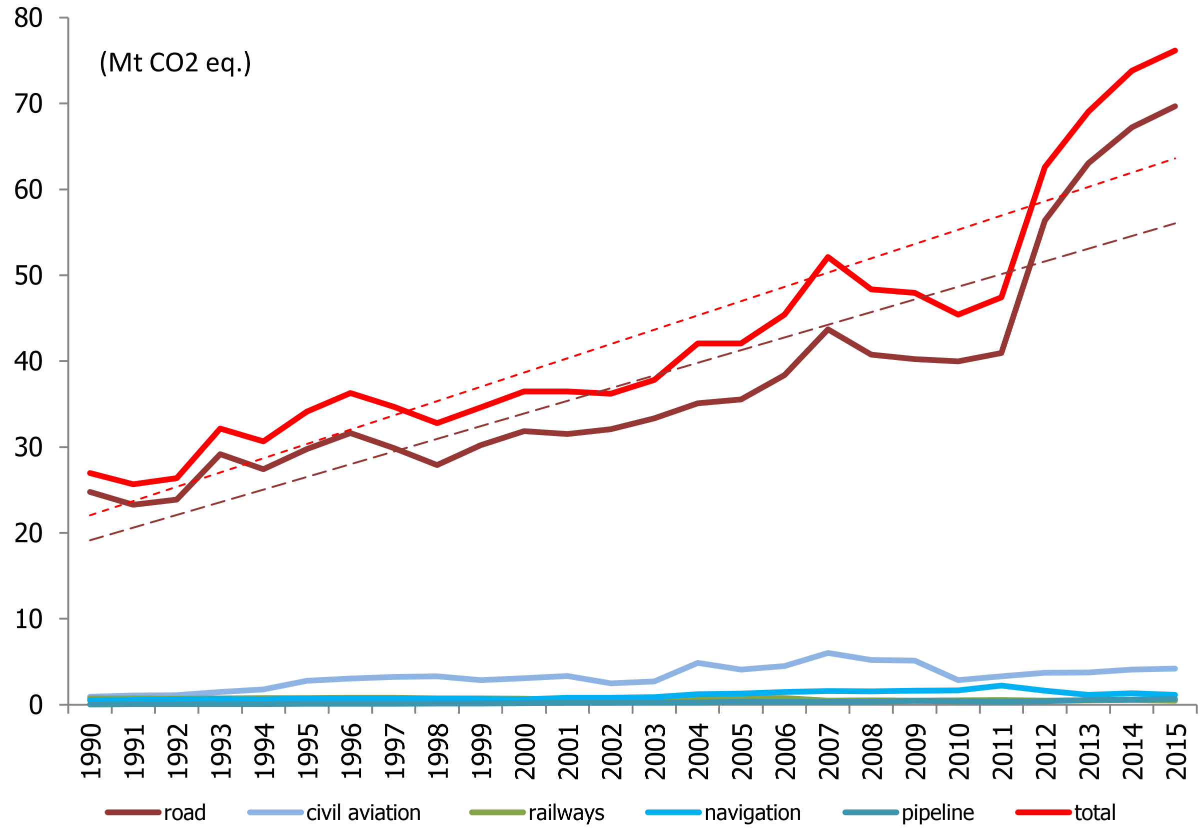
Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	26 251	4.0	2.1	26 969	364 617
1991	24 982	3.8	2.0	25 673	347 164
1992	25 640	4.2	2.1	26 366	356 995
1993	31 269	5.0	2.5	32 143	435 401
1994	29 789	4.9	2.4	30 640	415 493
1995	33 180	5.5	2.7	34 113	463 044
1996	35 277	5.9	2.8	36 271	492 752
1997	33 702	7.0	2.7	34 690	474 602
1998	31 817	7.5	2.6	32 782	450 289
1999	33 635	7.8	2.6	34 617	475 418
2000	35 490	8.9	2.5	36 465	503 352
2001	35 534	8.4	2.4	36 455	503 006
2002	35 316	7.9	2.4	36 234	498 404
2003	36 893	8.1	2.4	37 825	520 124
2004	41 061	8.3	2.6	42 048	578 405
2005	41 044	8.6	2.6	42 041	578 712
2006	44 377	9.2	2.7	45 424	625 285
2007	50 989	10.4	2.8	52 099	718 824
2008	47 117	10.5	2.6	48 166	668 762
2009	46 871	11.0	2.6	47 907	664 439
2010	44 383	11.4	2.4	45 392	630 304
2011	46 367	11.5	2.5	47 386	657 982
2012	61 249	12.6	3.2	62 525	862 220
2013	67 478	13.0	3.6	68 865	948 734
2014	72 084	13.6	3.8	73 559	1 013 762
2015	74 263	14.5	3.9	75 789	1 047 749

Table 3.31 GHG emissions by transport mode, 1990-2015

(kt CO_2 eq.)

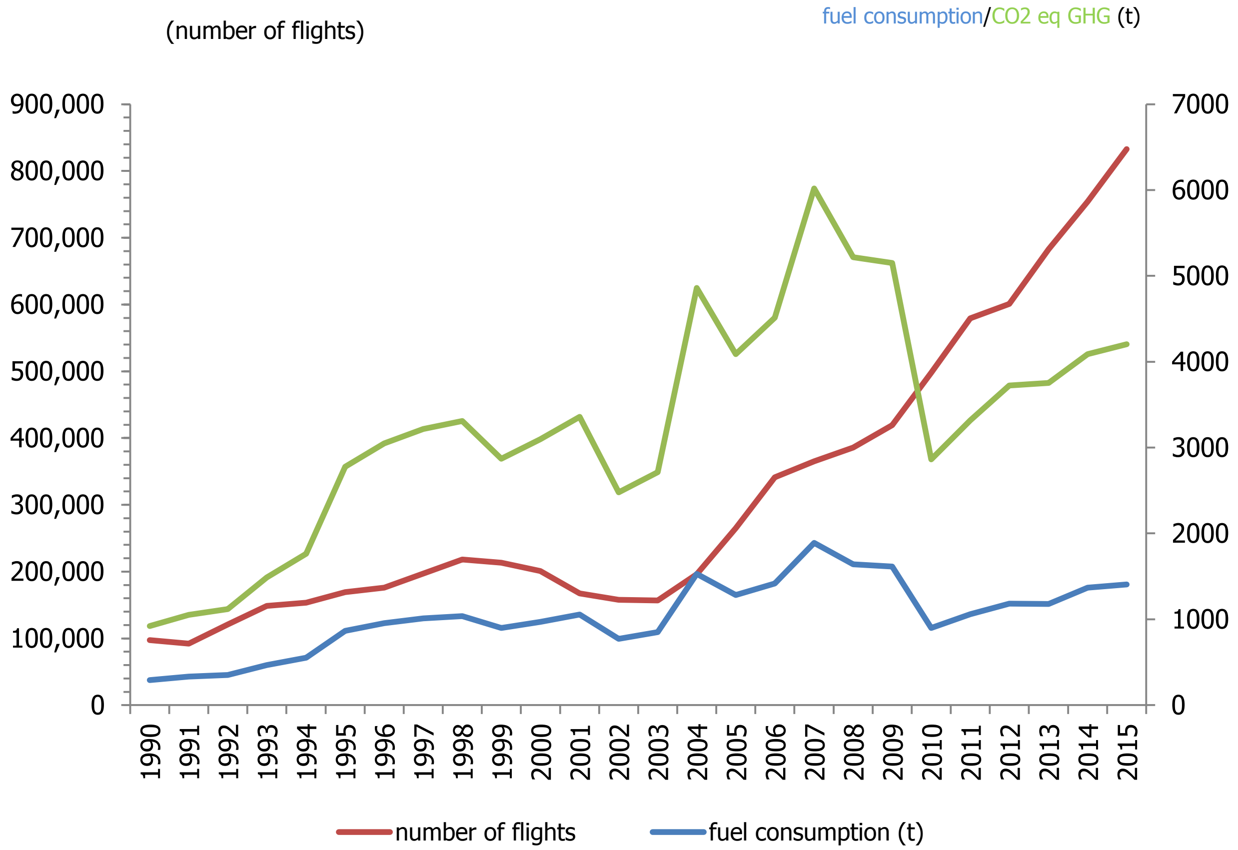
Year	Total	Domestic aviation	Road transportation	Railways	Domestic navigation	Other transportation
1990	26 969	923	24 777	721	509	39
1991	25 673	1 053	23 288	740	543	49
1992	26 366	1 118	23 871	685	638	54
1993	32 143	1 489	29 178	751	664	60
1994	30 640	1 764	27 419	768	623	65
1995	34 113	2 775	29 760	768	726	83
1996	36 271	3 048	31 628	799	699	97
1997	34 690	3 215	29 858	799	698	120
1998	32 782	3 311	27 881	740	726	124
1999	34 617	2 868	30 219	722	658	150
2000	36 465	3 099	31 850	713	623	180
2001	36 455	3 358	31 512	587	800	198
2002	36 234	2 503	32 084	612	822	213
2003	37 825	2 713	33 347	629	891	245
2004	42 048	4 859	35 090	629	1 228	242
2005	42 041	4 089	35 532	757	1 299	364
2006	45 424	4 512	38 370	761	1 464	317
2007	52 099	6 019	43 674	470	1 598	338
2008	48 166	5 218	40 559	499	1 543	348
2009	47 907	5 149	40 204	484	1 632	437
2010	45 392	2 862	39 941	517	1 682	390
2011	47 386	3 344	40 899	532	2 242	370
2012	62 525	3 727	56 310	492	1 614	381
2013	68 865	3 754	62 889	505	1 154	563
2014	73 559	4 090	66 967	562	1 348	593
2015	75 789	4 205	69 309	480	1 147	647

Figure 3.20 GHG emission trend by transport mode, 1990-2015



Throughout the time series, road transportation was the dominant source of emissions in the category, responsible for between 83% (2004) and 92% (1990). The second largest source was domestic aviation, ranging from 3% (1990) and 12% (2007). Between 2004 and 2009, when the share of emissions from road transportation was at their lowest, the share from domestic aviation was the highest.When analyzed in detail (Figure 3.19), there are different factors influencing GHG emissions resulting from domestic aviation. Fuel consumption rose steadily in domestic 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 resulted in a sudden improvement in civil aviation sector. Then again, the number of flights and fuel consumption started to increase. But, while the number of flights annually increased , fuel consumption and GHG emissions showed inter-annual variation following parallel trends. Especially, from 2007 to 2010 fuel consumption and GHG emissions declined by approximately 50% while the number of flights increased by roughly 35%. This decoupling could partially be explained with renewal of the Turkish air fleet and the global economic crisis. But main reason of decoupling could be determined with improving data quality in domestic aviation sector.

Figure 3.21 Comparison of number of flights, fuel consumption and GHG emissions of civil aviation, 1990-2015



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 the 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 was a large increase in GHG emissions resulting from diesel fuel between 2011 (27,035 kt CO2 eq) and 2015 (53,169 kt CO2 eq), an increase of 97%.

Figure 3.22 Emission distributions by fuel types in road transportation, 1990-2015

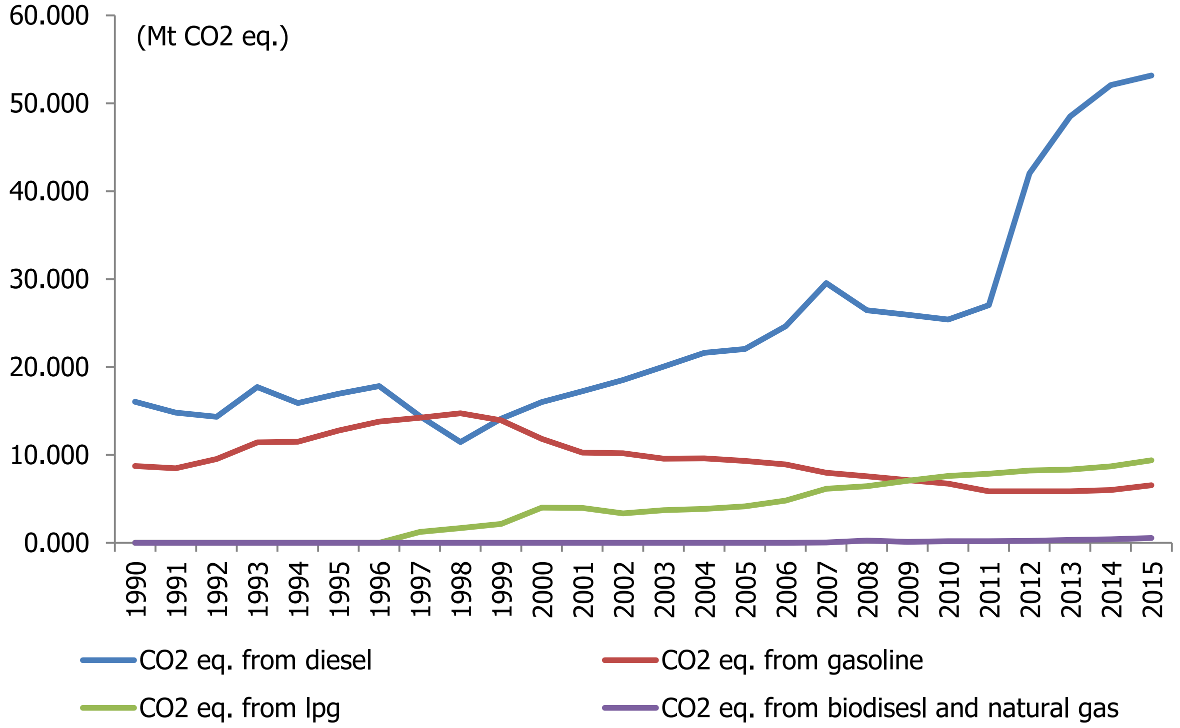
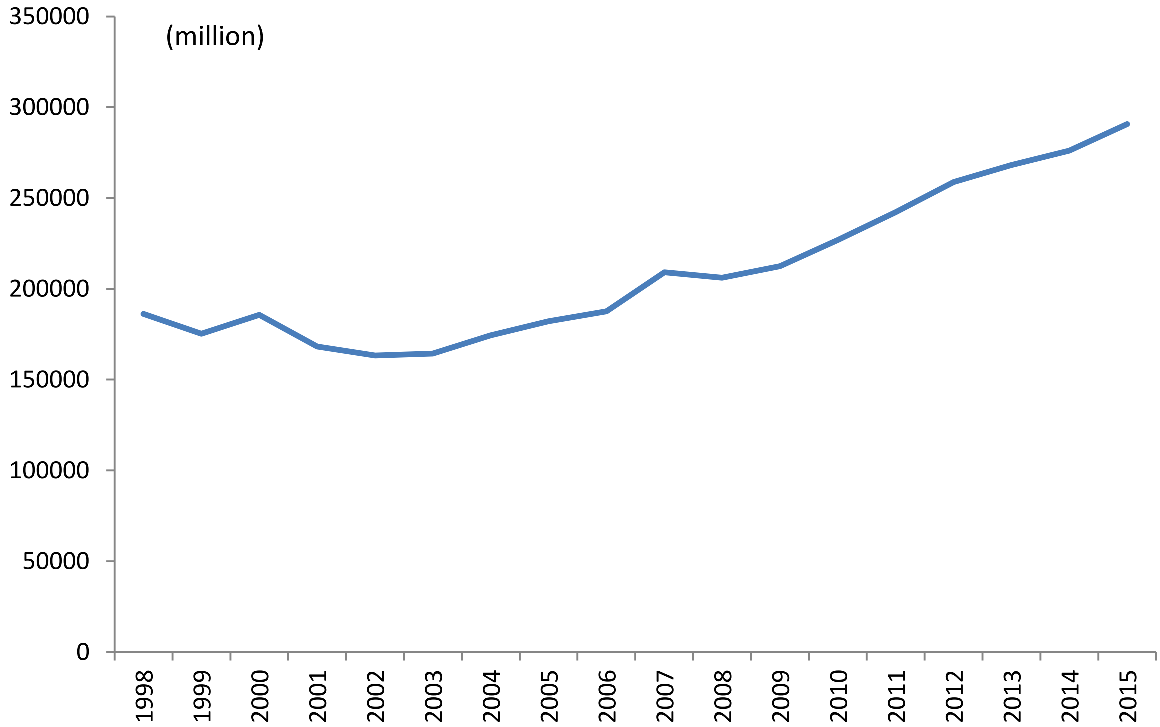
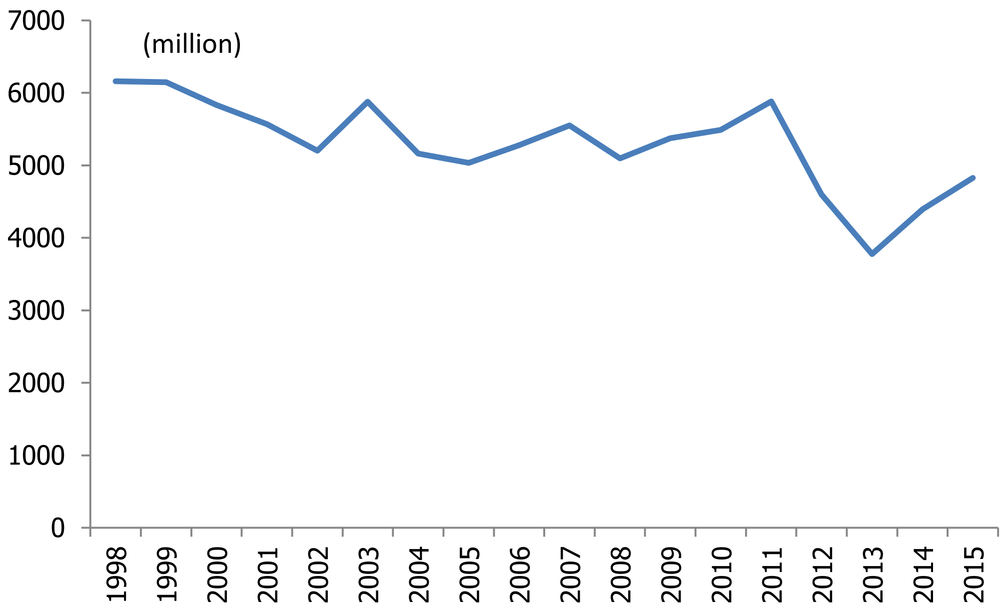


Figure 3.23 Passenger-km by road, 1998-2015



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 3.24 Passenger-km by railway, 1998-2015



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 resulting from transport sector as follows; aviation, railways, road transportation , navigation and pipeline transport (other transportation). In addition to these, international aviation and international navigation were also included in this category. Among these categories;

- Domestic aviation in terms of CO_2 emissions from jet fuel (level and trend),
- Road transportation in terms of CO_2 emissions from diesel fuel, LPG and gasoline (level and trend),

- Domestic navigation in terms of CO_2 emissions from diesel fuel and fuel oil,

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 emissions are reported under the category other transportation (1.A.3.e.i).

Methodological Issues:

Turkey implements tier 1 and tier 2 methodologies to estimate GHG emissions of mobile sources for the time series 1990-2015, as shown in equation below. The general method is presented here, and any specific circumstances in the implementation of the method is described separately for each category.

$$Emissions = \sum_a [Fuel_a * EF_a]$$

Where:
Emission = Emissions of CO2 (kg)
$Fuel_a$ = fuel sold (TJ)
EF_a = emission factor (kg/TJ). This is equal to the carbon content of the fuel multiplied by 44/12.
a = type of fuel (e.g. petrol, diesel, natural gas, LPG etc)

All EFs were taken from the 2006 IPCC Guidelines.

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

Table 3.32 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	
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, EMRA and BOTAŞ
- 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 1990-2015 by using 2006 IPCC guidelines. The rationale for the recalculations and the quantitative impact of the recalculations on individual categories are detailed below. Overall, for 2014, the impact of the recalculations on total transport emissions was 140.74 kt CO2eq as an decrease (0.19 per cent).

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

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

The domestic aviation source category was a key category in 2015, in terms of both the level and trend analysis of CO_2 emissions from the jet fuel. In domestic aviation only jet fuel is consumed.

Figure 3.23 and Figure 3.24 illustrate the total emissions and the emissions of N_2O and CH_4 increasing trends as CO_2 eq. CO_2 eq. emissions have increased approximately 356% since 1990 and reached to 4.21 Mt CO_2 in 2015. The calculated amounts of N_2O and CH_4 emissions were 41.98 kt CO_2 eq. and 1.44 kt CO_2 eq. respectively in 2015. There was a relatively large decrease in CO2 emissions observed between 2009 and 2010 (a 44% decline) owing to the global economic crisis. In spite of this. emissions in recent years have increased.

Figure 3.23 GHG emissions for domestic aviation, 1990-2015

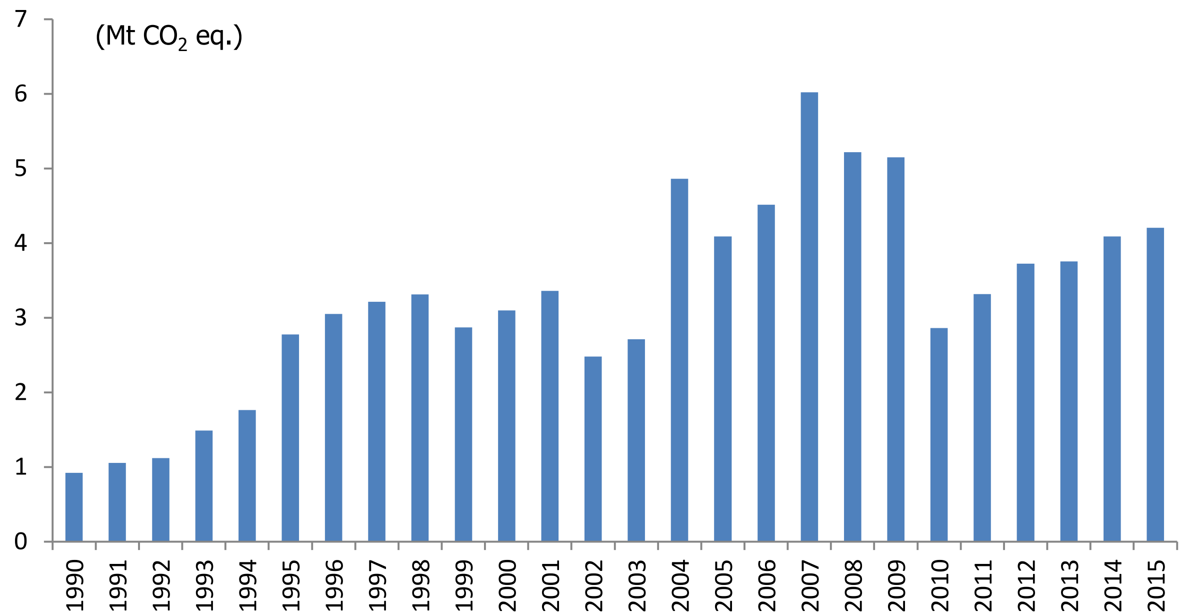
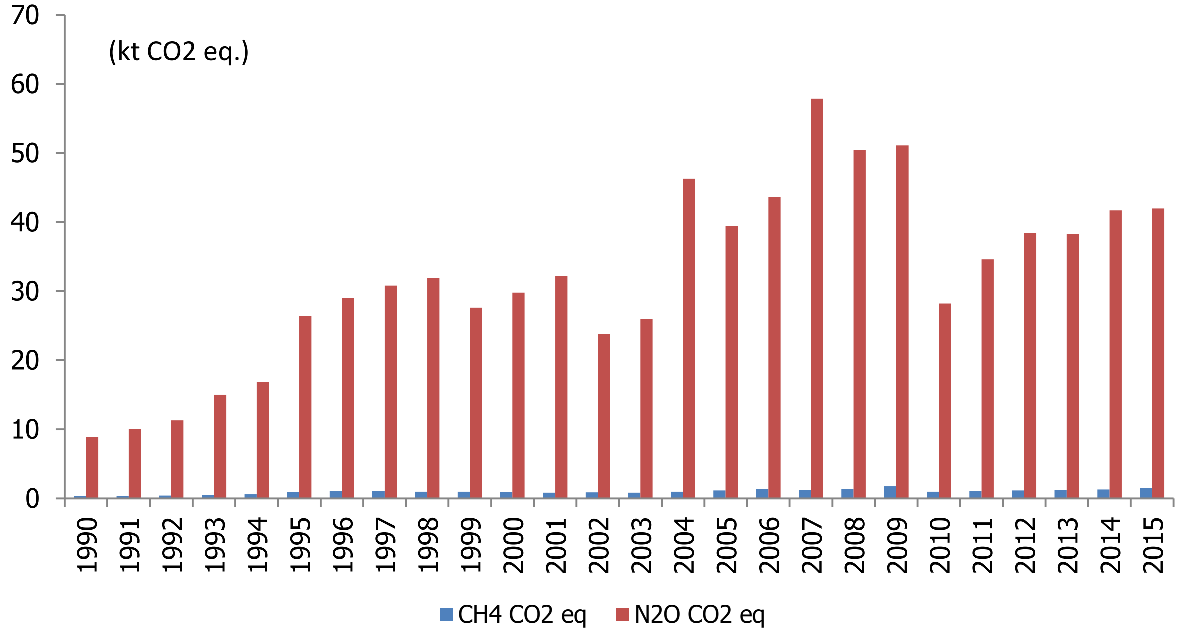


Figure 3.25 CH_4 and N_2O emissions for domestic aviation, 1990-2015



Methodological issues

Emissions were estimated by using the IPCC T2 methodology explained in the 2006 IPCC Guidelines. In the tier 2 method, it is necessary to divide the operations of aircraft into landing and take off (LTO) and cruise phases, as implemented through equations below. The calculation methodology is based on the national energy consumption data and air traffic data for each airport in terms of aircraft type.

$$\boldsymbol{Total\ emissions = LTO\ emissions + cruise\ emissions}$$

$$\boldsymbol{LTO\ emissions = Number\ of\ LTOs * EF_{LTO}}$$

$$\boldsymbol{LTO\ fuel\ consumption = Number\ of\ LTOs * Fuel\ consumption\ per\ LTO}$$

$$\boldsymbol{Cruise\ emissions = (Total\ Fuel\ Consumption - LTO\ Fuel\ Consumption) * EF_{Cruise}}$$

Collection of activity data

Air traffic data which consists of LTO cycles and cruise is provided by Directorate of General of State Airports Authority for all civil airports in Turkey. The number of LTO values for all aircraft types were provided for each airport. All activities below 914 m were included as LTO cycles; 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 In the year 2015 total number of LTO’s in domestic travel for all aircraft types is 832 958. The increase in passenger and freight traffic from 2005 to 2015 is also given in Figure 3.25 and Figure 3.26 respectively. Figure 3.27 shows the number of domestic LTOs for Turkish airports from 1990 to 2015.

Figure 3.25 Passenger traffic, 2005-2015

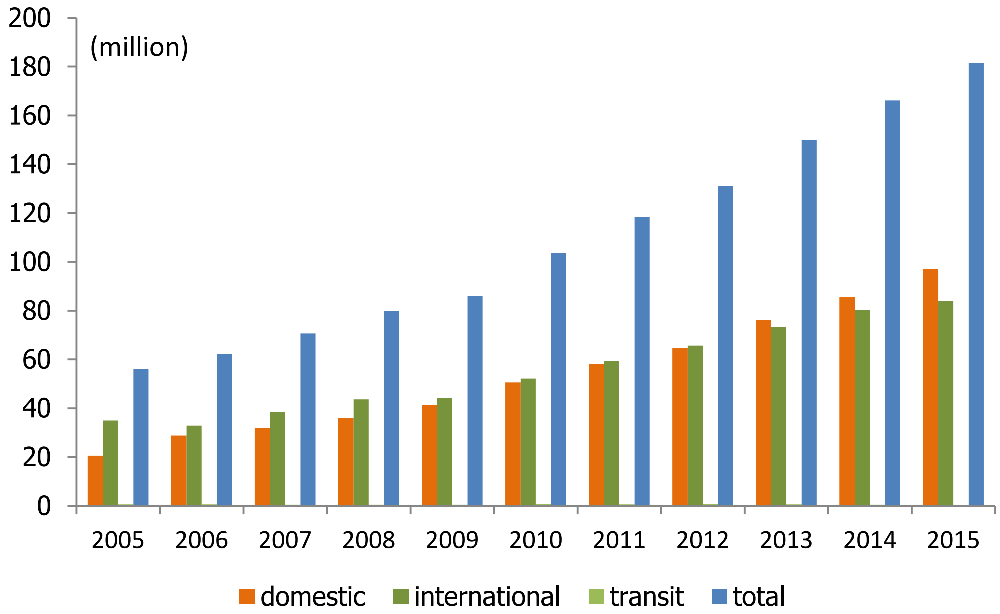
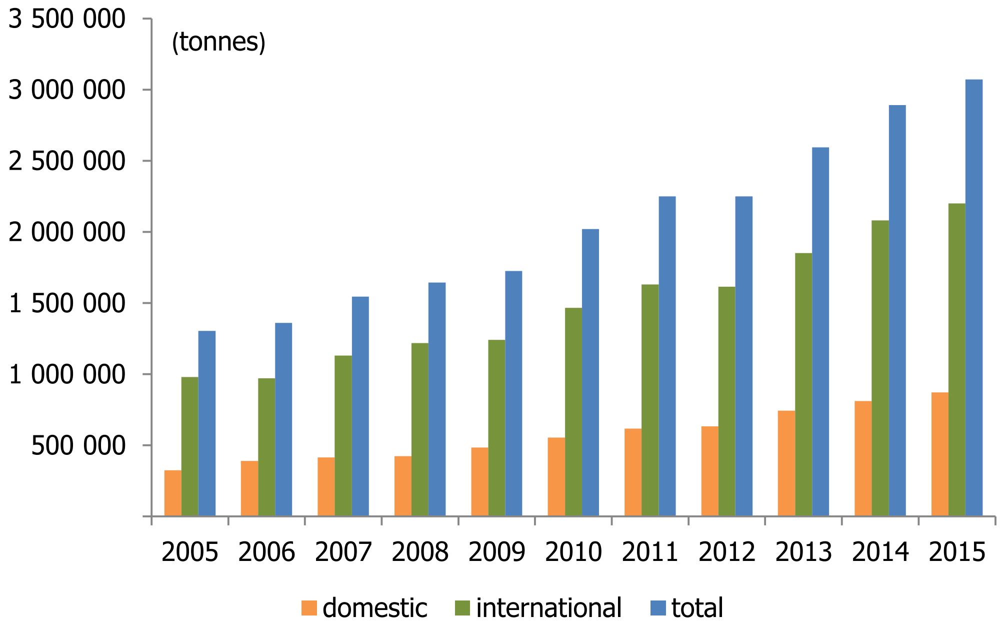


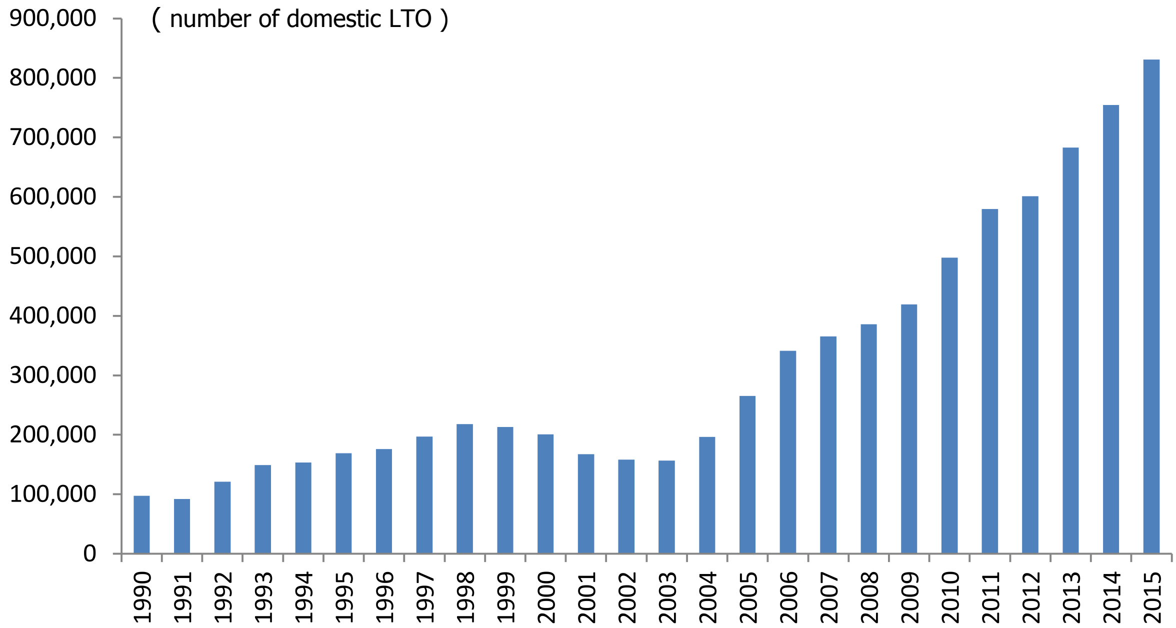
Figure 3.26 Freight traffic, 2005-2015



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 1.319 Mt. To calculate the LTO fuel consumption, Turkey multiplied the number of LTOs by the relevant LTO fuel consumption factors. The calculated total LTO fuel consumption is 0.635 Mt. To estimate cruise fuel consumption, Turkey subtracts LTO fuel consumption from total fuel consumption for each year of the time series. In 2015, cruise fuel consumption is 0.684 Mt.

Figure 3.27 Number of domestic LTO, 1990-2015



Choice of Emission Factor

LTO fuel consumption factors, as well as default CO2, CH4 and N2O emission factors for all aircraft types were obtained from the 2006 IPCC Guidelines (Table 3.6.9). Default emission factor values were applied for aircrafts where specific data are not available. The resulting CO_2 emission values of 2.008 Mt and 2.154 Mt were reported for LTO and cruise respectively. CO_2, CH_4 and N_2O emission values are given in Table 3.33.

Table 3.33 GHG emissions from domestic aviation, 1990-2015

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
2015	4162	0.06	0.14	4205	58824
Changes from 1990 (%)	355.4	500	366.7	355.6	351.4

Table 3.34 GHG emissions for LTO and cruise in domestic aviation, 2015

(kt)

	CO_2	CH_4	N_2O	Jet kerosene
Total	4 162	0.058	0.14	1 319
LTO	2 008	0.058	0.072	635
Cruise	2 154	-	0.068	684

Table 3.35 IEFs of domestic aviation 1990-2015

		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
2015	58 824	70.75	9.98	2.39

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.

Recalculation:

There is no recalculation in this category.

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 2015. 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 3.36.

Table 3.36 GHG emissions from road transportation, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	24 143	3.9	1.804	24 777	335 589
1991	22 686	3.7	1.712	23 288	315 543
1992	23 232	4.0	1.804	23 871	323 808
1993	28 403	4.9	2.192	29 178	395 708
1994	26 672	4.8	2.105	27 419	372 206
1995	28 942	5.3	2.301	29 760	404 093
1996	30 753	5.7	2.458	31 628	429 564
1997	28 993	6.9	2.329	29 858	408 624
1998	27 033	7.3	2.233	27 881	383 300
1999	29 346	7.6	2.287	30 219	415 241
2000	30 988	8.8	2.158	31 850	439 986
2001	30 694	8.3	2.050	31 512	434 724
2002	31 264	7.7	2.106	32 084	441 038
2003	32 517	7.9	2.119	33 347	458 427
2004	34 230	8.2	2.203	35 090	482 069
2005	34 668	8.4	2.195	35 532	488 494
2006	37 463	9.0	2.289	38 370	527 725
2007	42 689	10.2	2.447	43 674	601 495
2008	39 630	10.3	2.253	40 559	562 707
2009	39 289	10.7	2.170	40 204	556 696
2010	39 033	11.2	2.106	39 941	554 362
2011	39 995	11.2	2.093	40 899	567 688
2012	55 142	12.4	2.882	56 310	775 067
2013	61 607	12.8	3.224	62 889	864 602
2014	65 608	13.4	3.434	66 967	921 018
2015	67 889	14.3	3.561	69 309	955 968
Changes from 1990 (%)	181	266.7	100	180	185

In road transportation, gasoline, diesel, LPG, natural gas and biodiesel were used as fuel. Road transportation being the major source within the transportation sector contributed 69.3 Mt of CO_2 eq. The emissions of N_2O reached 1.06 Mt CO_2 eq. and CH_4 reached 0.36 Mt CO_2 eq. in 2015 (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, 1990-2015

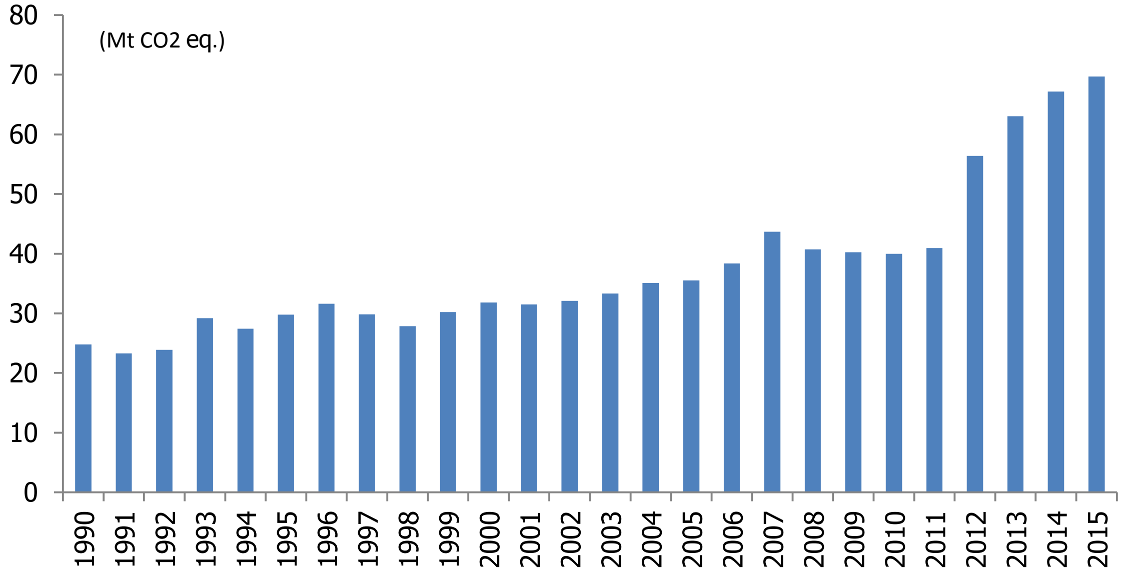
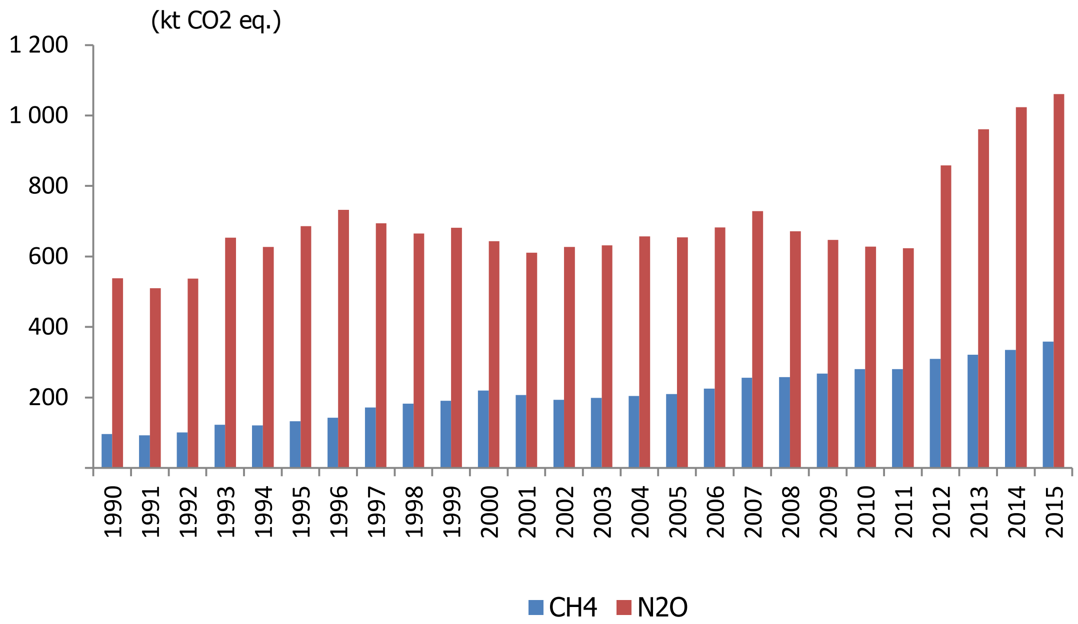
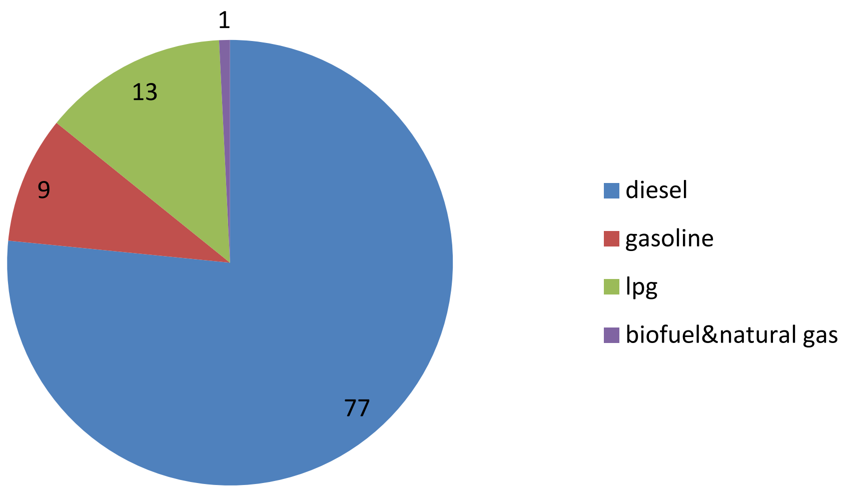


Figure 3.29 CH_4 and N_2O emissions for road transportation, 1990-2015



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 77% of total emissions of road transportation.

Figure 3.30 CO_2 emission distributions by fuel types (%), 2015



Methodological issues

As described in section 1.1.3, CO_2 emissions were calculated by multiplying estimated fuel consumption by a default or country-specific, depending on the fuel emission factor i.e. a tier 1 or tier 2 method. Country-specific carbon contents for diesel, and natural gas are used. CO_2 emissions resulting from those fuel types were estimated with Tier 2. CO_2 resulting from LPG and CH_4 and N_2O emissions were estimated by applying default emission factors from the 2006 IPCC Guidelines.

Collection of Activity Data

Fuel data used in the road transportation are taken from the national energy balance tables issued by MENR.

Choice of Emission Factor.

To estimate CO2 emissions, Turkey applies the country specific (diesel, natural gas) and default carbon contents as contained in .the 2006 IPCC Guidelines.

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 for correspondence with the 2006 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.

Recalculations:

There were recalculations for the entire time series of road transportation owing to revised country-specific carbon content. Overall, for 2014, emissions from road transportation decreased by 103 kt CO_2 eq (0.2 per cent decrease) due to these recalculations.

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)

Railway locomotives generally are one of three types: diesel, electric, or steam. Diesel locomotives generally use diesel engines in combination with an alternator or generator to produce the electricity required to power their traction motors. 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. The railways source category was not a key category in 2015.

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 33.5% since 1990. The amount of emissions calculated for railways is 0.43 Mt CO_2 in 2015.

Table 3.37 GHG emissions from railway, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	651	0.03	0.23	721	8 670
1991	668	0.04	0.24	740	8 923
1992	616	0.03	0.23	685	8 287
1993	675	0.04	0.25	751	9 110
1994	689	0.04	0.26	768	9 338
1995	688	0.04	0.27	768	9 348
1996	717	0.04	0.27	799	9 697
1997	717	0.04	0.27	799	9 717
1998	664	0.04	0.25	740	8 900
1999	647	0.04	0.25	722	8 780
2000	638	0.04	0.25	713	8 686
2001	525	0.03	0.20	587	7 150
2002	547	0.03	0.21	612	7 453
2003	563	0.03	0.22	629	7 670
2004	563	0.03	0.22	629	7 670
2005	678	0.04	0.26	757	9 230
2006	681	0.04	0.27	761	9 273
2007	420	0.02	0.16	470	5 724
2008	446	0.03	0.17	499	6 080
2009	433	0.02	0.17	484	5 900
2010	462	0.03	0.18	517	6 296
2011	476	0.03	0.19	532	6 485
2012	441	0.02	0.17	492	6 001
2013	452	0.03	0.18	505	6 154
2014	503	0.03	0.20	562	6 843
2015	429	0.02	0.17	480	5848
Changes from 1990 (%)	-34.1	-33.3	-26.1	-33.4	-32.5

Figure 3.31 GHG emissions for railways, 1990-2015

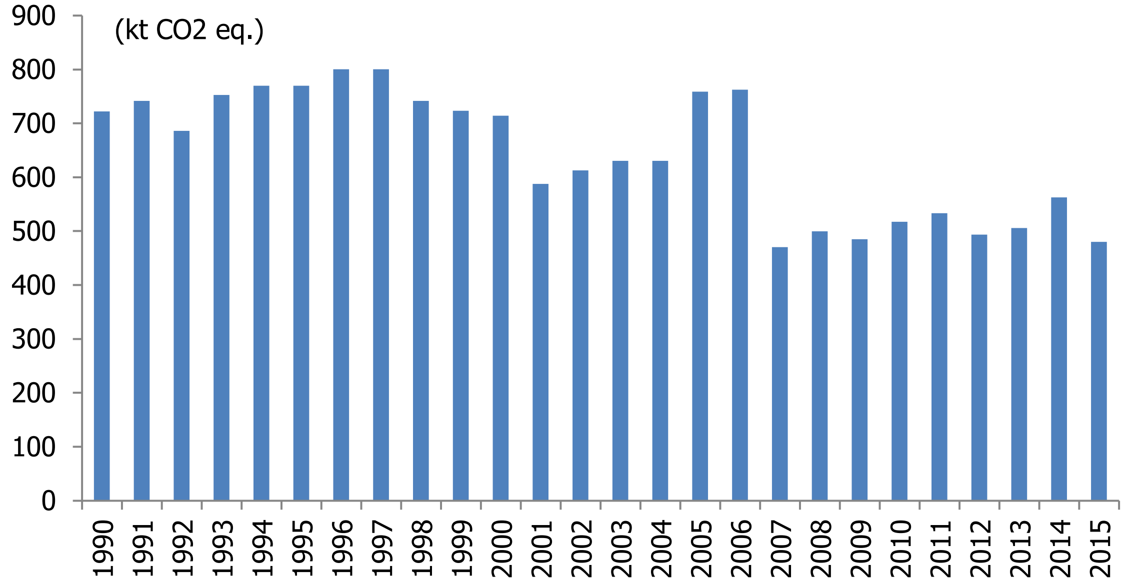
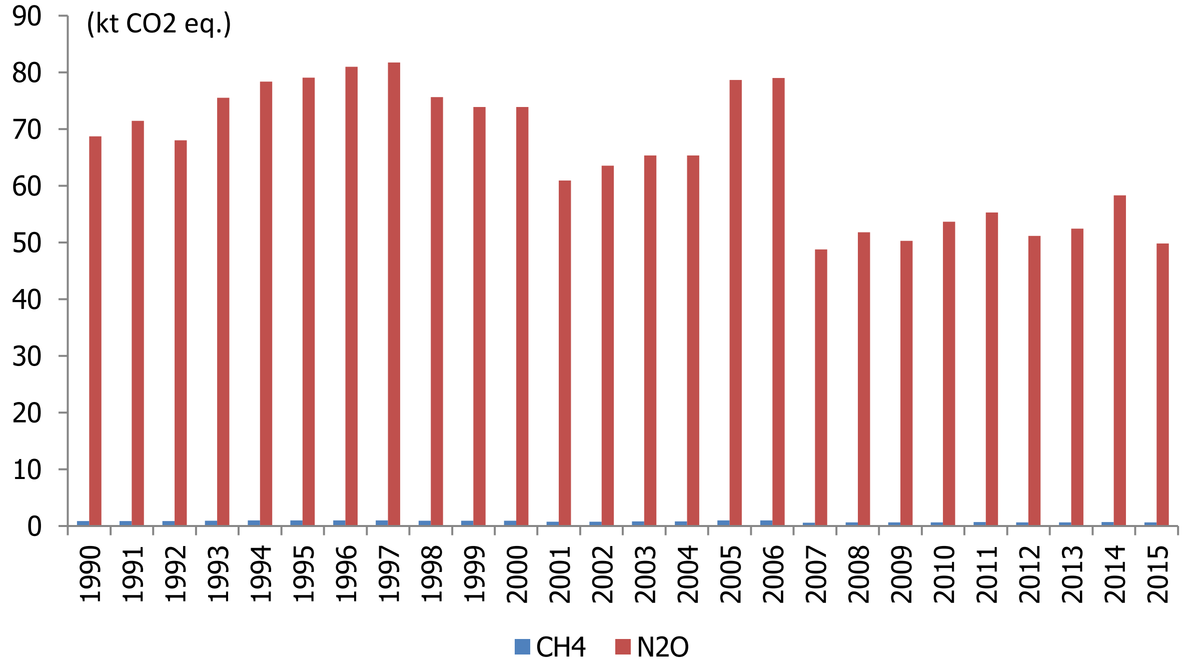


Figure 3.32 CH4 and N2O emissions from railways, 1990-2015



Methodological issues

The IPCC Tier 1&2 approach has been used to estimate CO2, CH4 and N2O emissions for this subcategory, as described in section 1.1.3 above. The tier 1 approach has been used to estimate CH4 and N2O emissions.

Collection of Activity Data

Energy consumption values for railways were provided by MENR in the form of national energy balance tables.

Choice of Emission Factor

To estimate CO2 emissions, Turkey applies the country specific carbon content. Turkey does not modify the emission factors for CH4 and N2O to take into account engine design parameters.

Source-Specific QA/QC and Verification:

In terms of calculations made by alternative methods; verification on this category 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.

Recalculations:

There were reaclulations for the entire time series of railways owing to country-specific carbon content for diesel fuel. Overall, for 2014, emissions from railways decreased by 0.99 kt CO2 eq (0.18% decrease) due to the recalculations.

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)

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

The domestic water borne navigation source category was not a key category in 2015. The data availability is limited in this sub-sector. In domestic water-borne navigation only, diesel and residual fuel oil were consumed as a fuel.

Domestic water-borne navigation contributed 0.89 Mt of CO_2 in 2015 while N_2O emissions were 6.97 kt CO_2 eq. and CH_4 2.05 kt CO_2 eq (Figure 3.33 and 3.34). Overall, between 1990 and 2015 emissions from water-borne navigation increased by 77.4%.

Table 3.38 GHG emissions from domestic navigation, 1990-2015

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	537	0.05	0.01	543	7 068
1992	632	0.06	0.02	638	8 290
1993	657	0.06	0.02	664	8 632
1994	617	0.06	0.02	623	8 129
1995	719	0.07	0.02	726	9 444
1996	692	0.06	0.02	699	9 104
1997	691	0.06	0.02	698	9 090
1998	718	0.07	0.02	726	9 466
1999	652	0.06	0.02	658	8 610
2000	617	0.06	0.02	623	8 167
2001	792	0.07	0.02	800	10 535
2002	813	0.08	0.02	822	10 821
2003	881	0.08	0.02	891	11 732
2004	1.215	0.11	0.03	1228	16 266
2005	1.286	0.12	0.03	1299	17 225
2006	1.449	0.14	0.04	1464	19 436
2007	1.581	0.15	0.04	1598	21 241
2008	1.527	0.14	0.04	1543	20 561
2009	1.615	0.15	0.04	1632	21 991
2010	1.664	0.16	0.05	1682	22 658
2011	2.218	0.21	0.06	2242	30 058
2012	1.598	0.15	0.04	1614	21 670
2013	1.142	0.11	0.03	1154	15 486
2014	1.334	0.13	0.04	1348	18 083
2015	1.136	0.11	0.03	1147	15 369
Changes from 1990 (%)	125.4	120	200	125.3	132

Figure 3.33 GHG emissions from domestic water-borne navigation, 1990-2015

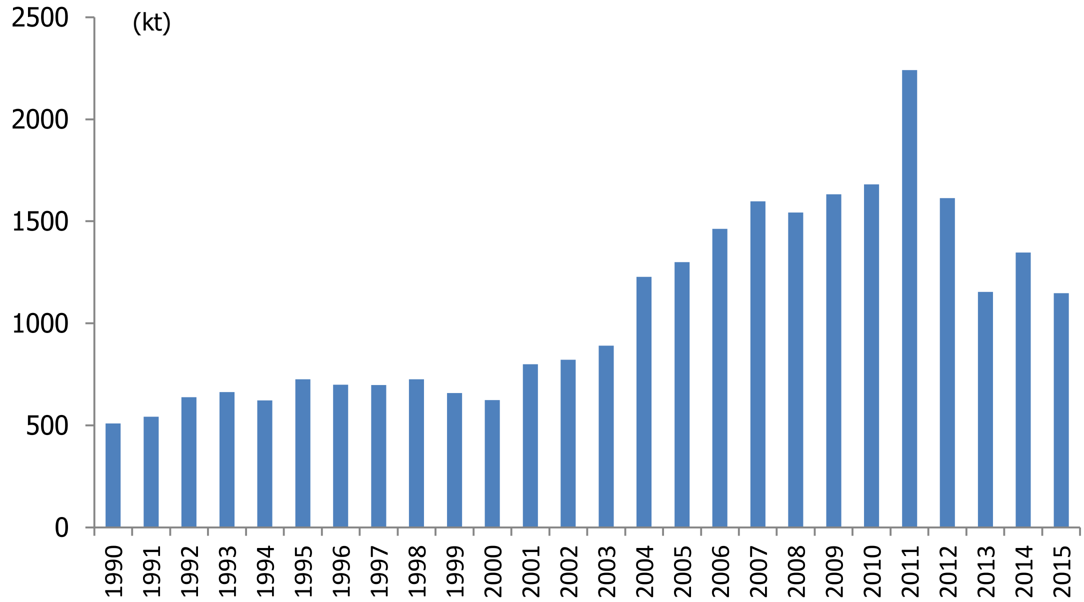
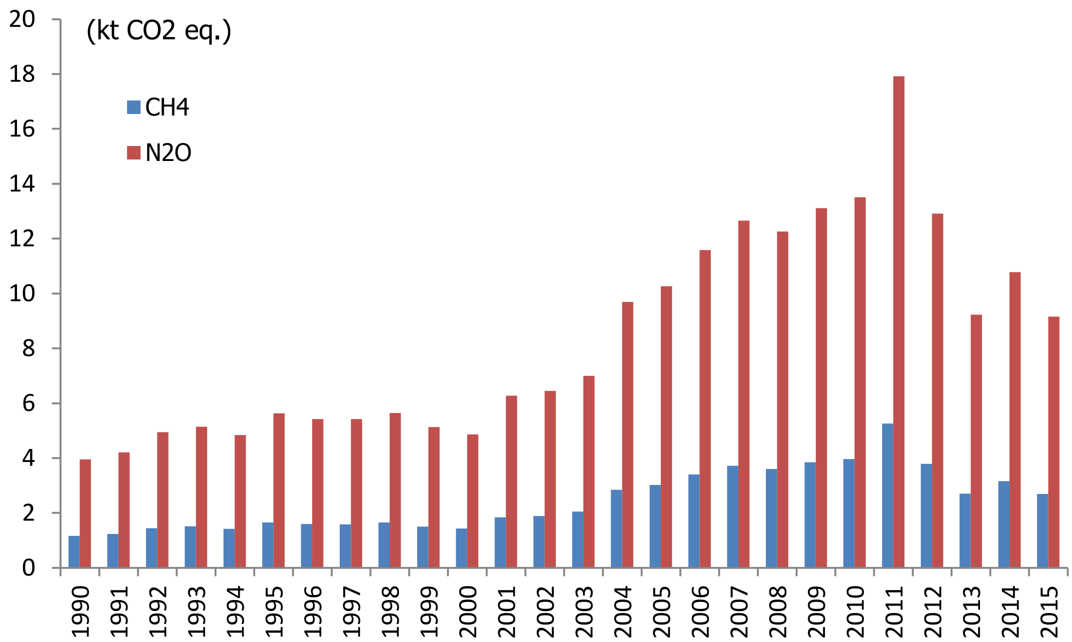


Figure 3.34 CH4 and N2O emissions from domestic water-borne navigation, 1990-2015



Methodological issues

The IPCC Tier 1&2 approach has been used to estimate CO_2, CH_4 and N_2O emissions for this subcategory. The tier 1 approach has been used to estimate CH_4 and N_2O emissions.

Collection of Activity Data

Energy consumption values for domestic navigation were provided by EMRA.

Choice of emission factor

For CO2 estimation, country-specific carbon contents were used. The EFs for CH_4 and N_2O are taken from IPCC 2006/CORINAIR and set to 7 and 2 kg per TJ respectively.

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 EMRA. 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.

Recalculations:

There were recalculations for the entire time series of domestic navigation to owing to revised data of country-specific carbon content. Overall, for 2014, emissions from domestic navigation decreased by 2.4 kt CO_2 eq (0.2% decrease) due to these recalculations

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:

$$E_{NOx}^{ME} = P^{ME} * EF_{NOx}^{ME} \tag{3.1}$$

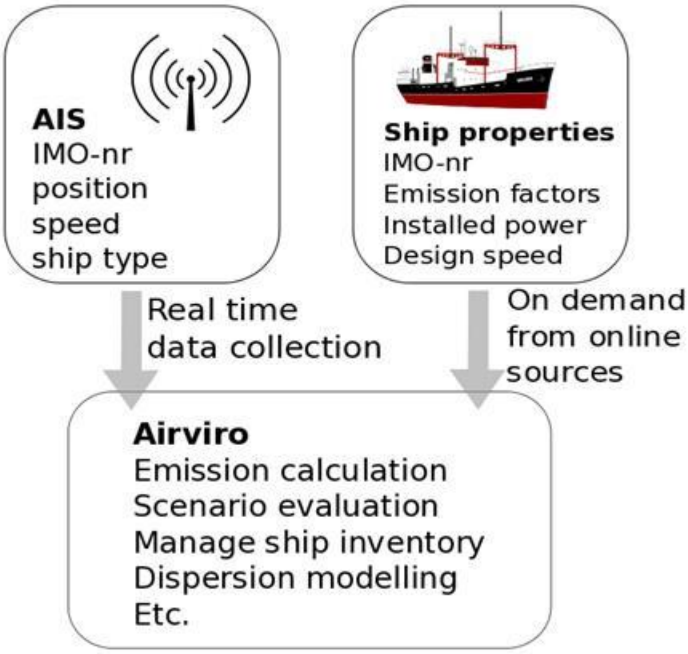
Where E_{NOx}^{ME} is the emission [g/h], P^{ME} represents output of the main engine in kW (denoted by ME) and EF_{NOx}^{ME} is the EF in [g/kWh]. For estimation of emissions of substances that are directly related to the content of the fuel, the EF should be expressed as emission per mass of fuel, 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:

$$E_{CO2}^{ME} = P^{ME} * SFOC^{ME} * EF_{CO2} \tag{3.2}$$

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 3.39 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.

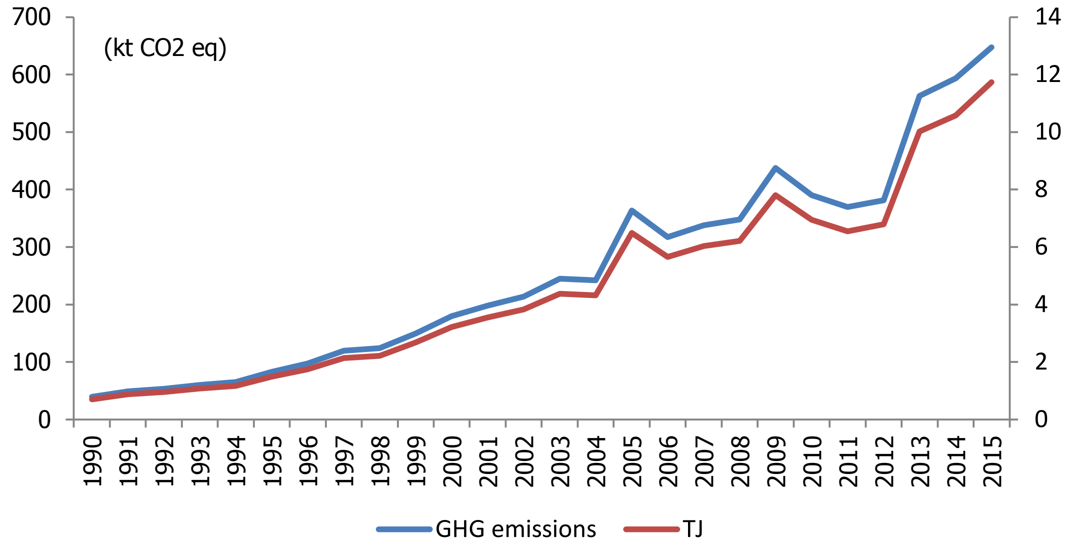
3.2.6.5. Pipeline transport (Category 1.A.3.e.i)

This category covers combustion related emissions from the operation of pump stations and maintance of pipelines. Transport via pipelines includes transport of gases, liquids, slurry and other commodities via pipelines. In Turkey, natural gas is used to carry out operations mentioned above.. Pipeline Transport contributed 0.65 Mt of CO_2 in 2015. Table 3.40 shows the trend in GHG emissions from pipeline transport

Table 3.40 The trend in GHG emissions from pipeline transport

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	39	0.0007	0.00007	39	705
1991	49	0.0009	0.00009	49	875
1992	54	0.0010	0.00010	54	962
1993	60	0.0011	0.00011	60	1075
1994	65	0.0012	0.00012	65	1167
1995	83	0.0015	0.00015	83	1489
1996	97	0.0017	0.00017	97	1745
1997	119	0.0021	0.00021	120	2143
1998	124	0.0022	0.00022	124	2221
1999	150	0.0027	0.00027	150	2682
2000	179	0.0032	0.00032	180	3217
2001	198	0.0036	0.00036	198	3553
2002	213	0.0038	0.00038	213	3826
2003	245	0.0044	0.00044	245	4372
2004	242	0.0043	0.00043	242	4317
2005	363	0.0065	0.00065	364	6487
2006	317	0.0057	0.00057	317	5658
2007	338	0.0060	0.00060	338	6030
2008	347	0.0062	0.00062	348	6216
2009	437	0.0078	0.00078	437	7803
2010	390	0.0069	0.00069	390	6945
2011	369	0.0066	0.00066	370	6552
2012	381	0.0068	0.00068	381	6796
2013	562	0.0100	0.00100	563	10025
2014	593	0.0106	0.00106	593	10575
2015	647	0.0116	0.00116	647	11740

Figure 3.36: GHG emissions from pipeline transport,1990-2015



Methodological issues

In emissions calculation, the 2006 IPCC Guidelines Tier 1&2 approaches are used**.** As described in section 1.1.3, CO_2 emissions were calculated by multiplying estimated fuel consumption by a country-specific emission factor. CH_4 and N_2O emissions were estimated by applying default emission factors from the 2006 IPCC Guidelines.

Collection of Activity Data

Fuel consumption data for pipeline transport were provided by Petroleum Pipeline Corporation.

Choice of emission factor;

For CO_2 estimation, country-specific carbon content was used. In Addition, default CH_4 (1 kg/TJ) and N_2O (0.1 kg/TJ) emission factors were obtained from the 2006 IPCC Guidelines.

Source-Specific QA/QC and Verification:

On the energy balance table provided by the MENR, natural gas data were compared with the value provided by Petroleum Pipeline Corporation.

Recalculations:

There were recalculations for the entire time series of pipeline transportation owing to revised data of fuel consumption (6215.504 TJ used instead of 11847.637 TJ in 2008), country-specific carbon content and default emission factors for CH4 and N2O. Overall, for 2014, emissions from pipeline transport decreased by 34.36 kt CO_2 eq (5.5%) due to the recalculations

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

GHG emissions from off road vehicles used for agricultural activities is included under 1.A.4.c 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 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 until 2015. The source category 1.A.4.c includes the emission from the agricultural activities but does not include forestry and fisheries.

The source category 1.A.4 is a key category in terms of emission level and emission trenf of CO_2 from solid, liquid and gaseous fuels in 2015. The source category is also a key category in terms of emission trend of CH_4 from solid fuels and biomass.

The share of GHG emissions as CO_2 eq. from other sectors in total fuel combustion was 19.5% in 2015 while it was 25.7% in 1990. It was 13.8% of total GHG emissions in 2015.

Table 3.41 Fuel combustion emissions from other sectors, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2-eq (kt)	TJ	Share in total fuel combustion (%)
1990	29 244	133	3.7	33 673	645 673	25.7
1991	30 403	134	3.7	34 860	657 785	25.8
1992	32 446	136	3.8	36 982	683 897	26.1
1993	33 218	132	4.3	37 801	701 321	25.3
1994	29 456	121	4.2	33 753	666 602	23.1
1995	33 282	126	4.3	37 706	713 243	23.5
1996	34 241	124	4.5	38 660	736 465	21.9
1997	36 956	128	4.6	41 517	770 586	22.0
1998	33 411	118	4.5	37 708	737 923	20.1
1999	31 648	110	4.5	35 745	714 961	19.2
2000	34 160	108	4.6	38 233	745 756	18.5
2001	28 072	96	4.4	31 784	658 026	16.7
2002	29 610	98	4.4	33 363	662 531	16.9
2003	32 735	99	4.4	36 541	692 872	17.2
2004	36 123	101	4.7	40 039	732 606	18.3
2005	39 218	100	4.7	43 101	776 556	18.2
2006	40 743	97	4.9	44 642	797 186	17.4
2007	43 607	98	5.2	47 620	828 176	16.7
2008	61 031	145	6.6	66 623	1006 080	23.7
2009	66 680	161	6.5	72 660	1043 701	25.2
2010	64 467	159	6.4	70 355	996 241	24.7
2011	69 389	133	7.0	74 803	1083 442	24.4
2012	59 979	133	2.1	63 943	882 014	20.5
2013	54 665	131	2.0	58 539	937 019	19.4
2014	50 244	106	2.0	53 480	854 114	17.1
2015	62 684	63	4.2	65 514	1009 062	19.5

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 CO_2 EFs are used for emission estimation. Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from 1.A.4 category were recalculated for 1990-2014 period.

CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs.

GHG emissions from biomass were estimated by using 2006 IPCC default EFs.

Recalculation:

Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO2 emissions from 1.A.4 category were recalculated for 1990-2014 period.

There is also a recalculation for 1990-2014 periods in GHG emissions due to reallocation of emissions from autoproducers as explained in section 3.2.5.

The impact of recalculation is related to revision of country specific CO_2 EFs, reallocation of autopruducers under 1A1a and inclusion of of road vehiclesin agricultural sector for the first time. There is 872 kt CO_2-eq decrease (1.6% decrease) in 2014 total GHG emissions from 1A4 category as compared to previous submission.

Table 3.42 Difference in GHG emissions from 1A4 between 2016 and 2017 submissions, 1990-2014

(kt)

Year	Total	Commercial/institutional	Residential	Agriculture
1990	601	IE	50	551
1991	900	IE	346	553
1992	929	IE	374	555
1993	988	IE	305	683
1994	773	IE	87	687
1995	959	IE	259	701
1996	915	IE	176	739
1997	1 053	IE	288	766
1998	856	IE	97	759
1999	672	IE	- 107	779
2000	717	IE	- 95	812
2001	779	IE	3	777
2002	790	IE	1	789
2003	875	IE	74	801
2004	651	IE	- 210	861
2005	720	IE	- 148	868
2006	584	IE	- 349	933
2007	693	IE	- 323	1 016
2008	1 103	IE	- 184	1 287
2009	1 552	IE	291	1 262
2010	1 944	IE	708	1 236
2011	1 347	IE	- 91	1 438
2012	529	IE	238	291
2013	213	IE	- 1	214
2014	- 872	IE	-1 133	262

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 untill 2015, it is given under residential sector for 1990-2014 period. Emissions are given under 1.A.4.a category in 2015 for the first time and they are included under (1.A.4.b) for 1990-2014 periods.

The share of GHG emissions as CO_2 eq. from 1.A.4.a in total other sector is 35.5% in 2015.

Table 3.43 Fuel combustion emissions from 1.A.4.a category, 2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2-eq (kt)	TJ	Share in 1A4 category (%)
2015	23 114	2	0.3	23 249	299 324	35.5

Methodological Issues:

GHG emissions from 1.A.4.a 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 CO_2 EFs are used for emission estimation. Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from 1.A.4.0 category were recalculated for 1990-2014 period.

CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been 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 7.07% for liquid fuels, 14.14% for solid fuels, and 5% 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 1A4a category was performed on the basis of QA/QC plan. Since only 2015 estimation is available for this category, emission trends couldn't be analyzed.

IEF for CO_2, CH_4, and N_2O are in the range of 2006 IPCC default EFs. CO_2 IEF is 63.07, 93.73 and 56.06 for liquid, solid and gaseous fuels respectively.

Recalculation:

There is no recalculation in this category.

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

Residential and commercial/institutional fuel consumptions are not separable in the national energy balance tables until 2015. Therefore emissions from residential and commercial/institutional category is included under 1.A.4.b for periods 1990-2014.In 2015 only residential sector is covered under 1.A.4.b category.

The share of GHG emissions as CO_2 eq. from 1.A.4.b category in total other sectors is 49.5% in 2015 while it was 80.8% in 1990.

Table 3.44 Fuel combustion emissions from residential sector, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2-eq (kt)	TJ	Share in 1A4 category %
1990	23 474	132	1.5	27 215	565 847	80.8
1991	24 609	133	1.5	28 374	577 618	81.4
1992	26 636	136	1.5	30 479	603 514	82.4
1993	26 062	132	1.4	29 791	602 311	78.8
1994	22 263	121	1.4	25 702	567 087	76.1
1995	25 942	125	1.4	29 490	611 695	78.2
1996	26 504	123	1.4	29 999	629 420	77.6
1997	28 937	127	1.4	32 541	659 636	78.4
1998	25 467	118	1.4	28 816	628 014	76.4
1999	23 484	110	1.3	26 608	602 018	74.4
2000	25 659	107	1.2	28 717	628 134	75.1
2001	19 937	96	1.2	22 678	545 474	71.4
2002	21 350	97	1.1	24 117	548 245	72.3
2003	24 348	99	1.1	27 153	576 834	74.3
2004	27 110	100	1.1	29 950	607 901	74.8
2005	30 123	99	1.1	32 921	650 724	76.4
2006	30 975	97	1.1	33 708	662 037	75.5
2007	32 966	97	1.0	35 709	680 952	75.0
2008	47 551	144	1.3	51 534	819 569	77.4
2009	53 463	160	1.3	57 866	860 849	79.6
2010	51 515	158	1.3	55 857	817 035	79.4
2011	54 276	132	1.1	57 892	874 166	77.4
2012	56 720	132	0.9	60 309	837 664	94.3
2013	52 231	130	1.1	55 831	903 172	95.4
2014	47 148	105	0.9	50 045	810 450	93.6
2015	30 771	60	0.6	32 445	586 966	49.5

The decrease between 2014 and 2015 is 17.6 Mt CO_2 eq. (35.2% of decrease) decrease in total emissions from 1.A.4.b. The main reason for decreasing emissions in this sector is due to the separation of commercial and institutional category from this category.

Methodological Issues:

GHG emissions from 1.A.4.b 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 CO_2 EFs are used for emission estimation. Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from 1.A.4.b category were recalculated for 1990-2014 period.

CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs.

GHG emissions from biomass were 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 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.

CO_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC guidelines but are changing based on fuel mix used in the sector. CO_2 IEF for liquid fuels, ranges from 63.47-68.74 based on the share of diesel oil, and LPG used. Mostly the share of LPG is the highest. CO_2 IEF for solid fuels, ranges from 97.1-108.42 based on share of Turkish lignite used. CO_2 IEF for gaseous fuels, ranges from 55.75-56.36.

Recalculation:

Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and

lignite was determined. So based on revised EFs, CO2 emissions from 1.A.4.b category were recalculated for 1990-2014 period.

There is also a recalculation for 1990-2014 periods in GHG emissions due to reallocation of emissions from autoproducers in the commercial sector which was included under this category for that periods.

There is 1133 kt CO_2-eq decrease (2.21% decrease) in 2014 total GHG emissions from 1A4b category as compared to previous submission.

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. The share of GHG emissions as CO_2 eq. from 1.A.4.c category in other sectors fuel combustion emissions was 15% in 2015 while it was 19.2% 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 due to classification problem with diesel oil consumption. Before 2012, diesel fuel was distributed in accordance with the definitions given below:

- Diesel oil (sulfur content up to 10 mg/kg) is used for road transportation
- Rural diesel (maximum sulfur content of 1000 mg/kg) is used in agricultural sector.

Based on this definition, diesel oil consumption in road transportation and agriculture was 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 table, some of diesel oil used in agricultural sector 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. MENR worked on agricultural association for modelling the agricultural diesel oil consumption and some improvement on the dissaggregation of diesel oil consumption was achieved in 2015 national energy balance tables. MENR will work on further improvement.

Table 3.45 Fuel combustion emissions from agriculture sector, 1990-2015

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2-eq (kt)	TJ	Share in 1A4 category %
1990	5 770	0.3	2.3	6 458	79 826	19.2
1991	5 794	0.3	2.3	6 486	80 167	18.6
1992	5 810	0.3	2.3	6 503	80 383	17.6
1993	7 156	0.4	2.8	8 010	99 010	21.2
1994	7 193	0.4	2.8	8 051	99 515	23.9
1995	7 340	0.4	2.9	8 216	101 548	21.8
1996	7 737	0.4	3.1	8 660	107 045	22.4
1997	8 019	0.5	3.2	8 976	110 950	21.6
1998	7 944	0.5	3.1	8 892	109 909	23.6
1999	8 163	0.5	3.2	9 138	112 943	25.6
2000	8 501	0.5	3.4	9 516	117 623	24.9
2001	8 135	0.5	3.2	9 106	112 553	28.6
2002	8 260	0.5	3.3	9 246	114 286	27.7
2003	8 387	0.5	3.3	9 388	116 039	25.7
2004	9 013	0.5	3.6	10 089	124 705	25.2
2005	9 095	0.5	3.6	10 180	125 832	23.6
2006	9 768	0.6	3.9	10 934	135 149	24.5
2007	10 641	0.6	4.2	11 911	147 224	25.0
2008	13 481	0.8	5.3	15 089	186 511	22.6
2009	13 217	0.8	5.2	14 794	182 852	20.4
2010	12 952	0.8	5.1	14 498	179 206	20.6
2011	15 113	0.9	6.0	16 911	209 276	22.6
2012	3 259	0.9	1.2	3 635	44 349	5.7
2013	2 434	0.4	0.9	2 708	33 847	4.6
2014	3 096	0.3	1.1	3 435	43 664	6.4
2015	8 799	0.5	3.4	9 819	122 772	15.0

Methodological Issues:

GHG emissions from 1.A.4.c 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 CO_2 EFs are used for emission estimation from for both stationary and mobile source categories. Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from 1.A.4.c category were recalculated for 1990-2014 period.

CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs for both stationary and mobile source 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 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.

CO_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC guidelines but are changing based on fuel mix used in the sector. CO_2 IEF for liquid fuels is 72.28 which is related to diesel oil used in off road vehicles. CO_2 IEF for solid fuels, ranges from 94.75-98.56 which is related to other bituminous coal used. CO_2 IEF for gaseous fuels, ranges from 55.99-56.36.

Recalculation:

Based on recently obtained fuel analysis reports, country specific carbon contents for lignite, hard coal and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from 1.A.4.c category were recalculated for 1990-2014 period.

GHG emissions from off road vehicles are estimated for the first time in this submission. In the previous submission all fuels consumed in agricultural sector were considered under stationary combustion. Diesel oil consumption is considered as for off road vehicles and other machinery in this category, while all other fuels are considered as stationary combustion.

Therefore there is also a recalculation in liquid fuels due to the separation of off road vehicles fuel consumption from stationary combustion.

There is 262 kt CO_2-eq increase (8.24% increase) in 2014 total GHG emissions from 1A4c category as compared to previous submission. It is mainly related to inclusion of off road vehicles used in this category.

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 1990-2014 periods and 1A4a for 2015 (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 are also covered for the first time in this submission.

Table 3.46 Fugitive emissions from fuels, 1990-2015

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	220	125	0.0	3 350
1991	263	119	0.0	3 234
1992	254	115	0.0	3 128
1993	231	115	0.0	3 098
1994	219	105	0.0	2 835
1995	209	102	0.0	2 748
1996	208	99	0.0	2 681
1997	206	110	0.0	2 960
1998	194	121	0.0	3 222
1999	178	164	0.0	4 291
2000	168	183	0.0	4 743
2001	155	178	0.0	4 596
2002	148	163	0.0	4 232
2003	145	159	0.0	4 113
2004	140	155	0.0	4 016
2005	142	171	0.0	4 418
2006	135	181	0.0	4 653
2007	133	250	0.0	6 390
2008	135	267	0.0	6 802
2009	138	256	0.0	6 537
2010	156	265	0.0	6 792
2011	151	294	0.0	7 498
2012	144	310	0.0	7 900
2013	146	277	0.0	7 075
2014	145	346	0.0	8 803
2015	155	159	0.0	4 131

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 0.9% of total energy emissions in 2015. 70.1% of fugitive emissions as CO_2 eq. were from oil and gas systems 29.9% were from solid fuels and in the same year.

Table 3.47 Fugitive emissions from fuels by subcategory, 1990-2015

(kt CO_2 eq.)

Year	Total	Solid fuels	Oil and natural gas
1990	3 350	2 459	891
1991	3 234	2 173	1 060
1992	3 128	2 082	1 046
1993	3 098	2 101	997
1994	2 835	1 857	977
1995	2 748	1 735	1 013
1996	2 681	1 614	1 067
1997	2 960	1 808	1 152
1998	3 222	2 067	1 155
1999	4 291	3 076	1 215
2000	4 743	3 457	1 286
2001	4 596	3 305	1 291
2002	4 232	2 899	1 333
2003	4 113	2 613	1 500
2004	4 016	2 476	1 540
2005	4 418	2 634	1 784
2006	4 653	2 715	1 938
2007	6 390	4 194	2 196
2008	6 802	4 537	2 265
2009	6 537	4 488	2 049
2010	6 792	4 737	2 054
2011	7 498	5 117	2 381
2012	7 900	5 393	2 507
2013	7 075	4 899	2 176
2014	8 803	5 926	2 876
2015	4 131	1 236	2 894

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:

Abondened undergroung coal mines are included for the first time in this submission. Therefore there is a recalculation for 1990-2014 in solid fuels.

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_4 emissions from coal mining and handling were calculated. Also, abandoned underground mines is covered for the first time in this submission.

The share of fugitive CH_4 emissions from coal mining was 31.1% in total fugitive CH_4 emissions and 20.5% in total energy sector CH_4 emissions in 2015.

Table 3.48 Fugitive emissions from solid fuels, 1990-2015

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	NE	98	NE,NO	2 459
1991	NE	87	NE,NO	2 173
1992	NE	83	NE,NO	2 082
1993	NE	84	NE,NO	2 101
1994	NE	74	NE,NO	1 857
1995	NE	69	NE,NO	1 735
1996	NE	65	NE,NO	1 614
1997	NE	72	NE,NO	1 808
1998	NE	83	NE,NO	2 067
1999	NE	123	NE,NO	3 076
2000	NE	138	NE,NO	3 457
2001	NE	132	NE,NO	3 305
2002	NE	116	NE,NO	2 899
2003	NE	105	NE,NO	2 613
2004	NE	99	NE,NO	2 476
2005	NE	105	NE,NO	2 634
2006	NE	109	NE,NO	2 715
2007	NE	168	NE,NO	4 194
2008	NE	181	NE,NO	4 537
2009	NE	180	NE,NO	4 488
2010	NE	189	NE,NO	4 737
2011	NE	205	NE,NO	5 117
2012	NE	216	NE,NO	5 393
2013	NE	196	NE,NO	4 899
2014	NE	237	NE,NO	5 926
2015	NE	49	NE,NO	1 236

The share of underground coal production is 5.8% in 2015 but the share of CH_4 emissions from underground mines is more than 99%.

There is 187.6 kt (79.1%) decrease in CH_4 emissions from coal mining between 2014 and 2015. The main reason for that is the decrease in from underground coal production. Since serious mining accidents occurred in 2014, mining activities of some of underground mines has been stopped by the government authorities. Therefore the share of coal production decreased significantly (80.2%) from 17 Mt to 3.4 Mt in 2015.

Figure 3.26 Domestic coal production, 1990–2015

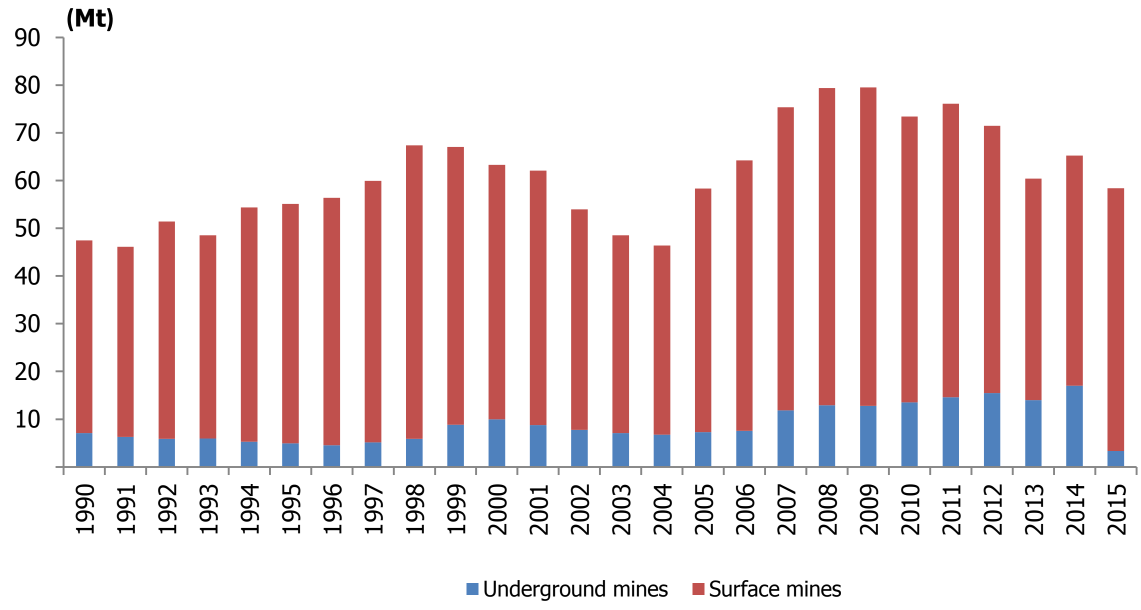


Figure 3.27 CH_4 emissions from coal mining, 1990-2015

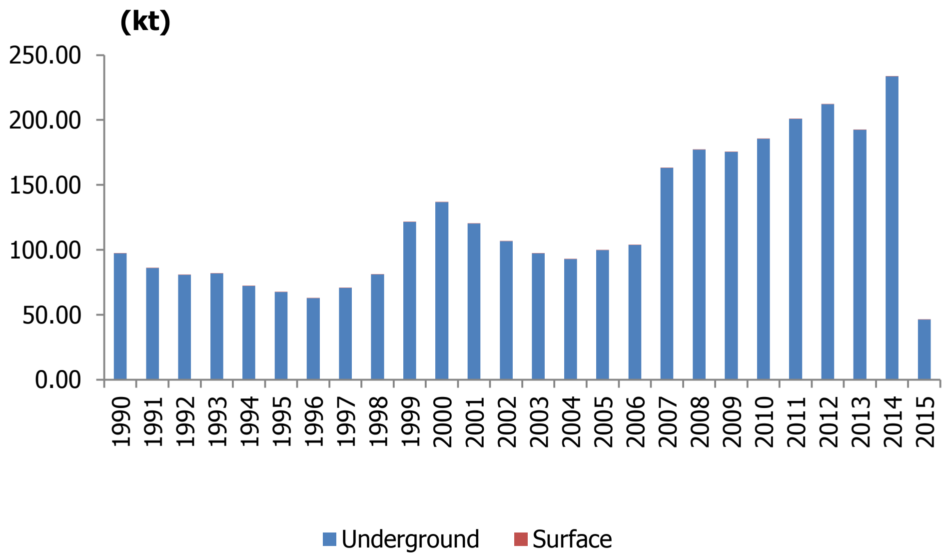


Table 3.49 Fugitive emissions from abondened coal mines,1990-2015

Year	CO_2 (kt)	CH_4 (kt)	CO_2-eq (kt)
1990	NE	1.0	26
1991	NE	0.9	22
1992	NE	2.4	60
1993	NE	2.2	54
1994	NE	2.0	50
1995	NE	1.9	46
1996	NE	1.7	44
1997	NE	1.6	41
1998	NE	1.6	39
1999	NE	1.5	37
2000	NE	1.4	36
2001	NE	12.0	300
2002	NE	9.4	234
2003	NE	7.2	180
2004	NE	6.1	153
2005	NE	5.5	136
2006	NE	5.0	124
2007	NE	4.6	115
2008	NE	4.3	108
2009	NE	4.1	102
2010	NE	3.9	97
2011	NE	3.7	93
2012	NE	3.6	90
2013	NE	3.4	86
2014	NE	3.3	83
2015	NE	3.2	81

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 in terms of emission trend of CH_4, 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.

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%.

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.

CH_4 IEFs are in the range of 2006 IPCC guidelines.

Planned Improvement:

In order to increase the Tiers for CH_4 emission estimation, availability of detailed information have been searched. It is planned to continue the investigation 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 and trend of CH_4 emission. 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 system in total

CH_4 emissions from oil and gas systems increased from 21.4% in 1990 to 73% in 2015 while the share of CH_4 from oil production decreased from 59.6 % in 1990 to 9.9% in 2015.

Table 3.50 Fugitive emissions from oil and natural gas systems,1990-2015

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	220	27	0.0	891
1991	263	32	0.0	1 060
1992	254	32	0.0	1 046
1993	231	31	0.0	997
1994	219	30	0.0	977
1995	209	32	0.0	1 013
1996	208	34	0.0	1 067
1997	206	38	0.0	1 152
1998	194	38	0.0	1 155
1999	178	41	0.0	1 215
2000	168	45	0.0	1 286
2001	155	45	0.0	1 291
2002	148	47	0.0	1 333
2003	145	54	0.0	1 500
2004	140	56	0.0	1 540
2005	142	66	0.0	1 784
2006	135	72	0.0	1 938
2007	133	83	0.0	2 196
2008	135	85	0.0	2 265
2009	138	76	0.0	2 049
2010	156	76	0.0	2 054
2011	151	89	0.0	2 381
2012	144	94	0.0	2 507
2013	146	81	0.0	2 176
2014	145	109	0.0	2 876
2015	155	110	0.0	2 894

Figure 3.28 Oil production, 1990–2015

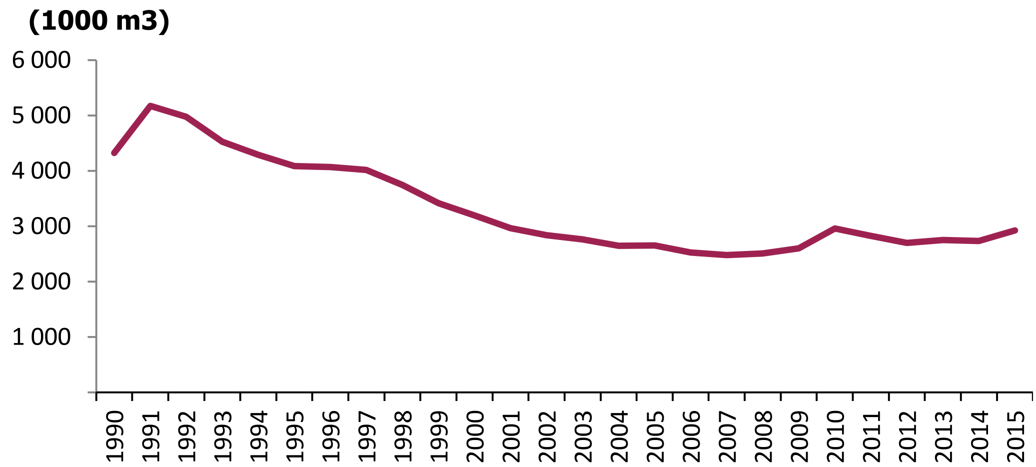


Figure 3.29 Natural gas production, 1990-2015

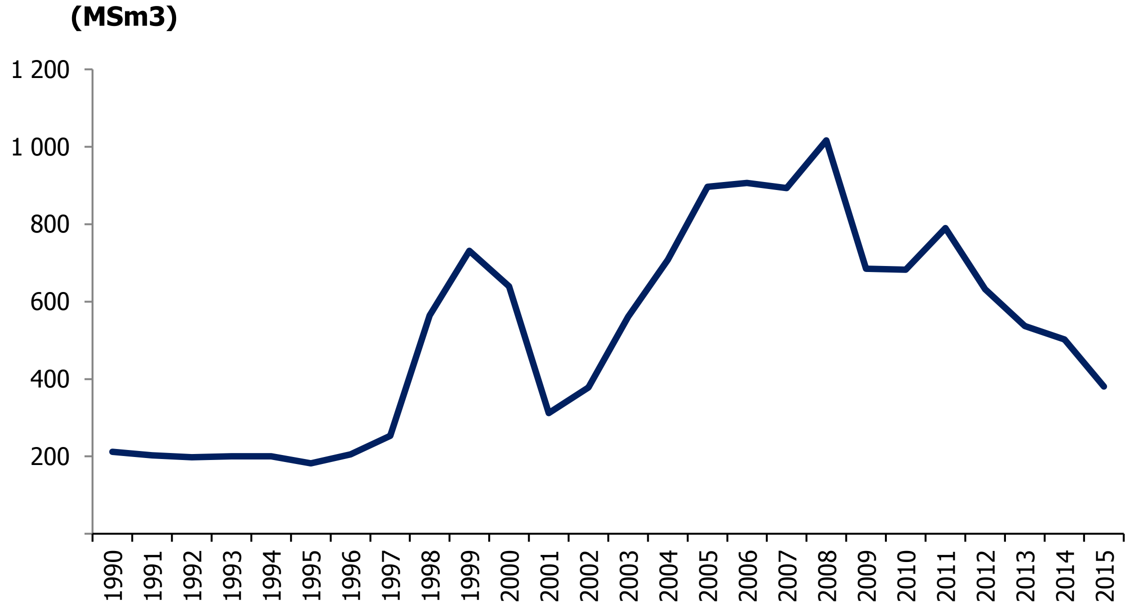


Figure 3.30 Natural gas transmission by pipeline, 1990-2015

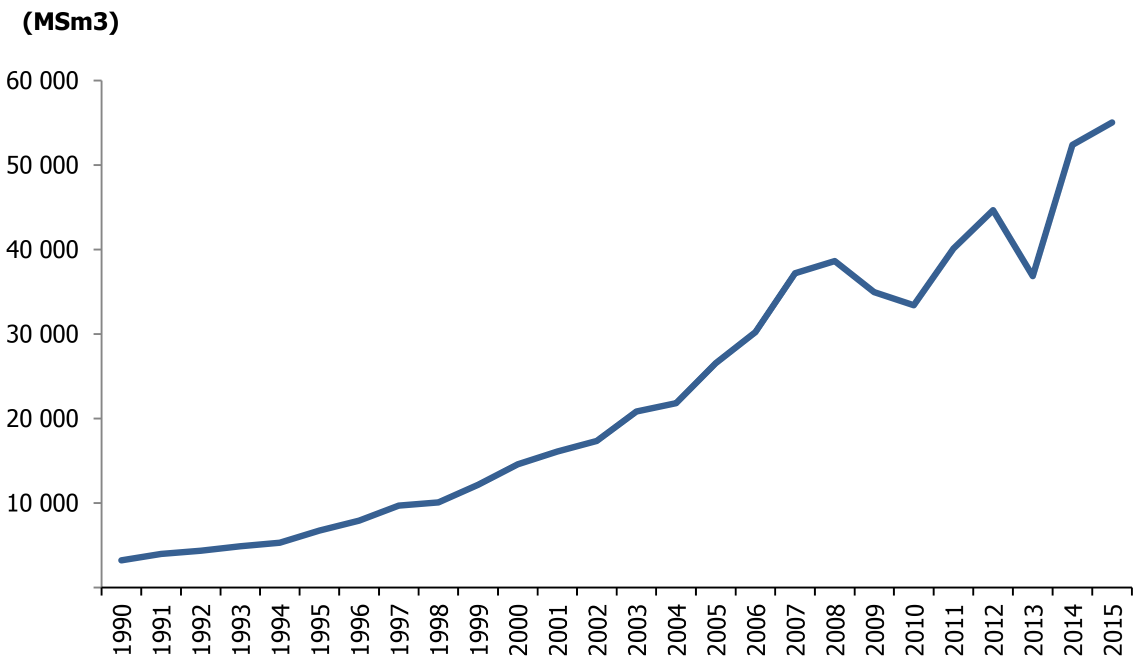
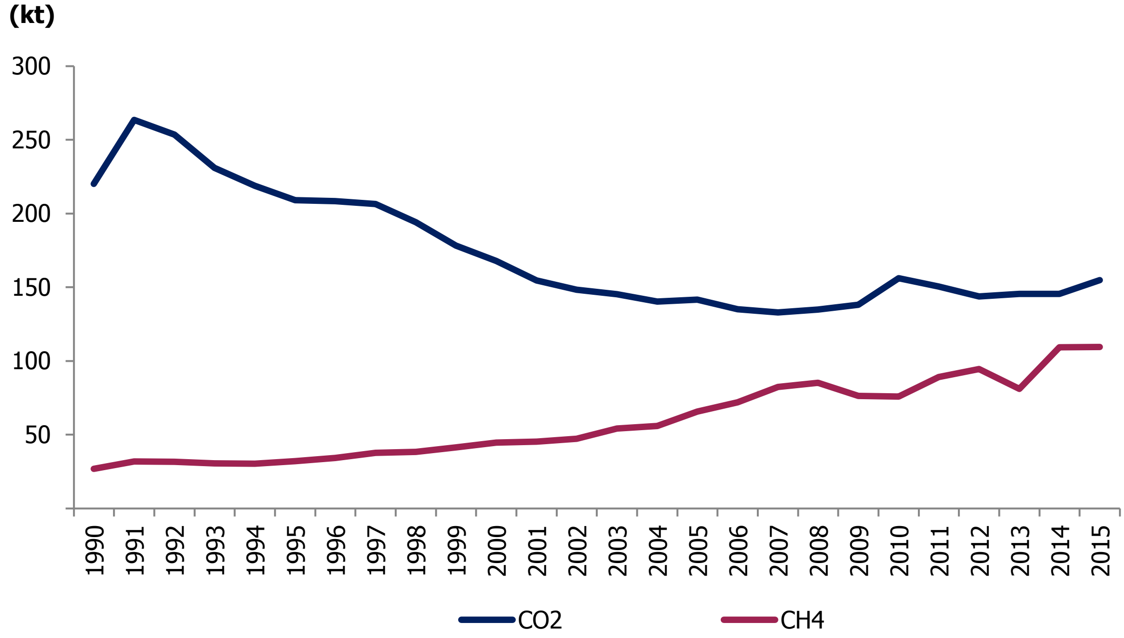


Figure 3.31 Fugitive eimisions from oil and gas system, 1990-2015



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.

Since the category is a key category in terms of emission level and trend of CH_4, the Tiers in CH_4 estimation needs to be increased. Detailed investigation has been performed to find out the availability of country specific EF. It is necessary to communicate and cooperate with related authorities directly to search the availability of required information for T2 estimation of CH_4. It is planned to continue with investigations.

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.

IEFs are controlled and they are all in the range of 2006 IPCC default values.

Recalculation:

There is no recalculation in this category.

Planned Improvement:

In order to increase the Tiers for CH_4 emission estimation, availability of detailed information have been searched. It is planned to continue the investigation to find out the availability or possibility of availability of 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 1990-2015 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 1990-2015 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.

GHG emissions from industrial processes and product use contributed 12.8% to the total anthropogenic GHG emissions in Turkey in 2015 (Table 4.1), in total 60 718 kt CO_2eq.

Table 4.1 Industrial processes and product use sector CO_2eq. emissions, 2015

(kt CO_2eq.)

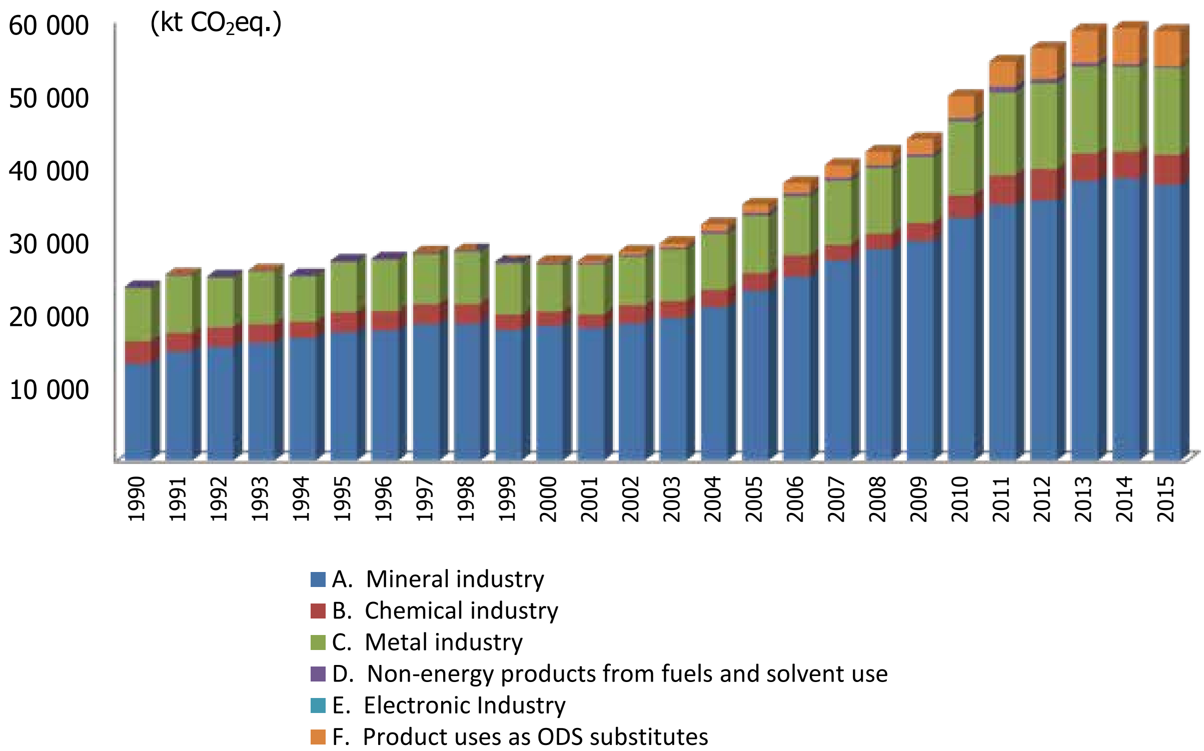
GHG sources and sink categories	CO_2	CH_4	N_2O	HFCs /PFCs/SF_6	Total
Industrial processes and product use	52 336	57	1 415	4 925	60 718
A. Mineral industry	37 708	NA	NA	NA	37 708
B. Chemical industry	2 717	42	1 415	NA	4 174
C. Metal industry	11 654	15	NA	120	11 789
D. Non-energy products from fuels and solvent use	257	NA,NE	NA,NE	NA	257
E. Electronic Industry	NA	NA	NA	0.1	0.1
F. Product uses as ODS substitutes	NA	NA	NA	4 805	4 805
G. Other product manufacture and use					
H. Other	NE	NE	NA		

The most important GHG emission sources of IPPU in 2015 were CO_2 emissions from cement production and iron and steel production, with 6.9% and 2.4% shares of the total national GHG emissions, respectively.

The mineral industry contributed 62.1% of the sector's emissions, the metal industry contributed 19.4%, product uses as ODS substitutes contributed 7.9%, while the chemical industry contributed 6.9%.

The main gas emitted by the IPPU sector in 2015 was CO_2, contributing 86.2% (52 336 kt) of the sector emissions in 2015. HFCs, PFCs and SF_6 contributed 8.1% (4 925 kt CO_2eq.) while the share of N_2O emissions was 2.3% (1 415 kt CO_2eq.) and CH_4 emissions was 0.1% (57 kt CO_2eq.).

Figure 4.1 Emissions from industrial processes and product use by subsector, 1990–2015



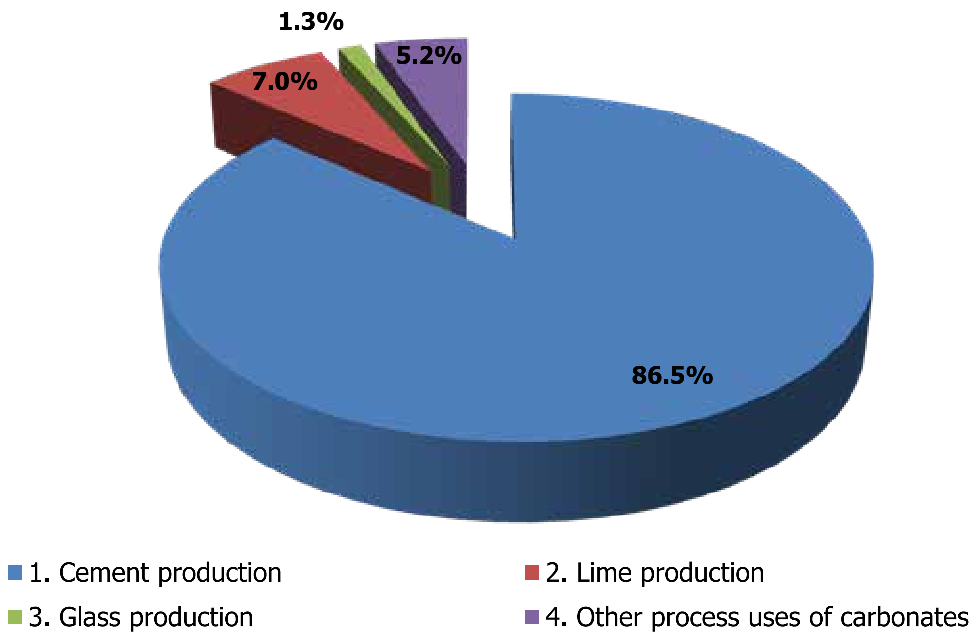
Total emissions from industrial process and product use increased by 156.2% between 1990 (23 699 kt CO_2eq) and 2015, and did not change significantly between 2014 and 2015. The increases in sectoral emissions observed over the longer term are principally due to growth in emissions associated with the mineral industry, predominantly cement production, and metal industry, primarily iron and steel production. The increases in emissions in these sectors are because of the industrial growth 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 2015 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 (86.5%) results from 2A1 cement production, 7.0% from 2A3 lime production and 5.2% from 2A4 other process uses of carbonates. Glass production is responsible for 1.3% of emissions in the mineral industry.

Figure 4.2 Share of CO_2 emissions from mineral production, 2015



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

Source Category Description:

Cement production causes CO_2 emissions due to calcination reaction of limestone during production and these emissions are reported under 2.A.1 CRF category. Moreover cement production is an energy intensive process. Heating up the kiln with its load to such a high temperature is extremely energy consuming. Most of the kilns in Turkey uses coal, petroleum coke, lignite as the primary energy source. The emissions due to combusting of these fuels to heat up the kilns are included in 1.A.2f CRF category. The table below shows allocation of cement production emissions in the CRF categories.

Table 4.2 Allocations of cement production emissions

CRF category	Emission source
CRF 2.A.1	Emissions from calcination reactions in the kilns
CRF 1.A.2f	Emissions from fuel consuming for the energy demand of the production plant.

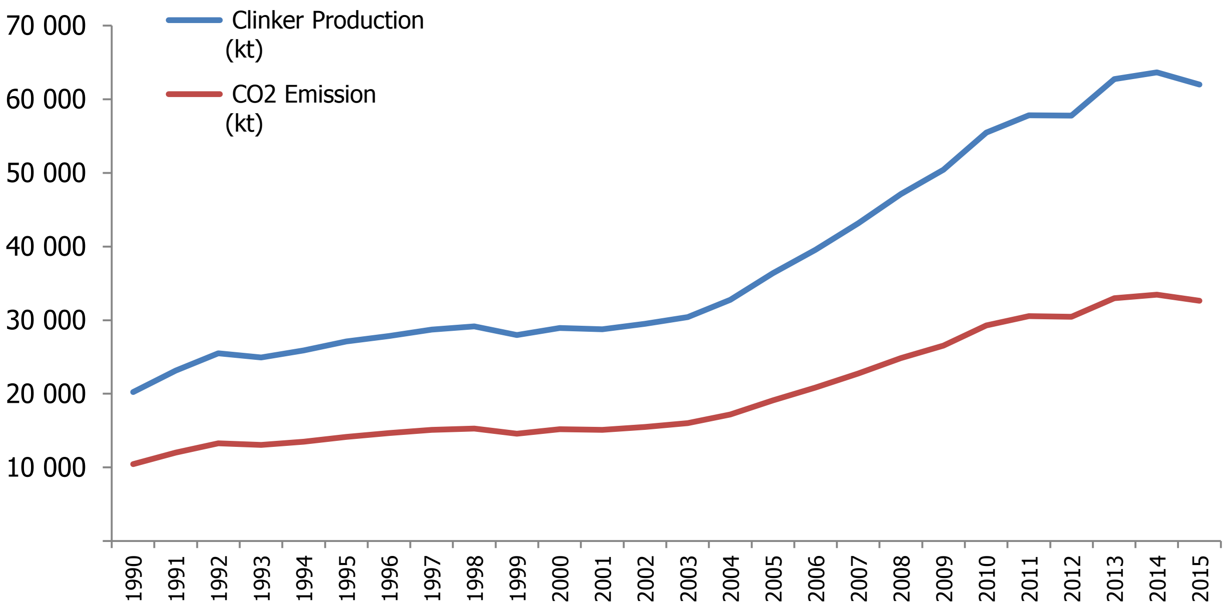
In cement production, limestone is fed to the cement kiln and heated up to 1400-1500 °C to produce lime. At this temperature calcium carbonate ($CaCO_3$) breaks into lime (CaO) and carbon dioxide (CO_2). The reaction is shown below.

$$CaCO_3 \rightarrow CaO + CO_2$$

Then, silica containing materials are combined with the lime to make the clinker. Clinker is the most important intermediate product. It is also traded as a commodity. Cement is produced by mixing the clinker with small amount of gypsum and potentially other materials (e.g slag) and grinding it. All the CO_2 emissions are released from the kilns during the clinker production step.

Figure 4.3 below shows the trend at clinker production and the related CO_2 emissions between 1990 and 2015.

Figure 4.3 Trend at clinker production and related CO_2 emissions, 1990-2015



Turkey started cement production in 1911 and Turkey was a cement importer till 1970s. Turkey started exporting cement in 1978. By 2015, Turkey is the Europe's biggest cement producer with its 76 million tons of clinker production capacity and the production plants are distributed all over the country because transportation costs in the cement sector is quite high. In Turkey mostly portland cement is produced. Slag cement, puzzolan added cement and their modifications are also produced.

As can be seen from the figures above, CO_2 emissions increased by 206% between 1990 and 2015. Except some minor reductions in 2001 due to Turkey's economical recessions and in 2015 due to war at Turkey's southern neighborhood (Syria and Iraq) , cement industry showed a continuous growth in general. Construction sector and cement export are the strongest drivers in the cement sector. Since Turkish construction industry slowed down in recent years and cement export is decreased due to conflicts in the nearby countries, clinker production was decreased by 2.6% with respect to 2014. In 2015 clinker production was 62.0 million tons (85% capacity is used) and it caused 32 611 kt of CO_2 emission.

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 as illustrated below.

$$O_2\ emissions = M_{Cl} * EF_{Cl} * \ \ F_{CKD}$$

Where:

CO_2 Emissions = emissions of CO_2 from cement production, tonnes

M_{cl} = weight (mass) of clinker produced, tonnes

EF_{cl} = emission factor for clinker, tonnes CO_2/tonne clinker

CF_{ckd} = emissions correction factor for CKD, dimensionless

Collection of activity data

There are many cement plants in Turkey spread all over Turkey. Most of the cement plants in Turkey are members of TCMA and they report their activity data to TCMA on monthly basis and TCMA publish the data as industry specific statistics on their website. For those plants who are not a member of TCMA, their activity data is estimated by TCMA. Annual amount of national clinker production of Turkey is gathered from the clinker production statistics of the TCMA website.

Choice of emission factor

Data for the carbonate content in clinker was gathered from the production plants for the years 1990-2015. It was determined that the average weight percentage of CaO varies between 64% - 66% throughout the time series and was 65.7% in 2015. The corresponding EF in 2015 is 0.515913. Turkey applies the IPCC default CKD correction factor of 1.02. In the following table, all the activity data and emission factors used for the emission calculation in the time series are shown. In addition annual CO_2 emissions from clinker production are tabulated.

Table 4.3 CO_2 emissions from cement production, 1990-2015

Year	Clinker Production (kt)	Cemet Production (kt)	CaO Content (%)	CO_2 EF	CKD	CO_2 Emission (kt)
1990	20 252	24 416	64.4	0.506	1.02	**10 445**
1991	23 153	26 261	64.9	0.509	1.02	**12 021**
1992	25 489	28 607	65.0	0.510	1.02	**13 265**
1993	24 941	31 366	65.4	0.513	1.02	**13 049**
1994	25 880	29 515	65.1	0.511	1.02	**13 493**
1995	27 094	33 140	65.2	0.511	1.02	**14 133**
1996	27 852	35 233	65.8	0.516	1.02	**14 662**
1997	28 706	36 007	65.7	0.516	1.02	**15 105**
1998	29 148	37 488	65.5	0.514	1.02	**15 292**
1999	27 966	34 817	65.2	0.511	1.02	**14 590**
2000	28 950	35 953	65.5	0.514	1.02	**15 184**
2001	28 746	29 959	65.6	0.515	1.02	**15 087**
2002	29 499	32 758	65.7	0.516	1.02	**15 513**
2003	30 419	35 095	65.8	0.516	1.02	**16 022**
2004	32 779	38 796	65.6	0.515	1.02	**17 207**
2005	36 382	42 787	65.6	0.515	1.02	**19 117**
2006	39 569	49 100	65.8	0.516	1.02	**20 841**
2007	43 174	51 226	65.9	0.517	1.02	**22 780**
2008	47 095	54 362	65.9	0.517	1.02	**24 837**
2009	50 436	59 273	65.8	0.516	1.02	**26 558**
2010	55 485	66 027	65.9	0.517	1.02	**29 284**
2011	57 823	67 805	66.0	0.518	1.02	**30 527**
2012	57 758	67 519	65.9	0.517	1.02	**30 449**
2013	62 736	74 437	65.7	0.516	1.02	**32 995**
2014	63 642	72 639	65.7	0.516	1.02	**33 472**
2015	61 971	71 419	65.8	0.516	1.02	**32 619**

Uncertainties and Time-Series Consistency:

The uncertainty value of the AD was estimated to be ±5%. Although aggregated plant production data was used for the calculation, plant specific production data also gathered and their summation is compared with the aggregated production data that TCMA supplied and it is found that they are close for 2015. The uncertainty value of the EF is 2% due to chemical analysis of clinker to determine CaO percentage and default factor used for CKD.

Source-Specific QA/QC and Verification:

Clinker production data is gathered by the Turkish Cement Manufacturers Assembly (TCMA) and reported monthly on their website. However TCMA do not report on CaO contents in the clinker. The annual average CaO contents of all the cement factories are asked by a questionnaire and meanwhile clinker production amount of the factories are also asked for quality assurance purpose. Turkey's specifc CaO content in the clinker is calculated by weighted average. Although every plant could report the CaO content in the clinker for 2015, not every plant could report for earlier years. The table 4.4 below shows the average CaO content in the clinker and the corresponding country specific emission factor. It can be seen in the tables that as the years go back the representativeness of the emission factor decreases.

Table 4.4 Country specific emission factor and its representativeness

Year	Turkey's total clinker production (kt)	Total clinker production of the plants reporting CaO content	CaO content (%)	County specific emission factor	Representative-ness (%)
1990	20 252	2 578	64.4	0.506	12.7
1991	23 153	2 696	64.9	0.509	11.6
1992	25 489	2 729	65.0	0.510	10.7
1993	24 941	4 171	65.4	0.513	16.7
1994	25 880	4 270	65.1	0.511	16.5
1995	27 094	4 701	65.2	0.511	17.3
1996	27 852	6 358	65.8	0.516	22.8
1997	28 706	7 566	65.7	0.516	26.4
1998	29 148	9 747	65.5	0.514	33.4
1999	27 966	9 557	65.2	0.511	34.2
2000	28 950	13 273	65.5	0.514	45.8
2001	28 746	18 433	65.6	0.515	64.1
2002	29 499	22 194	65.7	0.516	75.2
2003	30 419	23 050	65.8	0.516	75.8
2004	32 779	25 936	65.6	0.515	79.1
2005	36 382	29 212	65.6	0.515	80.3
2006	39 569	32 574	65.8	0.516	82.3
2007	43 174	36 586	65.9	0.517	84.7
2008	47 095	42 276	65.9	0.517	89.8
2009	50 436	49 315	65.8	0.516	97.8
2010	55 485	54 311	65.9	0.517	97.9
2011	57 823	57 312	66.0	0.518	99.1
2012	57 758	55 710	65.9	0.517	96.5
2013	62 736	61 428	65.7	0.516	97.9
2014	63 642	62 669	65.7	0.516	98.5
2015	61 971	63 779	65.8	0.516	100.0

Note that representativeness indicates that the amount of clinker with known CaO content divided by the total clinker production of Turkey for each year. Obviously for recent years almost all of the cement plants can report their clinker's CaO content while for the earlier years some of the plants cannot due to data unavailability. Therefore the representativeness of the country specific emission factor decreases as the years go back.

Moreover the clinker production data gathered from the TCMA are compared to the PRODCOM (Turkish national industrial production statistics). They are found to be consistent.

Moreover plant specific clinker production data also gathered by a questionnaire from all of the clinker producers. Only for 2015 all of the plants reported their production data. Their sum should be the national production data. However, when compared we found that there is a difference of 3% with aggregated national production data that TCMA supplied.

Recalculations

In the previous inventory report country specific EF were calculated by using data from only 12-14 plants. In this inventory all the plants are asked for their CaO content between 1990 and 2015. The country specific emission factor was revised and accordingly emissions were recalculated. In the table below difference in the emissions are shown.

Table 4.5 Comparison on clinker production emissions recalculation in the 2016 and 2017 inventory submissions

Years	Clinker production emissions in 2016 Inventory (kt)	Clinker production emissions in 2017 Inventory (kt)	Difference in emissions (kt)	Percental difference (%)
1990	10 521	10 445	- 76	-0.7
1991	11 915	12 021	106	0.9
1992	13 182	13 265	83	0.6
1993	12 817	13 049	232	1.8
1994	13 355	13 493	138	1.0
1995	14 179	14 133	- 47	-0.3
1996	14 498	14 662	164	1.1
1997	15 146	15 105	- 41	-0.3
1998	15 047	15 292	246	1.6
1999	14 626	14 590	- 36	-0.2
2000	14 690	15 184	494	3.4
2001	15 115	15 087	- 28	-0.2
2002	15 511	15 513	2	0.0
2003	16 037	16 022	- 16	-0.1
2004	17 225	17 207	- 18	-0.1
2005	19 237	19 117	- 120	-0.6
2006	19 185	20 841	1 656	8.6
2007	20 925	22 780	1 854	8.9
2008	24 609	24 837	228	0.9
2009	25 301	26 558	1 257	5.0
2010	27 563	29 284	1 721	6.2
2011	30 057	30 527	470	1.6
2012	31 068	30 449	- 619	-2.0
2013	33 585	32 995	- 591	-1.8
2014	34 070	33 472	- 599	-1.8

Planned improvements

Turkey recently made improvements in the representativeness of the country specific carbonate content of the clinker. In the next years it is planned to collect data on plant specific CKD.

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

Source Category Description:

The word lime refers to product obtained by calcining the limestone. The production of lime involves a series of steps which include quarrying the raw material, crushing and sizing, and calcination. Limestone is a naturally occurring and abundant rock that consists of high levels of calcium carbonate (and maybe some magnesium carbonate). Lime production begins by extracting limestone from quarries. Then limestone enters into a crusher and screened to obtain small pieces of limestone. Then the crushed and sized limestone particles are heated in the kiln. Heating up the limestone causes the calcination of the calcium carbonate molecules (and magnesium carbonate molecules if any). CO_2 is generated during the calcination stage, when limestone ($CaCO_3$) are burned at high temperature (900-1200°C) in a kiln to produce quicklime (CaO) and CO_2 is released in the atmosphere. Magnesium carbonate ($MgCO_3$) breaks into MgO and CO_2 in the same manner. The calcination reactions are shown below in the chemical equations.

$$CaCO_3 \rightarrow CaO + CO_2$$

$$MgCO_3 \rightarrow MgO + CO_2$$

Lime production results in CO_2 emissions due to calcination reaction of limestone during production and these emissions are reported under 2.A.1 CRF category. Moreover lime production is an energy intensive process. Heating up the kiln with its load to such a high temperature is extremely energy consuming. Most of the kilns in Turkey uses coal, petroleum coke, lignite as the primary energy source. The emissions due to combusting of these fuels to heat up the kilns are included in 1.A.2f CRF category. The following table below shows allocation of lime production emissions in the CRF categories.

Table 4.6 Allocation of lime production emissions

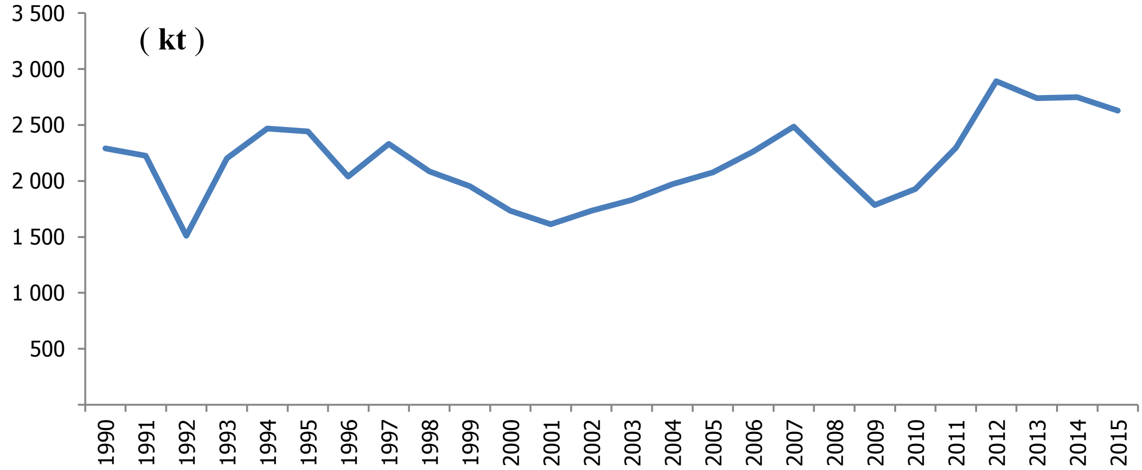
CRF category	Emission source
CRF 2.A.1	Emissions from calcinations reactions in the kilns
CRF 1.A.2f	Emissions from fuel consuming for the energy demand of the production plant.

In Turkey lime is produced by a wide range of technology from old fashioned kilns to computer controlled plants. Most of the lime plants in Turkey are technologically new or modified to best available technologies. The old technology lime plants are minority in Turkey and their number is decreasing every year. Lime producers can be divided into two sub-categories, producers for the market and producers for their own internal consumption. Sugar refiners, soda ash manufacturers, and iron steel manufacturers produce lime for their own need. Sugar refiners and soda ash producers however use the produced CO_2 in their process steps and CO_2 is absorbed. Therefore lime production of the sugar refiners and soda ash producers do not contribute to the green house gas inventory.

Almost all of the lime produced in Turkey is quick lime and dolomitic. There is also some minor amount of hydrolic lime production in Turkey. However it is known to be negligible amount of production with respect to total lime production.

The figure below shows the trend at lime production and the related CO_2 emissions between 1990 and 2015. The lime produced in Turkey is mostly used in the manufacturing and construction sector. Emissions from lime production are increased by 14.7% between 1990 and 2015. It is seen in the graph, emissions are decreased remarkably in 1992, in 2000-2001 period, and in 2008-2009 period due to slow down of the construction sector and economic recessions. The emissions from lime production seems to be going to increase in the future since manufacturing and construction sectors grow overall and the demand for lime increases.

Figure 4.4 CO_2 emissions from lime production, 1990-2015



Methodological Issues:

The formula below is used to calculate emission from lime production.

$$2\ emissions = (M_{ql} - M_{cl}) \times EF_{ql} + M_{dl} \times EF_{dl}$$

Where:
CO_2 emissions = emissions of CO_2 from lime production, tonnes
Mql = Production of quick lime
Mcl = Amount of captive lime (non emissive quick lime production)

Mdl = Production of dolomitic lime
EFql = Emission factor for quick lime
EFdl = Emission factor for dolomitic lime

In sugar industry lime is produced for sugar refining. Both the quick lime and the CO_2 is used for precipitating the impurities in the sugar. In Turkish inventory it is assumed that all the CO_2 produced in lime production for sugar refining is precipitating and no CO_2 is emitted. Also in the soda ash production with solvay process, lime is produced and the resulting CO_2 is used in the process as an intermediate product. It is assumed that all the CO_2 produced from limestone in the soda ash production process is captured and no CO_2 emitted. Therefore the lime produced for sugar industry and the soda ash production industry is deducted from the national lime production data and the emissions are calculated accordingly.

Consistent with the use of the tier 1 method, Turkey does not make any corrections to the emissions estimates to account for emissions from production of hydrated lime or lime kiln dust.

Collection of activity data

Quick lime (CaO) production data are collected from the Lime Producers Association (KİSAD). KİSAD gatehers about 88% (by 2015) of all the lime production data either by asking to member production plants or searching for the activity reports of other producers. The remaining 12% is estimated by KİSAD using the lime import and export data and related activity data in the industry. In addition sectoral lime consumption data is also taken from KİSAD and therefore the amount of captive lime (lime produced for sugar industry and soda ash production industry) is obtained. The dolomitic lime is mostly used in the steel production. The dolomitic lime consumption data were collected from the steel plants and the sum is assumed to be the national dolomitic lime production data.

Table 4.7 Lime production and CO_2 emissions, 1990-2015

Years	Quick Lime Production (kt)	Quick Lime produced for sugar industry and synthetic soda ash production (kt)	Dolomitic lime production (kt)	CO_2 Emissions (kt)
1990	4 000	415	101	2 291
1991	3 930	472	102	2 226
1992	2 775	485	125	1 510
1993	3 860	502	149	2 203
1994	4 168	455	157	2 468
1995	4 090	474	173	2 441
1996	3 575	555	170	2 041
1997	4 049	633	182	2 330
1998	3 789	767	183	2 084
1999	3 527	716	187	1 952
2000	3 241	745	186	1 733
2001	2 972	660	198	1 614
2002	3 150	722	231	1 734
2003	3 231	678	256	1 830
2004	3 380	701	299	1 970
2005	3 584	730	303	2 077
2006	3 735	760	352	2 264
2007	3 952	709	395	2 485
2008	3 385	703	403	2 127
2009	2 877	668	362	1 786
2010	3 225	898	426	1 926
2011	3 819	1 049	516	2 296
2012	4 621	1 022	542	2 893
2013	4 400	1 015	504	2 740
2014	4 443	1 019	485	2 749
2015	4 325	996	418	2 628

Choice of emission factor

Country specific emission factor is used for quick lime whereas default emission factor is used for dolomitic lime (0.77 tone CO_2 per tone lime) from the IPCC 2006 Guidelines. For calculating the country specific emission factor of quick lime factories are asked for their amount of production and the CaO content of their product. By averaging on weight basis the country specific CaO content of quick lime is calculated. The table below shows the average CaO content of quicklime and corresponding EF for each year.

Table 4.8 Quick lime emission factors, 1990-2015

Years	Turkey's total quick lime production (kt)	Total quick lime production of the plants reporting CaO content	CaO Content (%)	County specific emission factor	Representative-ness (%)
1990	4 000	281	78.6	0.617	7.0
1991	3 930	320	79.1	0.621	8.2
1992	2 775	348	78.7	0.618	12.5
1993	3 860	383	79.3	0.622	9.9
1994	4 168	400	80.5	0.632	9.6
1995	4 090	399	81.3	0.638	9.8
1996	3 575	410	80.6	0.632	11.5
1997	4 049	439	81.6	0.641	10.8
1998	3 789	439	81.9	0.643	11.6
1999	3 527	405	81.9	0.643	11.5
2000	3 241	415	81.1	0.637	12.8
2001	2 972	371	80.5	0.632	12.5
2002	3 150	333	81.6	0.641	10.6
2003	3 231	327	81.5	0.640	10.1
2004	3 380	431	82.7	0.649	12.7
2005	3 584	426	82.3	0.646	11.9
2006	3 735	1 252	85.3	0.670	33.5
2007	3 952	1 368	85.7	0.672	34.6
2008	3 385	1 337	86.2	0.677	39.5
2009	2 877	1 180	86.9	0.682	41.0
2010	3 225	1 533	87.5	0.687	47.5
2011	3 819	1 786	87.3	0.685	46.8
2012	4 621	1 901	87.6	0.688	41.1
2013	4 400	1 829	88.5	0.695	41.6
2014	4 443	1 883	88.4	0.694	42.4
2015	4 325	1 854	88.3	0.693	42.9

Note that representativeness indicates that the amount of quick lime with known CaO content divided by the total lime production of Turkey for each year. Obviously for the recent years more lime plants can report their CaO content while for the earlier years most plants cannot due to data unavailability. Therefore the representativeness country specific emission factor decreases as the years go back.

Uncertainties and Time-Series Consistency:

There is uncertainty due to not collecting data from each of the production plant but estimating some amount of the production. In addition, there is uncertainty associated with assuming the dolomitic lime production is equal to the consumption of dolomitic lime in steel industry. Overall ±10% uncertainty for the activity data is estimated.

The uncertainty value of the EF is estimated to be ±6 % as there is uncertainty in assuming the average CaO in lime.

Source-Specific QA/QC and Verification:

Plant specific lime production data from KİSAD is compared with ILA (International Lime Association) Although ILA report is based on the sales, KİSAD data and ILA data are found to be consistent. ILA reports 4 300 kilotons of lime sales in Turkey while KİSAD reports 4 325 kilotons of lime production in Turkey in 2015.

In addition Turkey's 8th five years development plan released an annex special to building materials. One part of this report was allocated for the lime production in Turkey and it includes historical lime production data for the years 1994 - 1998 which are exactly the same with our lime production data for those years in the time series.

Recalculations

The activity data was revised and it is found that some of the lime production data was double counted. Besides that the lime produced for sugar refining and synthetic soda ash production is deducted from the national lime production data because the CO_2 is reabsorbed and processed in these industries. Moreover in 2016 submission report the dolomitic lime production was not covered, and in this submission it is covered. The following table compares the recalculation with the previous estimates.

Table 4.9 Comparison on lime production emissions recalculation in the 2016 and 2017 inventory submissions

Years	Amount of quick lime that was double counted in 2016 inventory (kt)	Amount of captive lime that was not deducted from emissions in 2016 inventory (kt)	Amount of dolomitic lime that was not covered in 2016 inventory (kt)	Lime production emissions in 2016 inventory (kt)	Lime production emissions in 2017 inventory (kt)	Difference in emissions (kt)	Percental difference (%)
1990	1 050	415	101	3 788	2 291	- 1 497	- 40
1991	1 065	472	102	3 746	2 226	- 1 520	- 41
1992	1 008	485	125	2 837	1 510	- 1 327	- 47
1993	1 110	502	149	3 728	2 203	- 1 524	- 41
1994	1 155	455	157	3 769	2 468	- 1 301	- 35
1995	1 160	474	173	3 938	2 441	- 1 496	- 38
1996	1 220	555	170	3 596	2 041	- 1 556	- 43
1997	1 245	633	182	3 971	2 330	- 1 641	- 41
1998	1 270	767	183	3 794	2 084	- 1 711	- 45
1999	1 250	716	187	3 583	1 952	- 1 630	- 46
2000	1 371	745	186	3 459	1 733	- 1 726	- 50
2001	1 400	660	198	3 279	1 614	- 1 665	- 51
2002	1 525	722	231	3 506	1 734	- 1 773	- 51
2003	1 550	678	256	3 586	1 830	- 1 756	- 49
2004	1 660	701	299	3 780	1 970	- 1 810	- 48
2005	1 695	730	303	3 959	2 077	- 1 882	- 48
2006	1 710	760	352	4 084	2 264	- 1 820	- 45
2007	1 740	709	395	4 269	2 485	- 1 784	- 42
2008	1 700	703	403	3 814	2 127	- 1 687	- 44
2009	1 860	668	362	3 553	1 786	- 1 767	- 50
2010	1 910	898	426	3 851	1 926	- 1 925	- 50
2011	1 970	1049	516	4 342	2 296	- 2 046	- 47
2012	2 020	1022	542	4 981	2 893	- 2 088	- 42
2013	2 060	1015	504	4 845	2 740	- 2 105	- 43
2014	2 180	1019	485	4 967	2 749	- 2 218	- 45

Planned Improvement:

It is planned make a research for the possible data sources to obtain the amount of dolomitic lime production in Turkey. Therefore the uncertainty in the emission factor can be decreased. Moreover it is planned to obtain a country specific emission factor for dolomitic lime.

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

Source Category Description:

A variety of raw materials are involved during glass production. Limestone, dolomite and soda ash are the carbonates that compose the majority of raw materials. These carbonates emit CO_2 when heated (calcined) during the glass production and it is reported under 2.A.3 CRF category. Glass makers also use a certain amount of recycled scrap glass (cullet). Cullet usage decreases the raw material consumption and hence it reduces the costs and CO_2 emissions. During glass production carbon based fuels are burnt in order to melt the glass batch and as a result of this CO_2 emissions, which are reported under 1.A.2f CRF category, is emitted. Table below shows allocation of glass production emissions in the CRF categories.

Table 4.10 Allocations of glass production emissions

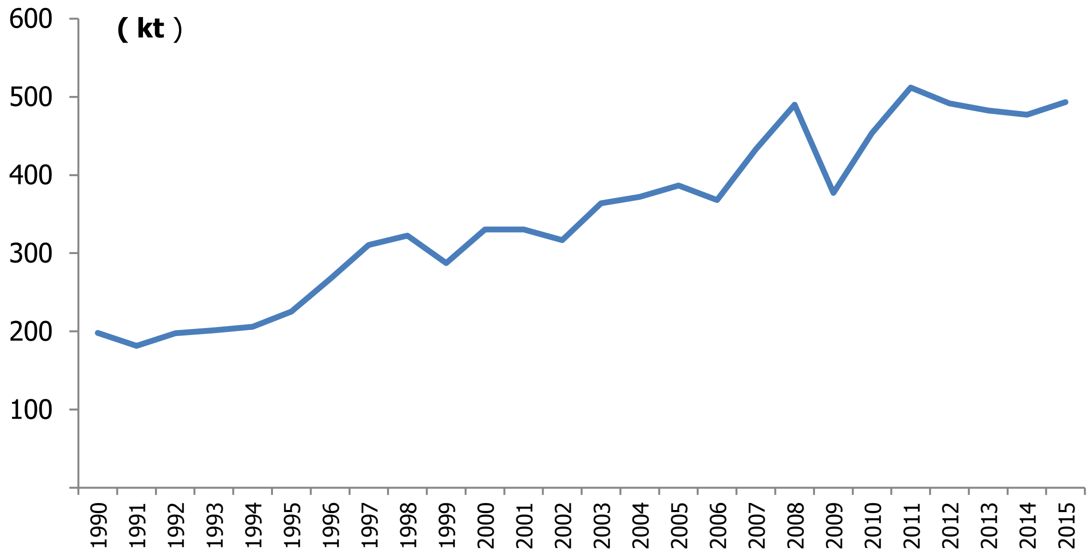
CRF category	Emission source
CRF 2.A.3	Emissions from calcination reactions during production
CRF 1.A.2f	Emissions from fuel consuming for the energy demand of the production process.

Turkish glass industry produces various type of glasses with different chemical and physical properties. Turkey's glass sector comprises the three main categories: container (household goods and bottles), float glass and fiber glass. The majority of the glass production is container and flat glass in all the time series.

Turkish glass industry has roots back to the establishment of Pasabahce in 1935 with a production capacity of only 3 kt. Turkey glass industry production peaked 3.12 Mt in 2014 and it was 3.08 Mt in 2015. 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 (1.25 Mt molten glass produced) and 2015 (3.08 Mt molten glass produced), increasing 146%. By 2016, Turkey is Europe's second and the world's fifth biggest float glass producer.

The trend in CO_2 emissions from glass production is given in the Figure 4.5. The emissions are increasing in general due to increasing glass production of Turkey. The time series shows a considerable decrease in 2009 due to effects of global economic recession in that year.

Figure 4.5 CO_2 emissions from glass production, 1990-2015



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 to the various types of glass produced in Turkey.

$$_2\ Emissions = \left[M_{g,i} \times EF_i \times (1 - \quad R_i)\right]$$

Where:
CO_2 Emissions = emissions of CO_2 from glass production, tonnes
$M_{g,i}$ = mass of molten glass of type *i* (e.g., float, container, fibre glass, etc.), tonnes
EF_i = emission factor for manufacturing of glass of type *i*, tonnes CO_2/tone glass melted
CR_i = cullet ratio for manufacturing of glass of type *i*, fraction

Collection of activity data

Turkey produces float glass, container glass (including household glassware) and fiberglass for insulation. About 90% of the total glass production of Turkey is done by a single company, Şişecam. Activity data of the Şişecam, including molten glass production by glass type and cullet ratio are gathered directly from the plant for all the years 1990-2015. On the other hand Turkey's total glass production data by glass type are gathered from The Union of Chambers and Commodity Exchanges of Turkey (TOBB) for the years 2010-2015. Turkey's total production data from 1990 to 2009 were estimated by assuming that the company Şişecam produces 90% of float glass and container glass and 100% of fiber glass in Turkey.

In the following table, total CO_2 emissions and glass production by type are given.

Table 4.11 Total molten glass production and CO_2 emissions by type of glass, 1990-2015

(kt)

Year	Float Glass	Container	Fiberglass	Total Glass Production	Total CO_2 emissions
1990	722	507	23	1 252	198
1991	743	474	17	1 235	182
1992	694	564	24	1 283	198
1993	673	592	24	1 290	201
1994	682	608	22	1 312	206
1995	694	714	22	1 431	225
1996	831	858	21	1 710	267
1997	869	1 087	29	1 985	310
1998	916	1 100	32	2 048	323
1999	857	976	32	1 864	287
2000	1 082	1 024	38	2 145	330
2001	978	1 021	44	2 043	331
2002	967	1 061	45	2 073	317
2003	1 101	1 129	62	2 292	364
2004	1 113	1 163	70	2 347	372
2005	1 129	1 206	74	2 409	387
2006	1 042	1 200	72	2 314	368
2007	1 268	1 348	73	2 689	433
2008	1 539	1 443	70	3 052	490
2009	1 194	1 164	51	2 410	377
2010	1 328	1 415	53	2 797	453
2011	1 542	1 463	75	3 081	512
2012	1 302	1 577	82	2 962	491
2013	1 416	1 491	76	2 983	483
2014	1 611	1 442	63	3 116	477
2015	1 447	1 570	65	3 082	493

According to the figures in table above, glass production shows a steady increase for the years 2002-2008 after the economical recession years of 1999-2001 of Turkey (2 072 kt in 2002 and 3 052 kt in 2008). The production decreased in the year 2009 (2 410 kt) due to the global economic recession. Then it showed a general trend of growth till 2015 (3 082 kt). In 2014, float glass production increased dramatically (14%) due to a 1% growth of the European construction sector and increasing float glass export of Turkey, in 2015 the growth is slowed down and total glass production become 3 082 kt, and CO_2 emissions become 493 kt.

Choice of emission factor

CO_2 emissions are calculated using the 2006 IPCC default EFs and country specific cullet ratio. The emission factors for each type of glass product are given below whereas the cullet ratio is confidential since 90% of Turkey's glass is produced by one single company, Şişecam.

Table 4.12 EFs for glass production, 1990-2015

Glass type	EF (tone CO_2/tone glass)
Float Glass	0.21
Container (glassware and bottles)	0.21
Fiberglass (Insulation)	0.25

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%. Since emissions from glass production are estimated based on the carbonate input the emission factor uncertainty is 2% as suggested in the 2006 IPCC guideline.

Source-Specific QA/QC and Verification:

Turkey's total glass production data are gathered from TOBB and it is compared with Şişecam company which is the Turkey's biggest producer by a share of 90%. Based on the assumption the compared data are found to be convenient.

Recalculations

In the previous inventory the amount of final glass product was used as the activity data. However, in this inventory report molten glass production data is used as the activity data which is compulsory for tier 2 methodology. Secondly, in this inventory report country specific cullet ratios for each type of glass for each year in the time series are used for emission calculations. Finally, a different approach is applied in this inventory report in order to estimate the 1990-2009 total glass production. For this estimation it is assumed that Şişecam company produced 90% of all the glasses in Turkey between 1990 and 2009. In the table below the results of the recalculation are tabulated.

Table 4.13 Comparison on glass production emissions recalculation in the 2016 and 2017 inventory submissions

Years	Glass production emissions in 2016 Inventory (kt)	Glass production emissions in 2017 Inventory (kt)	Difference (kt)	Percental difference (%)
1990	230	198	-32	-14
1991	222	182	-41	-18
1992	170	198	28	16
1993	177	201	24	14
1994	175	206	31	18
1995	200	225	25	13
1996	232	267	36	15
1997	268	310	43	16
1998	276	323	47	17
1999	248	287	39	16
2000	300	330	30	10
2001	296	331	35	12
2002	223	317	94	42
2003	266	364	98	37
2004	290	372	82	28
2005	318	387	69	22
2006	364	368	4	1
2007	436	433	-3	-1
2008	503	490	-13	-3
2009	389	377	-12	-3
2010	494	453	-41	-8
2011	544	512	-32	-6
2012	527	491	-35	-7
2013	522	483	-39	-8
2014	610	477	-133	-22

Planned Improvements

In 2017 inventory submission country specific cullet ratios are gathered and emissions are calculated accordingly. No further improvements are planned at this time.

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

The category, other process uses of carbonates, is a key category. In this category, emissions from ceramics production, other uses of soda ash and non-metallurgical magnesia production are reported. Between 1990 (258 kt CO_2eq) and 2014 (2 237 kt CO_2eq) 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 emissions since raw materials like limestone and magnesite are calcined during manufacturing. Moreover ceramic production is an energy intensive process. Heating up the ceramics to such a high temperature for calcination is extremely energy consuming. Most of the ceramic manufacturers in Turkey use natural gas for this purpose. The emissions due to combusting of fuels to heat up the ceramics are included in 1.A.2f CRF category. Table below shows allocation of cement production emissions in the CRF categories.

Table 4.14 Allocations of ceramic production emissions

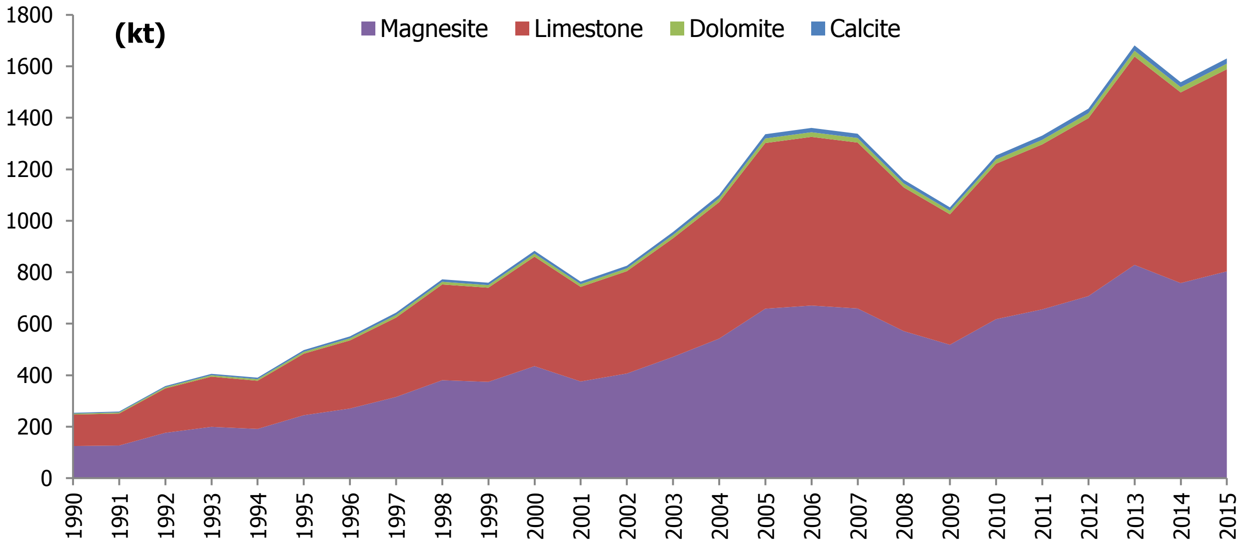
CRF category	Emission source
CRF 2.A.1	Emissions from calcination reactions in the ceramic ovens
CRF 1.A.2f	Emissions from fuel consuming for the energy demand of the production process.

The Turkish ceramics industry, which started production in an 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 5 280 kilotons of tiles and again, the third largest in ceramic sanitary ware with production over 300 kilotons. Turkey is the world's sixth and Europe's third largest ceramic tile manufacturer.

Ceramics includes the production of vitrified clay pipes, refractory products, expanded clay products, wall and floor tiles, table and ornamental ware, sanitary ware.

CO_2 emissions from ceramic production show an increasing trend for the years 1990-2015 overall. In 2015, ceramic production and the resulting CO_2 emissions increased by 6% with respect to 2014.

Figure 4.6 Carbonate emissions, by raw materials type, in ceramics, 1990-2015



Methodological Issues:

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

$$_2\ emissions = \sum (M_i * EF_i)$$

Where:
CO_2 Emissions = emissions of CO_2 from other process uses of carbonates, tonnes
M_i= mass of limestone or dolomite respectively (consumption), tonnes.
EF_i= emission factor for carbonate calcination, tonnes CO_2/tonne carbonate

Collection of activity data

Calcite, limestone, dolomite, magnesite and hydro-magnesite are consumed as raw materials in the ceramics industry. Production of ceramic tile and sanitary ware and carbonate consumption data (see the following table) are gathered from the Turkish Ceramics Federation for all years in the time series 1990-2015.

Table 4.15 Raw material consumption and production, 1990-2015

	Raw material consumption (tonnes)				Products (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
2015	45 622	1 786 117	45 622	1 539 756	5 280 000	300 000	5 580

Choice of emission factor

Default EFs 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. The following table shows the default emission factors used in the calculations.

Table 4.16 Carbonate EFs for all years in the time series

Carbonate	**EF (tonnes CO_2/ ton carbonate)**
Calcite and limestone	0.43971
Dolomite	0.47732
Magnesite	0.52197

Source: Table 2.1 of the 2006 IPCC Guidelines

CO_2 emissions from each raw material are given in the table below and Figure 4.6.

Table 4.17 CO_2 emissions from raw material consumption, 1990-2015

(kt)

Years	Calcite	Limestone	Dolomite	Magnesite	Total
1990	3.3	122.2	3.6	125.1	254.1
1991	3.8	124.2	4.1	127.0	259.1
1992	4.4	172.4	4.8	176.4	358.1
1993	5.2	195.0	5.7	199.6	405.5
1994	5.8	187.1	6.3	191.5	390.7
1995	6.7	239.1	7.2	244.7	497.8
1996	7.5	264.6	8.1	270.8	551.0
1997	9.2	308.4	10.0	315.6	643.2
1998	9.6	372.1	10.4	380.7	772.7
1999	9.3	365.8	10.1	374.4	759.7
2000	10.9	425.4	11.8	435.4	883.4
2001	9.8	367.4	10.6	376.0	763.8
2002	10.2	397.5	11.0	406.8	825.5
2003	11.8	460.7	12.8	471.4	956.6
2004	13.5	530.1	14.7	542.5	1 100.8
2005	16.4	643.6	17.9	658.7	1 336.6
2006	16.7	655.4	18.2	670.7	1 361.1
2007	16.5	644.5	17.9	659.6	1 338.4
2008	14.3	558.4	15.5	571.5	1 159.7
2009	12.9	506.8	14.1	518.6	1 052.4
2010	15.4	603.9	16.7	618.0	1 254.0
2011	16.4	640.0	17.8	656.0	1 331.2
2012	17.7	691.3	19.8	707.5	1 435.6
2013	20.7	809.8	22.5	828.7	1 681.6
2014	18.9	740.9	20.5	758.2	1 538.6
2015	20.1	785.4	21.8	803.7	1 630.9

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. Although there is a significant amount of roof tiles and bricks production in Turkey, unfortunately there is no verified activity data for this type of production. Only ceramic tiles and sanitary ware productions were taken into account. Therefore for this category AD uncertainty is considered as +30% while the EF uncertainty is considered ±2% which is in line with the 2006 IPCC Guidelines, Volume 3 (page 2.39).

Source-Specific QA/QC and Verification:

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

Recalculations

There were no recalculations of CO_2 emissions from ceramics between the 2015 and 2016 inventory submissions.

Planned Improvements

Although there is a significant amount of roof tiles and bricks production in Turkey, these type of ceramics production is not taken into account, because of insufficient activity data. In the next years it is aimed to gather production data for the mentioned type of ceramics.

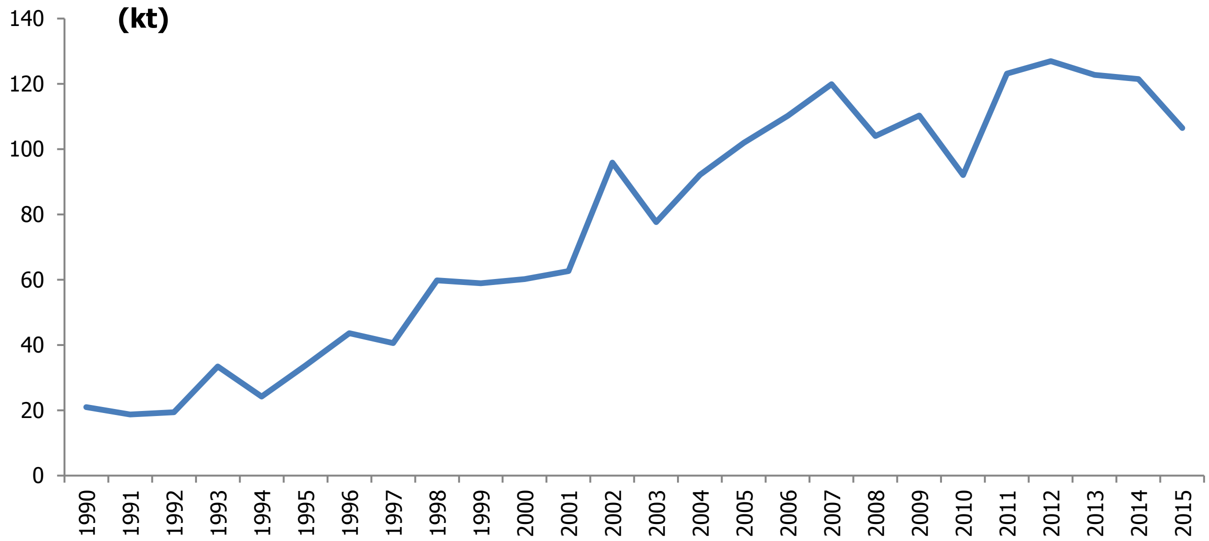
4.2.4.2. Other uses of soda ash (Category 2.A.4.b)

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. There are no other uses of soda ash included elsewhere in the Turkish Inventory.

Since soda ash is an important intermediate product primarily for the glass industry and detergent industry and it is used in many other industries. Soda ash apparent consumption increased dramatically between 1990 (8 382 tonnes) and 2015 (256 483 tonnes) as the Turkish industry grew. During the 2001 and 2008 economic recessions, soda ash consumption decreased remarkably. Since 2009 consumption has increased dramatically, driven by the growth of the glass industry in particular and the growth of Turkish industry in general. In 2015 the GHG release due to the apparent consumption of soda ash is 106 kilotons of CO_2.

Figure 4.7 CO_2 emissions from other use of soda ash, 1990-2015



Methodological Issues:

Turkey does not collect annual statistics on soda ash consumption by industry; instead the apparent consumption of soda ash is calculated by adding imports data to production data and then subtracting exports and the usage in the glass sector. In this methodology it is assumed that all of the apparent consumption of soda ash is emissive.

Collection of activity data

Apparent consumption is calculated by the following formula.

$$Total\ Consumption\ = Soda\ ash\ production + Imports - Exports$$

$$Apparent\ Consumption\ = Total\ Consumption - Use\ in\ Glass\ Industry$$

Total production values are gathered from the two soda ash producer plants while foreign trade statistics are provided by TurkStat. The data for the amount of soda ash used in the glass sector is estimated from the glass production data which was obtained from Union of Chambers and Commodity Exchanges of Turkey (TOBB) and Şişecam Company.

Choice of emission factor

The default EF (0.41492 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 consumption, use in glass industry, apparent consumption and CO_2 emissions from soda ash consumption are given in the following table.

Table 4.18 Activity data for the other use of soda ash and related CO_2 emissions, 1990-2015

Years	Total consumption in Turkey (kt)	Use in glass industry (kt)	Apparent consumption (kt)	CO_2 (kt)
1990	315	264	51	21
1991	307	262	45	19
1992	317	270	47	19
1993	352	272	80	33
1994	336	277	59	24
1995	385	304	81	34
1996	469	364	105	44
1997	519	422	97	41
1998	578	434	144	60
1999	536	394	142	59
2000	601	456	145	60
2001	582	431	151	63
2002	668	437	231	96
2003	668	481	187	78
2004	713	491	222	92
2005	749	503	246	102
2006	747	481	266	110
2007	850	561	289	120
2008	891	640	251	104
2009	772	506	266	110
2010	807	585	222	92
2011	939	642	297	123
2012	918	612	306	127
2013	915	619	296	123
2014	944	651	293	121
2015	897	641	256	106

Uncertainties and Time-Series Consistency:

AD uncertainty for this source is considered ±10% 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:

There are only two plants in Turkey producing soda ash. The production data of these two plants and Turkish soda ash export data are compared together and the data are found to be consistent.

Recalculations

There is recalculations of CO_2 emissions from other uses of soda ash in all the time series due to recalculation in the glass industry and due to a revision in the 2013-2014 production data of one soda ash producer. Furthermore soda ash trading data was also revised. In the following table the activity data subject to recalculation are compared for 2016 and 2017 submissions and its effect on the emission calculation is shown.

Table 4.19 Effect of recalculation in the 2017 inventory submission with respect to 2016

Years	Change in the total soda ash consumption (kt)	Change in the "use in the glass industry" (kt)	Change in the apperant consumption of soda ash (kt)	Change in terms of emissions (kt)
1990	-23.0	-65.1	42.2	17.5
1991	-25.2	-56.7	31.5	13.1
1992	-26.8	26.4	-53.2	-22.1
1993	-23.3	18.0	-41.3	-17.1
1994	-27.9	25.9	-53.8	-22.3
1995	-33.3	16.9	-50.2	-20.8
1996	-108.0	31.8	-139.8	-58.0
1997	-103.1	37.6	-140.7	-58.4
1998	-289.1	38.9	-327.9	-136.1
1999	-416.0	38.7	-454.7	-188.7
2000	-402.4	25.2	-427.6	-177.4
2001	-65.0	6.6	-71.5	-29.7
2002	-415.9	116.4	-532.3	-220.9
2003	-432.4	100.1	-532.6	-221.0
2004	-416.6	75.0	-491.6	-204.0
2005	-401.8	47.0	-448.7	-186.2
2006	-394.8	-40.8	-354.0	-146.9
2007	-409.7	-64.6	-345.1	-143.2
2008	-375.5	-81.9	-293.6	-121.8
2009	-585.5	-52.0	-533.5	-221.4
2010	-1403.3	-131.3	-1272.0	-527.8
2011	-1529.8	-138.8	-1391.0	-577.2
2012	-1436.3	-148.3	-1288.0	-534.4
2013	-1456.1	-129.5	-1326.6	-550.4
2014	-1569.2	-218.0	-1351.2	-560.6

Planned Improvements

No further improvement is planned at the moment.

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.

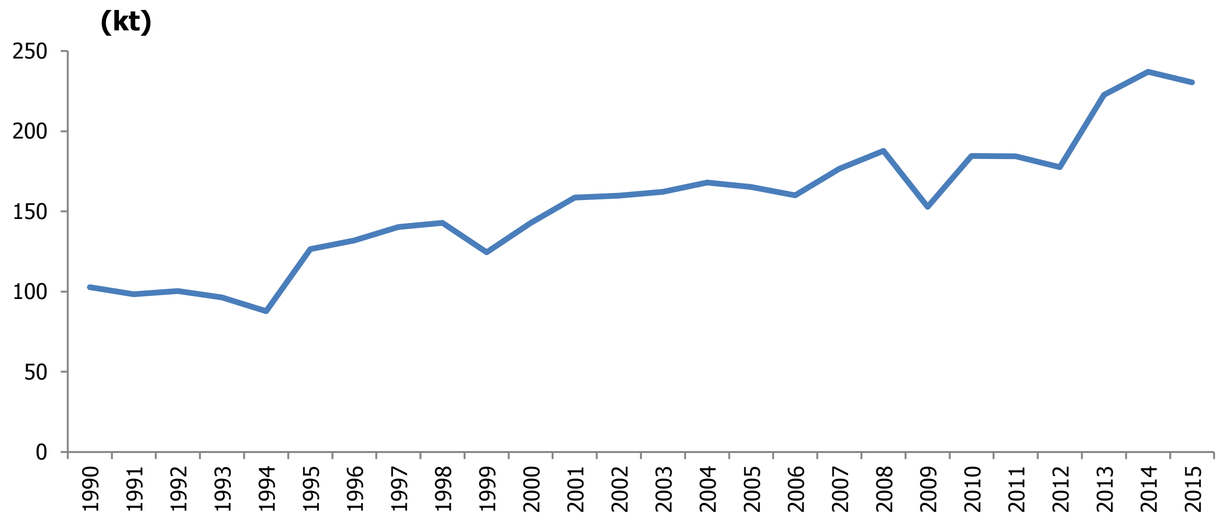
Magnesite ($MgCO_3$) is one of the key inputs into the production of magnesia, and ultimately fused magnesia. There are three major categories of magnesia products: calcined magnesia, deadburned magnesia (periclase) and fused magnesia. Calcined magnesia is used in many agricultural and industrial applications (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.

Magnesia (MgO) is produced by calcining magnesite ($MgCO_3$) which results in the release of CO_2 as shown in the chemical reaction below;

$$aCO_3 \rightarrow \quad aO + \quad O_2$$

Depending on the calcination temperature, calcined magnesia or deadburned magnesia is produced. Deadburned magnesia requires higher temperatures and its purity is higher than calcined magnesia in terms of MgO. Fused magnesia is produced in the electrical arc furnaces at very high temperatures and it is the purest among all. The figure below shows the CO_2 emissions from total magnesia production between 1990 and 2015.

Figure 4.8 CO_2 emissions from magnesia production, 1990-2015



Methodological Issues:

Turkey implements Tier 1 method. CO_2 emissions are calculated by using magnesia production (calcined production + deadburned magnesia) as AD and multiplied by the default IPCC EF. There is no significant amount of fused magnesia production in Turkey.

Collection of Activity Data

The magnesia production data are collected from the magnesia producers. There are six plants that are producing magnesia in Turkey. Each of them asked for their activity data till 1990 by a questionnaire.

Choice of Emission Factor

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 all the time series.

Table 4.20 Magnesia production and CO_2 emissions, 1990-2015

Years	Magnesia production (kt)	CO_2 (kt)
1990	196.8	102.7
1991	188.3	98.3
1992	192.1	100.3
1993	184.4	96.3
1994	168.1	87.7
1995	242.5	126.6
1996	252.5	131.8
1997	268.8	140.3
1998	273.7	142.8
1999	238.3	124.4
2000	273.7	142.8
2001	303.8	158.6
2002	306.1	159.8
2003	311.0	162.3
2004	322.1	168.1
2005	316.6	165.3
2006	306.5	160.0
2007	338.5	176.7
2008	359.7	187.7
2009	292.8	152.8
2010	353.7	184.6
2011	353.2	184.4
2012	340.3	177.6
2013	426.8	222.8
2014	454.1	237.0
2015	441.4	230.4

Uncertainties and Time-Series Consistency:

AD is collected from the companies and all the biggest producers are asked for their activity data. However there might be some small scale plants that are not asked for their activity data, or there might be small scale plants which were active in the past but closed now. Therefore the activity data uncertainty is 10%. Because the IPCC default EF is used for the emissions calculation, the 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 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.

Recalculation

Previously PRODCOM data were used as the activity data of magnesia production. The PRODCOM data classifies magnesia products as sinter and calcined according to degree of calcination. Both of them emissive magnesia products. However in the previous submission sinter magnesia was not taken into account. Moreover in this report the production data is asked to magnesia producers and emissions are calculated accordingly. The PRODCOM data is not available before 2005 whereas companies supplied data for the full time series. In the table below the results of the recalculation is tabulated.

Table 4.21 Comparison on magensia production emissions recalculation in the 2016 and 2017 inventory submissions

Years	Magnesia production emissions in 2016 Inventory (kt)	Magnesia production emissions in 2017 Inventory (kt)	Difference (kt)
1990	NE	102.7	102.7
1991	NE	98.3	98.3
1992	NE	100.3	100.3
1993	NE	96.3	96.3
1994	NE	87.7	87.7
1995	NE	126.6	126.6
1996	NE	131.8	131.8
1997	NE	140.3	140.3
1998	NE	142.8	142.8
1999	NE	124.4	124.4
2000	NE	142.8	142.8
2001	NE	158.6	158.6
2002	NE	159.8	159.8
2003	NE	162.3	162.3
2004	NE	168.1	168.1
2005	18.4	165.3	146.9
2006	16.6	160.0	143.4
2007	2.3	176.7	174.3
2008	0.6	187.7	187.1
2009	0.2	152.8	152.6
2010	12.3	184.6	172.3
2011	22.5	184.4	161.8
2012	10.2	177.6	167.4
2013	16.1	222.8	206.7
2014	16.7	237.0	220.4

Planned improvement:

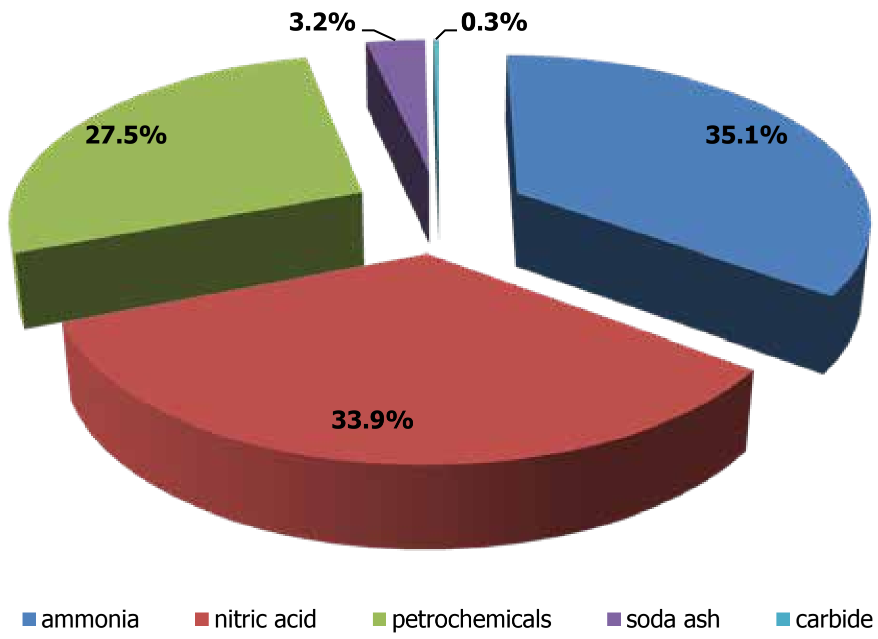
The small scale magnesia producers will be investigated for improving completeness.

4.3. Chemical Industry (Category 2.B)

In 2015, the chemical industry was responsible for 6.9 % of the total carbon dioxide equivalent emissions from the industrial processes and product use sector. Between 1990 (2 933 kt CO_2eq) and 2015 (4 174 kt CO_2eq), total carbon equivalent emissions increased by 42.3%. 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 1990-2015.

Figure 4.9 depicts the share of CO_2 equivalent emissions from chemical industry. The CO_2eq emissions from ammonia production are (35.1%), followed by nitric acid production and petrochemical industry (with 33.4 and 27.5 % respectively). Soda ash production and carbide production are much smaller contributors to emissions (3.2% and 0.3%, 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.

Figure 4.9 CO_2 emissions from chemical industry, 2015



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.

Natural gas is used as the feedstock for ammonia production in Turkish production plants. CO_2 is formed during reforming of natural gas for obtaining hydrogen and then it is reacted with nitrogen to synthesis ammonia. The overall reforming reaction and ammonia synthesis reactions are given below.

Overall reforming reaction: $0.88CH_4 + 1.26Air + 1.24H_2O \rightarrow 0.88CO_2 + N_2 + 3H_2$

Ammonia synthesis: $N_2 + 3H_2 \rightarrow 2NH_3$

Ammonia production requires the combustion of fuels for the energy demand of the process. Besides being used as feedstock, natural gas is also used for meeting the energy requirement of the process. Both the emissions due to the ammonia production process and the fuel combustion for the energy demand are included in 2.B.1 CFR category. 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. The following table shows the allocation of ammonia production emissions in the CRF categories.

Table 4.22 Allocations of ammonia production emissions

CRF category	Emission source
CRF 2.B.1	Emissions from ammonia production process and emissions from fuel consuming for the energy demand of the production plant.

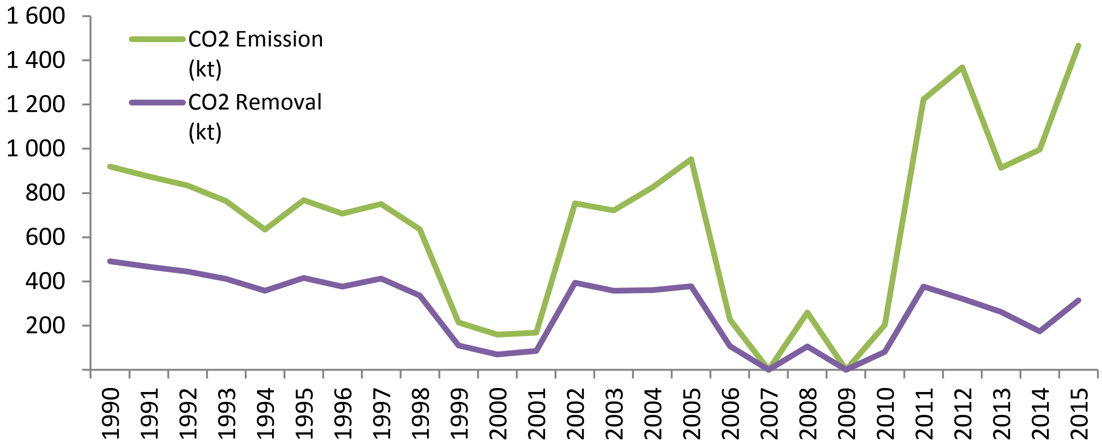
İGSAŞ is one of two ammonia plants in Turkey which started production in 1977. In 1993 a second ammonia plant, GEMLIK GUBRE, started its operation. İGSAŞ also produces urea using the CO_2 gas as feedstock. Therefore some of the CO_2 emitted during ammonia production is recovered. The chemical reaction that produces urea is:

$$2NH_3 + CO_2 \rightarrow NH_2COONH_4 \rightarrow CO(NH_2)_2 + H_2O$$

The figure 4.10 shows the CO_2 emissions from ammonia production as well as the amount of CO_2 recovered.

Overall, between 1990 (920 kt CO_2eq) and 2015 (1466 kt CO_2eq), emissions from ammonia production increased by 59%, due to increasing demand of ammonia. There are large inter-annual changes in CO_2 emissions from ammonia production, particularly in the last 10 years. Rapid increases in emissions can be seen shortly after periods of economic downturns.

Figure 4.10 CO_2 emissions and removals from ammonia production, 1990-2015



Methodological Issues:

In Turkey there are two ammonia production plants and both use natural gas as feedstock. Tier 2 method is used in accordance with the 2006 IPCC Guidelines. As an initial step, the total fuel requirement (both as feedstock and as combusted fuel for energy demand) is estimated by determining the total quantity of ammonia produced and the fuel requirement per unit of output. In order to calculate CO_2 emissions; the total fuel requirement is multiplied by the country-specific carbon content and the carbon oxidation factor.

$$TFR = \sum_j (AP_j * FR_j)$$

where:
TFR= total natural gas requirement, GJ
AP_j = ammonia production using natural gas in process type *j*, tonnes
FR_j = fuel requirement per unit of output in process type *j*, GJ/tonne ammonia produced

$$E_{CO2} = \sum \left(TFR * CCF * COF * \frac{44}{12} \right) - R_{CO2}$$

where:
E_{CO2} = emissions of CO_2, kg
TFR= total fuel requirement for natural gas, GJ

CCF= carbon content factor of natural gas, kg C/GJ
COF= carbon oxidation factor of natural gas, fraction
R_{CO2} = CO_2 recovered for downstream use (urea production), kg

Collection of activity data

Ammonia production and fuel requirement data are obtained from producers on annual basis. There is a survey related to the ammonia production and this survey is sent to the two producer company every year. The producers inform that ammonia production and natural gas consumption data are measured by on-line flow meters in the process whereas urea production data is calculated from the raw material consumption.

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.

The total amount of urea produced in ammonia plants is obtained from the survey which sent to ammonia production plants and it is included in the following table. The urea production data and the ammonia production data are given with respect to 1990=100 by years. Therefore one can compare the urea production and the ammonia production by years. Turkey assumes 0.733 tonnes of CO_2 are required per tonnes of urea produced. This value is taken from the 2006 IPCC Guidelines.

In Turkey; there was no ammonia production in 2007 and 2009 as shown in the table below. During these two years, ammonia was imported to meet domestic demand.

Table 4.23 Ammonia production and CO_2 emissions, 1990-2015

Year	Ammonia Production (1990=100)	Urea Production (1990=100)	CO_2 Emission (kt)	CO_2 Removal (kt)
1990	100	100	920	491
1991	95	95	874	466
1992	91	91	835	445
1993	82	84	763	412
1994	73	73	634	359
1995	82	85	768	415
1996	76	77	707	377
1997	81	84	750	413
1998	66	69	636	337
1999	22	22	214	110
2000	15	14	159	70
2001	18	17	168	85
2002	82	80	753	394
2003	79	73	721	358
2004	90	74	825	361
2005	104	77	953	378
2006	25	22	227	108
2007	0	0	0	0
2008	27	22	259	106
2009	0	0	0	0
2010	21	17	203	82
2011	128	77	1 223	376
2012	143	65	1 368	321
2013	97	54	914	263
2014	107	35	996	174
2015	157	64	1 466	314

Choice of emission factor

Turkey applies the carbon content of natural gas and an oxidation factor to the total fuel requirement to estimate emissions. The carbon content of the natural gas is the same as that used in the energy sector.

Uncertainties and Time-Series Consistency:

Because a country specific EF is used for the calculation of emissions from ammonia production, uncertainty is taken as ±5%.

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

Source-Specific QA/QC and Verification:

There are two ammonia producers in the Turkish market. Both producers utilize natural gas to produce ammonia and both use the same process. Hence their implied emission factors are comparable. When compared they are found consistent. Furthermore total ammonia production data of Turkey obtained from the producers is compared with data from PRODCOM and these two datasets are in the ±3% range since 2010.

Recalculation:

The carbon oxidation factor was taken as 0.9 in the previous submission. It is corrected with 1.0. Moreover carbon content of the natural gas between 1990 and 2015 was revised. The results of the recalculation are tabulated below.

Table 4.24 Comparison on ammonia production emissions recalculation in the 2016 and 2017 inventory submissions

Years	Emissions from ammonia production in 2016 submission report (kt)	Emissions from ammonia production in 2017 submission report (kt)	Difference in emissions (kt)	Percental change (%)
1990	843	920	76	9.1
1991	802	874	73	9.1
1992	765	835	69	9.1
1993	699	763	63	9.1
1994	581	634	53	9.1
1995	704	768	64	9.1
1996	648	707	59	9.1
1997	688	750	62	9.1
1998	583	636	53	9.1
1999	197	214	18	9.1
2000	146	159	13	9.1
2001	154	168	14	9.1
2002	684	753	69	10.2
2003	658	721	62	9.5
2004	754	825	72	9.5
2005	870	953	83	9.5
2006	208	227	19	9.3
2007	NO	NO	NO	NO
2008	236	259	23	9.8
2009	NO	NO	NO	NO
2010	186	203	17	9.4
2011	1110	1 223	113	10.2
2012	1249	1 368	118	9.5
2013	835	914	79	9.4
2014	910	996	86	9.5

Planned Improvement

An urea plant in Turkey is processing some of the downstream CO_2 emissions of an ammonia plant. In the previous submission report the amount of CO_2 used by the urea plant was subtracted from the ammonia plant emissions and the net emissions were reported as the ammonia production emissions. However in the final review the ERT suggested to report the amount of emissions by the ammonia plants and the amount of CO_2 used by the urea plant separately and in this submission report it is done so. However we are not sure that the CRF reporter reduces the captured emissions from the total emissions. In the next inventory report this issue will be investigated.

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

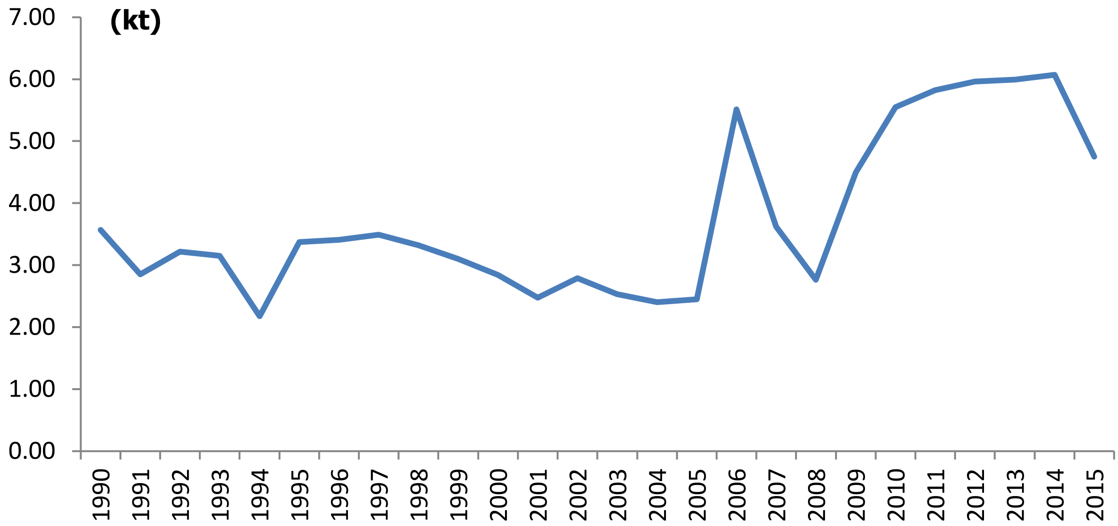
Source Category Description:

Nitrous oxide (N_2O) is emitted during the production of nitric acid which is a raw material mainly in the manufacturing of nitrogeneous-based fertilizer. Nitric acid is also used in the production of explosives, for metal etching and in the processing of ferrous metals.

In Turkey; these are four nitric acid plants, IGSAS (older names Yıldız Entegre and Kütahya Gübre) is in operation since 1961, Toros Tarım since 1972, Gemlik Gübre since 2006 and BAGFAŞ since 2015. These are medium pressure combustion plants. Some of these plants indicate their use of a selective catalytic reduction system.

N_2O emissions were relatively stable between 1990 (2.33 kt N_2O) and 2005 (2.45 kt N_2O), increasing by 5.2 percent. Emissions from nitric acid production is not stable between 2005 and 2009 as can be seen from the figure 4.11, this is due to a new nitric acid plant starts production in 2006 but stops its production in the same year and restarts production again in 2009. Moreover one of the nitric acid plants starts using an abatement technology in 2008 which decreases its emission factor. N_2O emissions reach its top in 2014 (6.07 kilotons). In 2015 N_2O emissions are decreased by 22% due to partial production stop in one big capacity nitric acid plant.

Figure 4.11 N_2O emissions from nitric acid productions, 1990-2015



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.

$$ {}_{N2O} = \quad F \times Nitric\ acid\ production $$

where:
E_{N2O} = N_2O emissions, kg
EF = N_2O emission factor (default), kg N_2O/tonne nitric acid produced

Collection of activity data

Nitric acid production data were obtained from plants. A questionnaire is sent to nitric acid production plants every year and the production data is filled by the operators. Production data are reported for 100% concentration HNO_3 and the quantities are determined by flow meters measuring the nitric acid production flow through the pipelines and a totalizer sums up to give the annular production data.

Choice of emission factor

There are four nitric acid production plants, İGSAŞ, Toros Tarım, Gemlik Gübre and BAGFAŞ. Emission factors are determined according to their usage of abatement technology and its efficiency. However the emission factors for each plant and the total nitric acid production cannot be revealed due to confidentiality reasons. Total nitric acid production is given relative to 1990, in the table below.

Table 4.25 Nitric acid production and N_2O emissions, 1990-2015

Year	Nitric acid production (1990=100)	Total N_2O emission (kt)
1990	100.0	3.57
1991	79.8	2.85
1992	90.1	3.22
1993	88.2	3.15
1994	61.0	2.18
1995	94.4	3.37
1996	95.5	3.41
1997	97.7	3.49
1998	93.0	3.32
1999	86.7	3.10
2000	79.6	2.84
2001	69.3	2.47
2002	78.2	2.79
2003	70.9	2.53
2004	67.4	2.40
2005	68.6	2.45
2006	154.4	5.51
2007	101.4	3.62
2008	102.0	2.76
2009	151.2	4.50
2010	179.8	5.55
2011	189.4	5.82
2012	190.2	5.96
2013	193.7	5.99
2014	194.6	6.07
2015	168.9	4.75

Uncertainties and Time-Series Consistency:

The2006 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 AD uncertainty of ± 2%, which is in line with the 2006 IPCC Guidelines Volume 3 (page 3.25)

Source-Specific QA/QC and Verification:

Plant specific nitric acid production data, which are collected from the plants by an annual questionnaire for this inventory calculations, are compared with TurkStat PRODCOM -Turkish national industrial production statistics- and found consistent.

Recalculation:

One of the nitric acid plants changed its owner in 2004. In the previous NIR the nitric acid production data of this plant before 2004 was not available. In this inventory the data is accessed and the time series between 1990 and 2004 is recalculated.

Table 4.26 Comparison on nitric acid production emissions recalculation in the 2016 and 2017 inventory submissions

Years	Nitric acid production emissions in 2016 submission (kt N_2O)	Nitric acid production emissions in 2017 submission (kt N_2O)	Difference in emissions (kt N_2O)	Percental change (%)
1990	2.33	3.57	1.23	52.9
1991	1.84	2.85	1.01	55.0
1992	2.09	3.22	1.13	54.0
1993	1.91	3.15	1.24	65.1
1994	1.35	2.18	0.83	61.6
1995	2.26	3.37	1.11	49.3
1996	2.31	3.41	1.10	47.4
1997	2.45	3.49	1.03	42.2
1998	2.32	3.32	1.00	43.2
1999	2.27	3.10	0.83	36.3
2000	2.04	2.84	0.80	39.0
2001	1.65	2.47	0.83	50.3
2002	1.92	2.79	0.87	45.3
2003	1.80	2.53	0.73	40.2
2004	1.90	2.40	0.50	26.5

Planned Improvements

As a legislative obligation nitric acid producers should install N_2O gas monitoring device. These devices measure the N_2O content of the flue gas instantaneously. Using the instant measurements and the working hours, companies estimated their own annual N_2O release. In the next years, the estimations of companies depending on the measuring device will be compared to emissions calculated depending on the nitric acid production data and emission factors.

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

There is no adipic acid production in Turkey during the period 1990-2015.

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

There is no caprolactam, glyoxal and glyoxylic acid production in Turkey during the period 1990-2015.

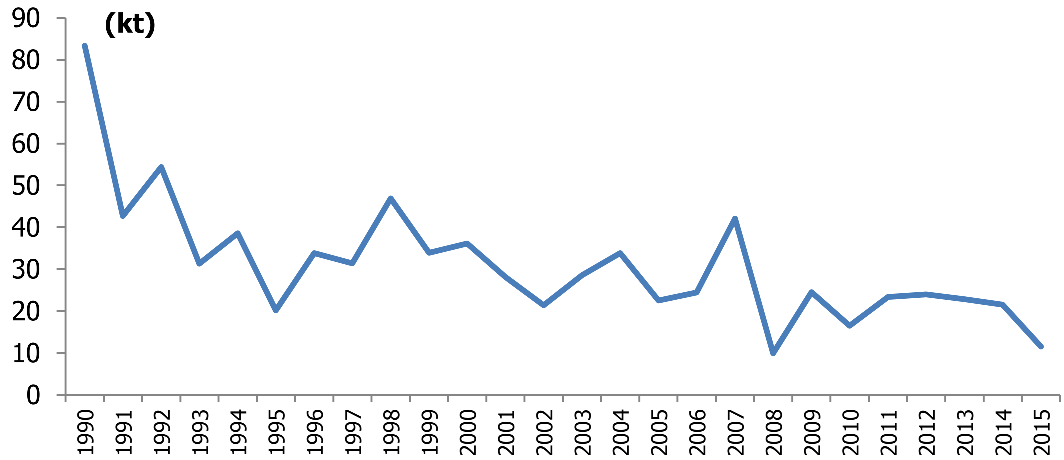
4.3.5. Carbide production (Category 2.B.5)

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 electric arc furnaces. The use of calcium carbide for acetylene production also leads to CO_2 emissions. Calcium carbide is made from two carbon containing raw materials: calcium carbonate (limestone) and coke. In Turkey there is no silicon carbide production. Calcium carbide has been produced in Turkey for the entire time series. The amount of coke used is deducted from the Energy part of the NIR to avoid double count.

CO_2 emissions from calcium carbide production have declined by 86 per cent between 1990 (75.5 kt CO_2) and 2015 (10.6 kt CO_2) as can be seen from the figure below showing the trend in the CO_2 emissions resulting from calcium carbide production. The decrease in the production has economical reasons.

Figure 4.12 CO_2 emissions due to carbide production, 1990-2015



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 tier 1 equation:

$$_{CO2} = AD * \quad F$$

Where:

E_{CO_2} = emissions of carbon dioxide in tonnes
AD = activity data on metallurgical coke consumption
EF = CO_2 emission factor.

Collection of activity data

AD on the amount of metallurgical coke is directly obtained from the producer on an annual basis by a questionnaire. Both amount of carbide produced and amount of raw material used as metallurgical coke data are obtained. However emissions are calculated by using the raw material consumption data. The plant does not report information on the use of CaC_2 in acetylene production for welding application, however most of the customers of carbide are purchasing for acetylene production. Therefore it is assumed that all of the carbide produced by Eti Metalurji is used for acetylene production for all the time series.

Confidential production data are provided relative to 1990, along with CO_2 emissions from calcium carbide production as can be seen in the table below.

Table 4.27 Calcium carbide production and CO_2 emissions, 1990-2015

Years	Calcium Carpide Production (1990=100)	CO_2 Emissions (kt)
1990	100.0	83.3
1991	51.2	42.7
1992	65.3	54.4
1993	37.5	31.3
1994	46.3	38.6
1995	24.2	20.2
1996	40.6	33.8
1997	37.7	31.4
1998	56.3	46.9
1999	40.7	33.9
2000	43.3	36.1
2001	33.8	28.2
2002	25.7	21.4
2003	34.3	28.5
2004	40.6	33.8
2005	27.1	22.6
2006	29.4	24.5
2007	50.5	42.1
2008	11.9	10.0
2009	29.4	24.5
2010	19.8	16.5
2011	28.0	23.3
2012	28.8	24.0
2013	27.4	22.9
2014	25.9	21.6
2015	13.9	11.6

Choice of emission factor

Due to confidentiality the emission factor of the carbide production cannot be revealed.

Uncertainties and Time-Series Consistency:

The greatest contributor to the uncertainty is that the assumption made upon all of the carbide is used for producing acetylene gas. Depending on the expert judgment the uncertainty value of the EF is taken ±20% while the default uncertainty value of the activity data is taken as 5% consistent with the 2006 IPCC Guidelines. (Volume 3 Page 3.45)

Source-Specific QA/QC and Verification:

Plant-specific production data are compared with national statistics data available from PRODCOM (Turkey's National Industrial Production Statistics). National statistics were available only for the 2009-2014. For the year 2014, the data are found to be different as much as 2% from each other whereas in the other years there found to be no difference.

Recalculation

In this inventory report the calcium carbide emission factor is revised due to the assumption that all the produced carbide is used for acetylene production. Moreover in this submission, calcium carbide production data is used as the activity data instead of raw material consumption data.

Table 4.28 Comparison on calcium carbide acid production emissions recalculation in the 2016 and 2017 inventory submissions

Years	Emissions from carbide production in 2016 submission report (kt)	Emissions from carbide production in 2017 submission report (kt)	Difference in emissions (kt)	Percental change (%)
1990	58	83	25	43.4
1992	31	43	12	39.1
1992	37	54	18	47.8
1993	21	31	10	50.3
1994	27	39	12	44.2
1995	14	20	6	41.4
1996	24	34	10	39.6
1997	22	31	9	39.8
1998	33	47	14	43.2
1999	23	34	11	45.1
2000	25	36	11	44.6
2001	20	28	8	41.6
2002	15	21	6	41.4
2003	21	29	7	34.4
2004	28	34	6	21.0
2005	19	23	4	19.4
2006	18	24	6	33.7
2007	31	42	11	37.2
2008	8	10	2	19.3
2009	18	24	7	37.2
2010	12	16	4	33.8
2011	17	23	7	39.1
2012	17	24	7	41.9
2013	16	23	7	44.4
2014	15	22	6	39.2

Planned Improvements

No further improvements are planned at this time.

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

There is no titanium dioxide production in Turkey during the period 1990-2015.

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.

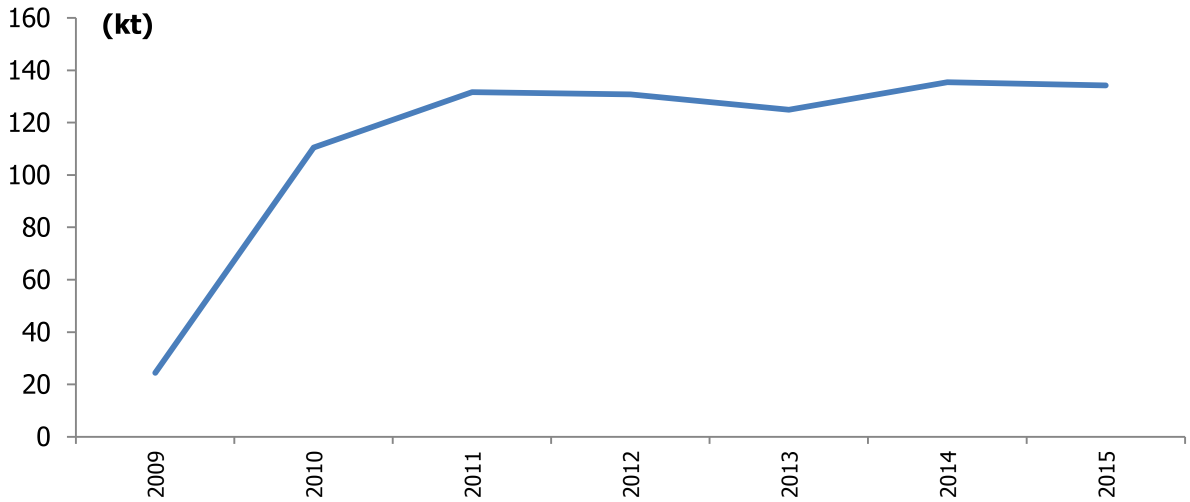
Emissions of CO_2 from the production of soda ash vary substantially with the manufacturing process. Four different processes may be used commercially to produce soda ash. Three of these processes, monohydrate, sodium sesquicarbonate (trona) and direct carbonation, are referred to as natural processes. 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.

There are two soda ash plants in Turkey. One of these plants produces soda ash by utilizing trona and began operation in 2009, while the other produce synthetic soda ash (solvay process) and began operation in 1969.

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 during calcination of limestone. 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.

Soda ash production by utilizing trona started in 2009 while emissions from soda ash production using the solvay process are not estimated due to the carbon neutral characteristic of the process. Therefore; for the years 1990-2008, emissive soda ash production is reported as not occurring. In the figure below you can see the trend of the CO_2 emissions from soda ash productions. In the year 2009 a small amount of CO_2 emitted due to plant was not working full capacity due to start up. In 2015 134 kilotons of CO_2 emitted from soda ash production remaining almost same with respect to 2014.

Figure 4.13 CO_2 emissions resulting from soda ash production 2009-2015



Methodological Issues:

The natural production process of soda ash results in CO_2 emissions. Turkey applies a Tier 2 method, for this non-key category, quantifying emissions based on the plant-specific activity data and emission factor, and using the following formula:

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

Where:
E_{CO2} = emissions of carbon dioxide in tonnes
AD = quantity of trona used in tonnes
EF = emission factor per unit of trona input

Collection of activity Data

The amount of trona utilized is the AD and it was directly taken from the plant. Data are acquired on a yearly basis based on a questionnaire sent to the plant. The plant mines the trona by solving it underwater and then pumps it into the process. The amount of solution pumped and its purity is known by the plant. Therefore the amount of trona utilized is calculated and reported by the plant.

Choice of emission Factor

The EF is confidential. The EF was held constant over the time series.

The production trend and emissions can be seen from the table below.

Table 4.29 Soda ash production and CO_2 emissions, 1990-2015

Year	Soda ash production by utilizing Trona (2009=100)	CO_2 Emissions (kt)
1990-2008	NO	NO
2009	100	24
2010	451	110
2011	538	132
2012	535	131
2013	511	125
2014	554	135
2015	549	134

Uncertainties and Time-Series Consistency:

Turkey assumes that the uncertainty of the EF is 1% and the uncertainty of the AD is ±5% in consistent with the 2006 IPCC Guidelines (2006 IPCC Guidelines, Volume 3 page 3.55).

Source-Specific QA/QC and Verification:

Soda Sanayi.A.Ş. produces soda ash by solvay process. On the PRODCOM (national industrial production statistics) its soda ash production data is available since 2006. PRODCOM data and plant specific data are compared and found consistent. On the other hand Eti Soda produces soda ash by utilizing trona. On the PRODCOM its trona mining data is available since 2009. PRODCOM data and plant specific data are compared and found consistent.

Recalculation:

There is no recalculation for this year's inventory.

Planned Improvements

No further improvements are planned at this time.

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. There is a single petrochemical producer in Turkey and the company name is PETKİM. However carbon black production unit is closed and Turkey do not produce carbon black since 2001. There is also no primary methanol production in Turkey. There is only some secondary production of methanol which is not causing IPPU category greenhouse gas.

The figures below show the trend in CO_2 emissions from the petrochemicals production industry between 1990 and 2015. Emissions from ethylene production contribute most to this category as can be seen from the tables 4.33. Total CO_2 emissions from petrochemicals industry was 838 kilotons in 1990 and it is 1 086 kilotons in 2015. The increase is mainly due to the increased amount of ethylene production of Turkey. The fluctuations in the production are closely related with the petroleum prices and demand.

Figure 4.14 Trend in total CO_2 emissions from petrochemicals

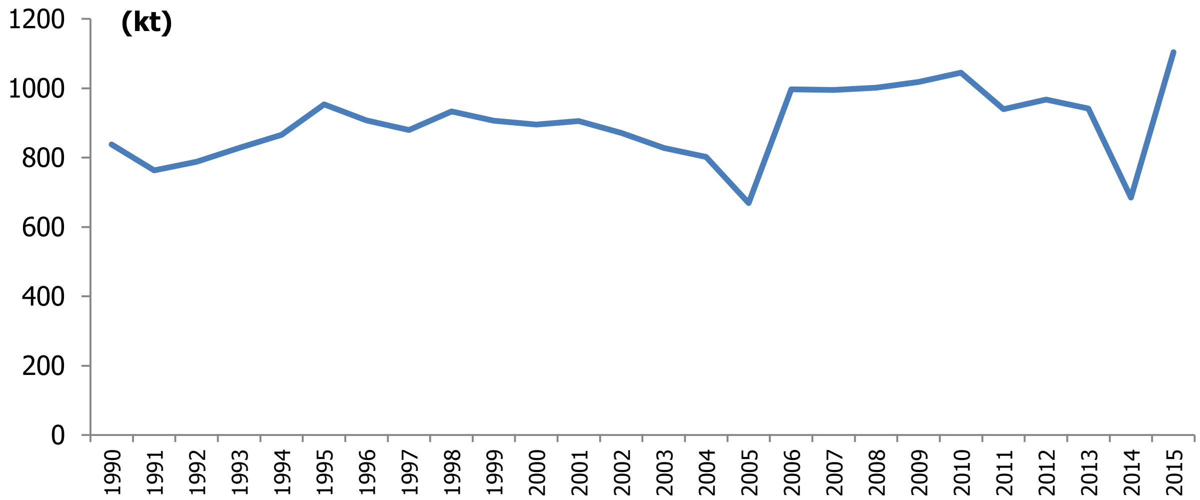


Table 4.30 CO_2 emissions from each petrochemical production, 1990-2015

Years	Ethylene (kt)	Vinyl Chloride Monomer (kt)	Acrylonitrile (kt)	Carbon Black (kt)
1990	645	45	68	80
1991	588	38	52	84
1992	586	47	64	91
1993	615	46	75	91
1994	659	44	89	73
1995	712	51	86	105
1996	679	53	83	92
1997	658	50	70	102
1998	697	52	79	105
1999	710	49	78	69
2000	683	43	77	92
2001	691	56	88	71
2002	724	56	91	0
2003	686	58	84	0
2004	651	63	88	0
2005	544	54	71	0
2006	848	58	91	0
2007	841	62	92	0
2008	857	55	90	0
2009	867	59	94	0
2010	887	64	94	0
2011	785	57	98	0
2012	811	61	95	0
2013	801	53	88	0
2014	568	42	75	0
2015	966	53	86	0

Although there is some amount of methane emissions from petrochemicals production, the amount is so small that it is not figured or tabulated in this report. However it is covered in the CRF reporting tables.

Methodological Issues:

CO_2 emissions are calculated from each petrochemical process following the Tier 1 method, multiplying the AD for production of each petrochemical and the process-specific EF for each petrochemical.

$$_{CO2} = PP * EF$$

Where:
E_{CO2}= CO_2 emissions from production of petrochemical in tonnes
PP_i= annual production of petrochemical in tonnes
EF= CO_2 emission factor for petrochemical in tonnes CO_2 / tonne product produced

CH_4 emissions from each petrochemical process are calculated by Tier 1 method which is multiplying the production amount of each petrochemical and the process-specific EF of each petrochemical.

$$_{CH4} = PP * EF$$

Where:
E_{CH4} = CH_4 emissions from production of petrochemical in tonnes
PP= annual production of petrochemical in tonnes
EF= CH_4 emission factor for petrochemical in tonnes CH_4 / tone product produced

Collection of activity data

In Turkey, there is a single producer of petrochemicals. This producer announces its production amount yearly on their website. Therefore the petrochemicals production data of the recent years are gathered from the activity reports of the company. However the earlier years are not covered in the website so a questionnaire was sent to the company and production amount of the petrochemicals since 1990 were asked and by this way data were collected. The production data for each petrochemical are tabulated in the table below.

Table 4.31 Petrochemicals and carbon black production, 1990-2015

Years	Ethylene (kt)	Vinyl Chloride Monomer (kt)	Acrylonitrile (kt)	Carbon Black (kt)
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	35
1997	380	110	70	39
1998	403	113	79	40
1999	411	108	78	26
2000	395	105	77	35
2001	400	117	88	27
2002	419	117	91	0
2003	396	127	84	0
2004	376	140	88	0
2005	314	120	71	0
2006	490	128	91	0
2007	486	144	92	0
2008	495	118	90	0
2009	501	132	94	0
2010	513	142	94	0
2011	454	129	98	0
2012	469	140	95	0
2013	463	118	88	0
2014	328	91	75	0
2015	558	119	86	0

Choice of emission factor

The tier 1 emission factors are used for the calculations. According to the 2006 IPCC Guidelines, Tier 1 petrochemical production emission factors depend on the process type and feedstock utilized. Ethylene is produced from naphta, so its CO_2 emission factor is 1.73 tone CO_2/tone product. Vinyl Chloride Monomer is produced by the direct chlorination process and its emission factor is 0.286 tone CO_2/tone product. During acrylonitrile production secondary products are flared, therefore its emission factor is 1.00 tone CO_2/tone product. For the carbon black production the default emission factor of 2.62 tone CO_2/tone product is used. CH_4 emission factors are also chosen accordingly. The table below summarizes the emission factors used in the calculation of petrochemical production process emissions.

Table 4.32 The emission factors used in the calculations, 1990-2015

Units	Ethylene	Vinyl Chloride Monomer	Acrylonitrile	Carbon Black
ton CO_2/ton product	1.730	0.286	1.000	2.620
kg CH_4/ton product	3.000	0.0226	0.180	0.060

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 3.27 in the 2006 IPCC Guidelines, Volume 3.

Source-Specific QA/QC and Verification:

The activity data are gathered from the activity reports of PETKİM. PETKİM is a company that its shares are traded at the exchange and its activity reports are shared to the public. Therefore the activity reports of PETKİM are reliable as data source. Moreover for this year a questionnaire was sent to the PETKİM and all the production data between 1990 and 2015 were gathered. Besides that the Turkstat's industrial productions statistics (PRODCOM) also reveals the production data of the petrochemicals since 2005. When compared, PRODCOM statistics also confirms the activity data of PETKİM.

Recalculation:

Previously PRODCOM data were used as the activity data of carbon black production. However in this report the production data is asked to PETKİM and emissions are calculated by using the PETKİM data. The next table below compares the emissions from the carbon black with the previous report.

Table 4.33 Comparison on carbon black production emissions recalculation in the 2016 and 2017 inventory submissions

Years	Emissions from carbon black production in 2016 submission (kt CO_2)	Emissions from carbon black production in 2017 submission (kt CO_2)	Difference in emissions (kt CO_2)	Percental change (%)
1990	80.1	80.1	0.0	0.0
1991	84.4	84.4	0.0	0.0
1992	91.2	91.2	0.0	0.0
1993	91.4	91.4	0.0	0.0
1994	73.3	73.3	0.0	0.0
1995	104.7	104.7	0.0	0.0
1996	102.9	91.9	-11.0	-10.7
1997	102.3	102.3	0.0	0.0
1998	104.7	104.8	0.1	0.1
1999	69.1	69.2	0.1	0.2
2000	92.1	91.9	-0.2	-0.2
2001	88.7	70.9	-17.9	-20.1
2002	97.8	0.0	-97.8	NA
2003	102.9	0.0	-102.9	NA
2004	67.9	0.0	-67.9	NA
2005	70.3	0.0	-70.3	NA
2006	135.7	0.0	-135.7	NA
2007	105.8	0.0	-105.8	NA
2008	52.1	0.0	-52.1	NA
2009	3.6	0.0	-3.6	NA
2010	0.0	0.0	0.0	0.0
2011	53.0	0.0	-53.0	NA
2012	55.8	0.0	-55.8	NA
2013	73.8	0.0	-73.8	NA
2014	79.0	0.0	-79.0	NA

Besides that VCM emissions are also recalculated in this inventory report. Previously the default emission factor of 0.294 was used for VCM production. In this inventory report PETKİM informed that VCM is produced by direct chlorination process. Therefore 0.286 is used as the emission factor. As a result IPPU emissions from VCM production decreased 3% in all the time series.

Planned Improvements

Recently Turkey started to use the activity data of the manufacturer instead of national statistics. Beside that emission factors are selected according to the process type and the feedstock utilized instead of using default values. Moreover a site visit was made to PETKİM in 2017 and its emission sources were discussed with plant operators and information about the chemical processes of the plant were gathered. In the next years it is planned to calculate CO_2 emissions by gathering the flaring data. The producer will be asked for the necessary activity data required.

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

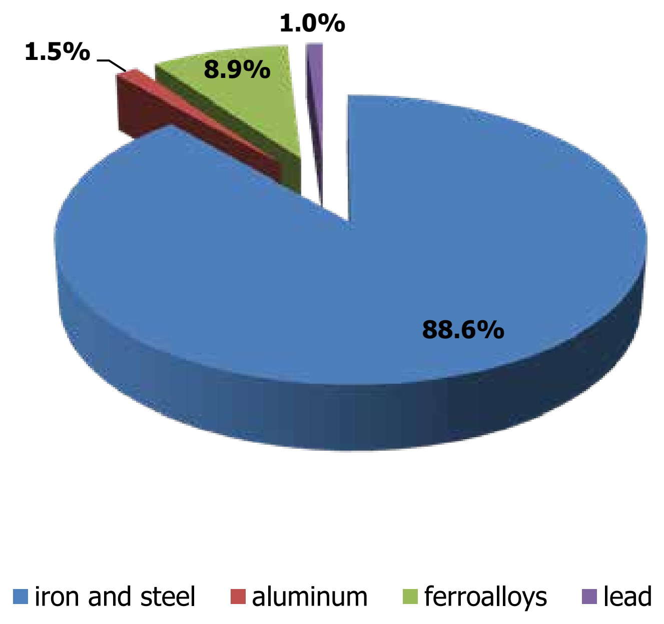
There is no fluorochemical production in Turkey during the period 1990-2015.

4.4. Metal Industry (Category 2.C)

In 2015, the metal industry was responsible for 11 789 kt CO_2eq, 19.4% of total emissions from the industrial processes and product use sector. The vast majority of emissions in the metal industry (97.3%) are from iron and steel production. Aluminum production was responsible for 195 kt CO_2eq, 1.7% of metal emissions, and ferroalloys production 118 kt CO_2eq, 1.0 % of metal emissions. Lead production was responsible for 8.6 kt CO_2eq contributed 0.07% of sector emissions (see Figure 4.15). Zinc was produced in Turkey till 1999, however zinc has not been produced since.

Between 1990 (7 278 kt CO_2eq) and 2015, emissions from the metal industry increased by 62%, again driven in large part by the iron and steel industry, which nearly doubled its emissions during the time period, from 6 379 kt CO_2eq in 1990 to 11 467 kt CO_2eq in 2015. This increase in emissions was partially offset by the elimination of PFC emissions in aluminium production (PFC emissions were 693 kt CO_2eq in 1990). There is no magnesium production in Turkey.

Figure 4.15 Emissions from metal industry, 2015



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

Source Category Description:

Iron and steel production processes result in CO_2 and CH_4 emissions to be covered under the IPPU category since carbon is used in the reduction process of iron oxides.

In Turkey currently there are three integrated iron and steel production plants. These facilities include sinter production units, blast furnaces for pig iron production, and basic oxygen furnaces. Besides these plants, there are electric arc furnace mills operating in Turkey. However there is no direct reduced iron (DRI) production in Turkey. Emissions from the combustion of carbon containing fuels (i.e natural gas, fuel oil) for energy purposes are included in the energy chapter of this report.

The integrated steel production plants demand iron ore. These plants meet their need from both domestic and foreign markets. In Turkey there is currently one plant producing pellet iron in order to supply the iron ore demand of the integrated steel plants.

Blast furnace units for pig iron production are the most emissive units among the iron and steel production processes. Iron oxide reduces into iron metal when reacted with carbon monoxide in the blast furnaces as shown in the reactions represented in equations below.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

$$3\ Fe_2O_3(s) + CO(g) \rightarrow 2\ Fe_3O_4(s) + CO_2(g)$$

$$Fe_3O_4(s) + CO(g) \rightarrow 3\ FeO(s) + CO_2(g)$$

Carbon monoxide is generated in the blast furnace from the carbon containing fuels (mainly coke) as can be seen in equation below. Coke both supplies the necessary carbon for the reduction reactions as well the heat needed for melting the iron and the impurities. Besides, coke provides mechanical strength for the blast furnace burden.

$$2\ C(s) + O_2(g) \rightarrow 2\ CO(g)$$

Limestone is also used in the blast furnaces for removing acidic impurities from the ore. When limestone is heated up to region of 1500 °C it releases carbon dioxide and left as CaO by the reaction shown in equation below. Then CaO reacts with the acidic impurities and deposits at the bottom of the blast furnace.

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

Sinter production is also an emissive process within the iron and steel industry. Sinter plants in Turkey are within the integrated steel plants. Sintering is a heat treatment process that agglomerates iron ore fines and metallurgical wastes (ie. collected dusts, sludge) into larger, stronger and porous particles necessary for blast furnaces charging. The sintering process involves the heating of iron ore fines by burning coke fines to produce a semi-molten mass that solidifies into porous pieces of sinter. Coke gas is usually used to ignite the sinter blend. This process also involves reduction of some iron oxides into iron metal within the iron ore fines. Therefore the same reactions given above for the reduction of iron oxides also works for the sintering process and causes CO_2 release. During the sintering process high temperatures are achieved and limestone is calcined and releasing CO_2 emissions.

Basic Oxygen Furnaces (BOF) are also a part of the integrated steel plants. BOF processes the product of the blast furnace which is molten iron to produce steel. The BOF process also emits CO_2. The process involves oxygen blowing into the molten iron and stirring it. The oxygen reacts with impurities to purify molten iron and also reacts with dissolved carbon leaving as CO_2. This process converts iron into steel.

Electric Arc Furnaces (EAF) is another process unit for producing steel. Unlike BOF, only scrap iron and steel is used in the EAF to produce steel. The scrap metal is melted using high voltage electric arcs. There would be iron oxides in the feed of the EAF. Therefore these iron oxides should be reduced to iron with the same reactions given above that cause CO_2 emissions. Metallurgical coke, petroleum coke, graffite, antrasite, carbon granules and natural gas may be used as the carbon source. Besides that oxygen is blown into the molten steel in order to remove excess carbon and other impurities and to improve steel quality. This process step also release CO_2 emissions due to reaction of oxygen and carbon.

Iron and steel production is classified as heavy industry and it requires vast amount of energy. All of the integrated steel plants in Turkey recycle exhaust gases of the Blast Furnaces and Basic Oxygen Furnaces to meet up their energy requirement. These gases are collected and burnt in order to heat up the coke ovens, produce the high pressure steam requirement of the plant, pre heat the blast furnace air, produce electricity, heat up the rolls and for other small issues. Their emissions are covered in the energy sector of this report. Besides, integrated iron and steel production plants produce lime for their own consumption and lime production also causes CO_2 emission and it is covered in lime production part of IPPU. Table below shows allocation of iron and steel production emissions in the CRF categories.

Table 4.34 Categorical allocation of emissions from iron and steel productions in Turkey

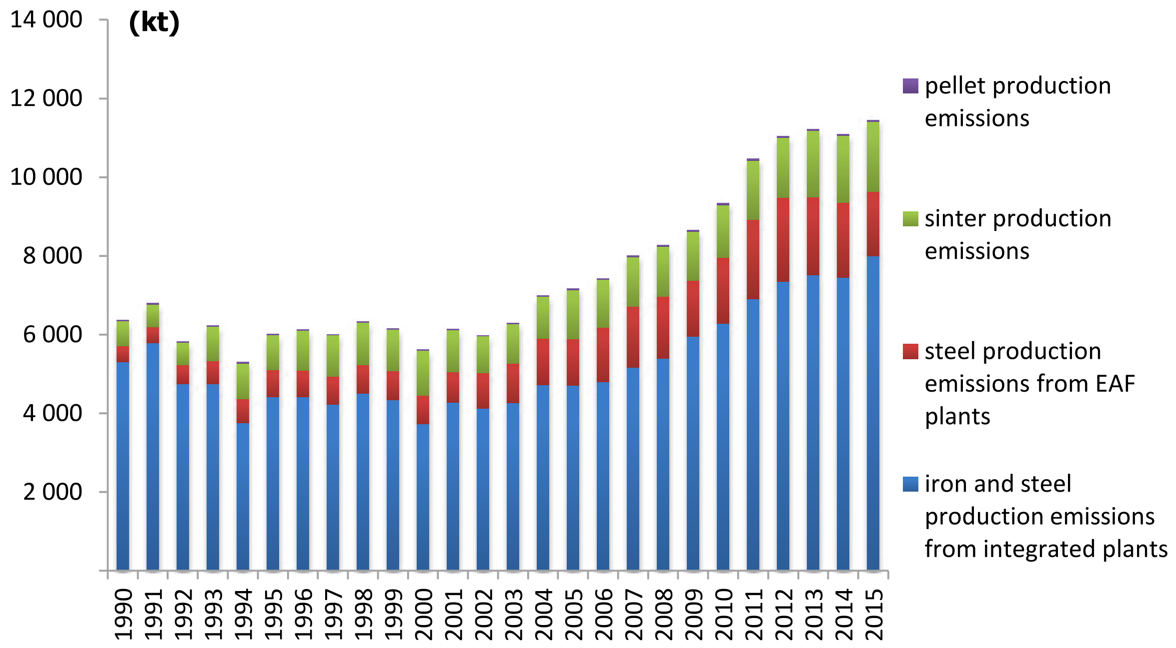
CRF category	Emission source
CRF 1.A.1a	Public electricity and heat production
CRF 1.A.1c	Emissions from fuels used in coking plants (coke oven gas and BF gases)
CRF 1.A.2a	Emissions from fuels used in iron and steel plants' processes and power plants
CRF 2.A.2	Process emissions from lime production in iron and steel plant
CRF 2.C.1	Process emissions from iron and steel production

In Turkey there are currently 3 integrated iron and steel plants and numerous electric arc furnaces mills operating. The table below presents 2.C.1 category CO_2 emissions between 1990 and 2015, and figure 4.16 shows the 2.C.1 category CO_2 emissions cumulatively revealing the emissions trend in the iron and steel production.

Table 4.35 CO_2 emissions allocations in 2015 in iron and steel production (2.C.1 category)

Year	Emissions from Iron and Steel Production (integrated plants) (kt)	Emissions from Steel Production (EAF plants) (kt)	Emissions from sinter production (kt)	Emissions from pellet production (kt)	Total emissions in 2.C.1 CRF category (kt)
1990	5 311	396	633	31	6 940
1991	5 792	399	578	30	7 319
1992	4 742	489	566	29	6 422
1993	4 752	583	868	30	6 726
1994	3 752	614	906	31	5 766
1995	4 417	680	889	26	6 254
1996	4 423	667	1 009	28	6 639
1997	4 226	713	1 048	22	6 541
1998	4 507	719	1 075	26	6 926
1999	4 345	734	1 046	26	6 651
2000	3 728	728	1 136	28	5 945
2001	4 272	776	1 066	26	6 637
2002	4 119	907	936	23	6 347
2003	4 263	1 004	1 006	23	6 774
2004	4 728	1 172	1 066	23	7 495
2005	4 704	1 188	1 244	34	7 635
2006	4 803	1 380	1 213	34	7 906
2007	5 172	1 549	1 250	39	8 474
2008	5 392	1 582	1 270	34	8 874
2009	5 959	1 419	1 242	41	9 333
2010	6 284	1 672	1 340	45	10 051
2011	6 899	2 022	1 502	45	11 511
2012	7 352	2 125	1 525	46	12 147
2013	7 512	1 978	1 688	44	12 546
2014	7 451	1 900	1 701	47	12 080
2015	7 993	1 639	1 774	46	12 488

Figure 4.16 CO_2 emissions allocations within the 2.C.1 CRF category, 2015



CO_2 emissions from iron and steel production in 2015 was 12.5 million ton and it increased by 80% since 1990. Beginning by the year 2000 steel production in Turkey have increased and Turkey became the world's 8th biggest crude steel producer reaching 31.7 million tons by 2015, it was 17th by 2000. However in 2015 steel production was decreased by 7 % due to reduction in domestic demand which was a result of the economy's loosing acceleration. Turkey's steel production capacity is over 50 million tons. Hence depending on both the domestic and the foreign demand, Turkey's steel production may increase in the next years.

Methodological Issues:

For the calculation of CO_2 emissions from iron and steel production and sinter production in the integrated plants, the 2006 IPCC Tier 3 method is used.

The Tier 3 methodology equation for calculating CO_2 emissions from pig iron production and sinter production in the integrated plants is as follows:

$$CO2 = \left[\sum_a (Q_a \times C_a) - \sum_b (Q_b \times C_b)\right] \times \frac{44}{12}$$

where;

$CO2 \quad = \quad Emissions\ from\ pig\ iron\ or\ sinter$

$= \quad Input\ materi\ \ l\ a$
$b \quad = \quad Output\ material\ b$
$Q_a \quad = \quad Quantity\ of\ input\ materi\ \ l\ a$
$C_a \quad = \quad Carbon\ content\ of\ materi\ \ l\ a$
$Q_b \quad = \quad Quantity\ of\ output\ material\ b$
$C_b \quad = \quad Carbon\ content\ of\ materi\ \ l\ b$
$44/12 \quad = \quad Stoichiometric\ ratio\ of\ CO_2 to\ C$

For the calculation of CO_2 emissions from pellet production, the 2006 IPCC Tier 1 method is used where total amount of pellet produced is multiplied with the emission factor.

$$E_{CO2} = P \times EF_P$$

where;
$E_{CO2} \quad = \quad Emissions\ from\ pig\ iron\ or\ sinter$
$P \quad = \quad Total\ pellet\ produced$
$EFp \quad = \quad Emission\ factor\ of\ pellet\ production$

CO_2 emissions from steel production in EAFs are calculated by applying the Tier 1 method which is the multiplication of aggregated EAF steel production data with the default emission factor. The equation is given below:

$$\mathrm{E_{CO2} = EAF \times EF_{EAF}}$$

where;
$E_{CO2} \quad = \quad Emissions\ from\ pig\ iron\ or\ sinter$
$EAF \quad = \quad Total\ steel\ produced\ in\ the\ EAFs$
$EF_{EAF} \quad = \quad Default\ emission\ factor\ for\ the\ EAF\ steel\ production$

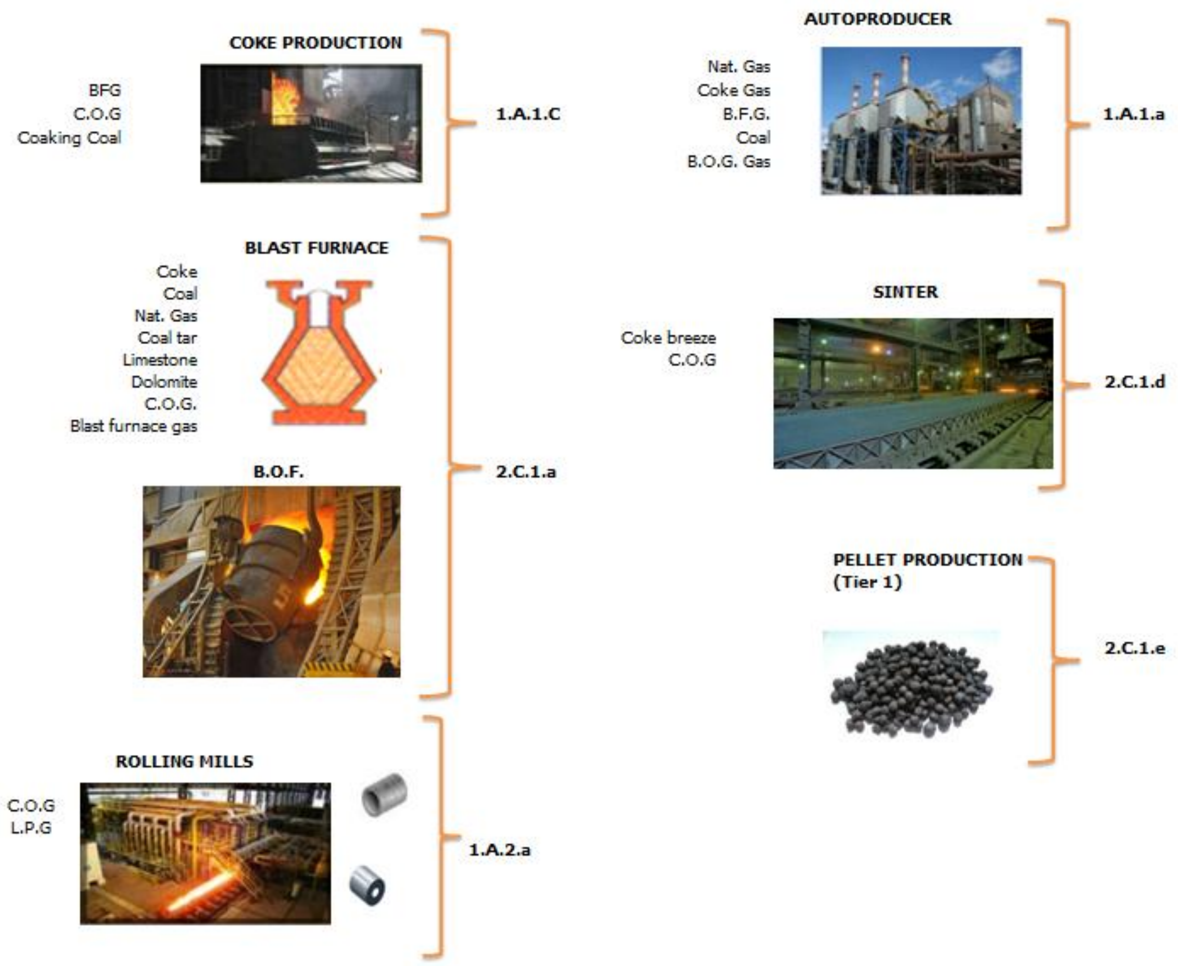
The CH_4 emissions from sinter production are also calculated using Tier 1 methodology. This is multiplication of the production data with the default emission factor as suggested in the 2006 IPCC Guidelines, the equations are shown below.

$$\mathrm{E_{CH4} = SI \times EF_{si}}$$

In Turkey almost all of the by-product gases are collected and burnt for energy recovery. Therefore it is assumed that no methane is emitted due to the pig iron production under 2C1 CRF category.

Figure 4.17 shows the allocations of the emissions from integrated iron and steel plants between Energy and IPPU sectors.

Figure 4.17 Allocations of the emissions from integrated iron and steel plants



Collection of activity data

To estimate CO_2 and CH_4 emissions at integrated facilities, Turkey collects activity data via annual basis questionnaire from each of the three facilities. All the solid materials are weighted by scales whereas gaseous materials are measured by flowmeters and the annual values are calculated by a computer programmed totalizer.

Pellet is produced by a single company beside an iron mine in Turkey. The activity data is obtained from this company.

The quantity data of crude steel produced at electric arc furnaces is obtained from Turkish Steel Producers Association by an annual basis questionnaire.

Each of the integrated facility keeps an energy balance table where all the fuel consumptions and generations are recorded annually. These tables are the main data source for the fuel consumptions. The consumption of non fuel materials, (eg. limestone, dolomite), are asked by a questionnaire.

Sinter, pellet production and steel production by plant type are included in the table below.

Table 4.36 Sinter production, pellet production and iron & steel production by plant type, 1990-2015

(kt)

Year	Total pellet production	Total sinter production	Steel production (BOF)	Steel production (EAF)	Total steel production
1990	1 032	4 507	4 431	4 955	9 386
1991	1 000	4 240	4 360	4 991	9 351
1992	963	4 451	4 096	6 110	10 206
1993	1 004	4 462	4 150	7 283	11 433
1994	1 043	4 496	4 429	7 680	12 109
1995	855	4 285	4 695	8 501	13 196
1996	935	4 620	5 095	8 337	13 432
1997	744	4 866	5 450	8 918	14 368
1998	878	4 592	5 259	8 992	14 251
1999	852	4 335	5 271	9 171	14 442
2000	948	5 007	5 372	9 096	14 468
2001	857	4 750	5 400	9 703	15 104
2002	754	4 237	5 274	11 334	16 608
2003	776	4 639	5 903	12 546	18 449
2004	776	4 756	6 003	14 646	20 649
2005	1 120	5 355	6 254	14 847	21 101
2006	1 135	5 032	6 300	17 252	23 553
2007	1 292	5 243	6 512	19 362	25 874
2008	1 118	5 437	7 180	19 771	26 951
2009	1 371	5 131	7 717	17 741	25 458
2010	1 493	5 845	8 444	20 905	29 349
2011	1 495	6 361	9 023	25 275	34 298
2012	1 543	7 356	9 500	26 560	36 059
2013	1 480	7 617	10 111	24 723	34 834
2014	1 550	7 928	10 483	23 752	34 235
2015	1 547	8 567	11 215	20 482	31 697

Choice of emission factor

To estimate CO_2 emissions from integrated facilities, Turkey collects any available plant-specific data on carbon content for integrated facilities and for the remaining materials the material-specific carbon content values from Table 4.3 of the 2006 IPCC Guidelines are applied for the entire time series. To determine carbon content, the facilities make laboratory analysis for the product iron and steel, for the process gases and for the coals used in the plant.

To estimate CO_2 emissions from electric arc furnaces, Turkey applies the default emission factor from the 2006 IPCC Guidelines (0.08 t CO_2 / t steel) for the entire time series.

To estimate CO_2 emissions from pellet production, Turkey uses the default emission factor from the 2006 IPCC Guidelines (0.03 t CO_2 / t pellet) for the entire time series.

To estimate CH_4 emissions from sinter production, Turkey applies the default emission factor of 0.07 kg CH_4 / t sinter.

Carbon contents and emission factors are provided in the table below for 2015 for the integrated facilities.

Table 4.37 Emission factors

CO_2 EFs	IPCC default EF
EAFs	0.08 t/t steel
Pellet production	0.03 t/t pellet

CH_4 EFs	IPCC default EF
Sinter production	0.07 kg/t sinter

Uncertainties and Time-Series Consistency:

Uncertainties for the activity data and the emission factors are estimated to be 10% and 25%, respectively. Because especially the activity data and the emission factors regarding the process gases (coke oven gas, blast furnace gas, oxygen steel furnace gas) are quite uncertain.

Source-Specific QA/QC and Verification:

There are three integrated iron and steel plants in Turkey and plant specific data are gathered from these plants. These integrated steel plants were built as public economic enterprises and all of them are privatized until 2006. Due to significant improvements on data recording after privatization, the integrated steel plants data are reliable after 2006. The integrated steel plants have similar steel production techniques therefore their data can be compared to each other. Coke consumed/steel produced, coke breeze consumed/sinter produced ratios are compared to each other in order to identify potential inconsistencies and reporting errors. Moreover Turkish inventory team had site visits and held meetings with experts from the field on integrated steel plants in 2016. Through the site visits and the meetings, processes and data reporting issues are discussed in order to identify potential inconsistencies and reporting errors. Moreover this year a carbon mass balance is done over each of the three integrated plant by considering all carbon containing material input and output to the factories. So that the total emissions (both IPPU and Energy) of the three plants are calculated. Then it is compared with the summation of the each emission categories (1A.1a, 1A1c, 1A2a, and 2C1) for iron and steel production. The comparison result is given in the below.

Emissions calculated by carbon mass balance over integrated plants = 22 137 ktons

Summed up emissions for each CRF category for integrated plants = 21 958 ktons

Percentage of equivalence = 99%

Note that the lime production in the integrated plants is not covered in this equivalence checking and has no effect on the comparision.

The percentage of equivalence is very close to perfect when the data of the three integrated plants are aggregated together, however the plants have a percentage of equivalence varying 92% to 107%. The percentage of equivalence shows that the calculated emissions are reliable, but still it can be improved as discussed in the planned improvements.

Recalculations:

This year, integrated facilities have begun to provide their energy balance tables which are more reliable sources of data. The tables go back to 5-10 years at most. Therefore the earlier years were adjusted with the previous data set accordingly. Moreover this year it is realized that the steel furnace gas is double counted in the both IPPU and Energy sectors. The steel furnace gas emissions are deducted from the IPPU category since all the steel furnace gas is recovered and used for heat production. In addition this year emissions from the pellet production are calculated for the first time. Despite a major recalculation is made in the integrated iron and steel facilities, no recalculation is made for the EAF steel production plants. The table below shows the comparison of total iron and steel production sector emissions calculated in 2016 and in 2017 submissions.

Table 4.38 Comparison on iron and steel production emissions recalculation in the 2016 and 2017 inventory submissions

Years	Iron and steel production emissions in 2016 submission (kt CO_2)	Iron and steel production emissions in 2017 submission (kt CO_2)	Difference in emissions (kt CO_2)	Percental change (%)
1990	5 304	6 371	1 067	20.1
1991	5 335	6 799	1 464	27.4
1992	5 120	5 826	705	13.8
1993	5 448	6 233	786	14.4
1994	5 126	5 304	178	3.5
1995	5 132	6 011	879	17.1
1996	5 707	6 128	421	7.4
1997	5 856	6 010	154	2.6
1998	6 096	6 328	233	3.8
1999	5 941	6 150	209	3.5
2000	5 668	5 620	-47	-0.8
2001	6 031	6 141	109	1.8
2002	5 926	5 984	58	1.0
2003	6 514	6 296	-218	-3.3
2004	7 054	6 989	-65	-0.9
2005	7 496	7 170	-327	-4.4
2006	8 115	7 430	-685	-8.4
2007	8 257	8 009	-247	-3.0
2008	7 786	8 277	490	6.3
2009	9 215	8 661	-554	-6.0
2010	10 462	9 341	-1 120	-10.7
2011	11 911	10 468	-1 442	-12.1
2012	12 644	11 049	-1 595	-12.6
2013	12 678	11 223	-1 455	-11.5
2014	11 819	11 099	-720	-6.1

Planned Improvements:

Two site visits are done to two of the integrated iron and steel plants of Turkey during 2016. Turkey investigated further how the activity data are collected on the site and gathered additional information from experts from the field on uncertainties. Also, as an extension to the improvement made in the 2016 inventory submission to remove double counting of the carbon contained in blast furnace gas, the double counting of the carbon in basic oxygen furnace gas is corrected. Like with blast furnace gas, emissions from the basic oxygen furnace are collected and sent offsite for combustion in a utility. The quality control activity of comparing the emissions calculated by general carbon mass balance and the emissions calculated by the summation of the each emission categories (1A.1a, 1A1c, 1A2a, and 2C1) for iron and steel production, revealed us that there would be potential errors in the calculations. Upon discussing with plant operators, it is understood that the data providers may provide the coal consumption data either in dry basis or wet basis and this should be clarified. Secondly, the lime and limestone terms may be interchangeably used by the data providers and this should be clarified.

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

Source Category Description:

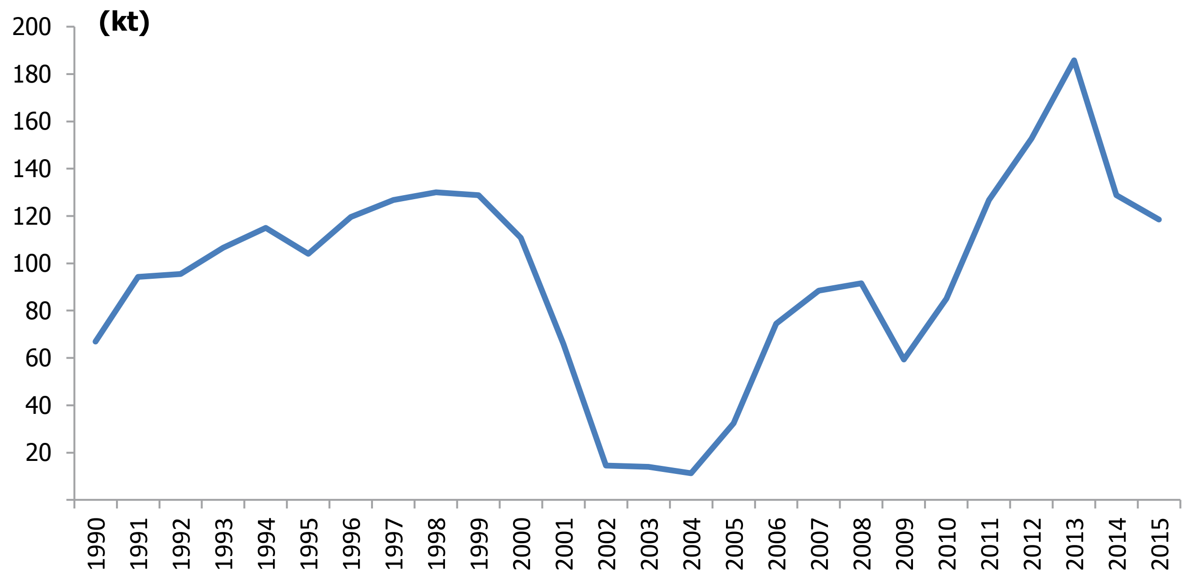
Ferroalloy is the term used to describe concentrated alloys of iron and one or more metals such as silicon, manganese, chromium, molybdenum, vanadium and tungsten. Silicon metal production is usually included in the ferroalloy group because silicon metal production process is quite similar to the ferrosilicon 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 electronics. Ferroalloy production involves a metallurgical reduction process that results in significant CO_2 emissions. In Turkey there are currently two ferrochrom producer. These two producer are using electric arc furnaces to melt scrap iron and chromite ore in the pot. Some metalurgical coke is added in the pot to reduce chromite and produce ferrochrom.

Between 2011 and 2014 some amount of ferrosilico manganese was also produced. However plants are closed due to the high production costs.

In this category; emissions from ferrochromium and ferrosilico manganese production are considered. Other types of ferroalloys are not produced in Turkey on industrial scale.

Although Turkey is rich in terms of chrome mines, ferrochrome production is relatively low. This is due to high prices of energy in Turkey. CO_2 emissions from ferroalloys production are driven by mainly ferrochrom production which is strongly depended on the energy prices. There was a decline in emissions between 1999 (129 kt CO_2) and 2004 (11 kt CO_2) owing to one of the ferrochromium producers was slowed down and finally out of operation during its privatization period. CO_2 emissions generally climbed until 2008 (92 kt CO_2) with economic growth before decreasing again in 2009 (89 kt CO_2) due to global economic recession and low demand on steel. There was then a steep increase between 2009 and 2013 (186 kt CO_2, an increase in emissions of 314%) due to two new investments on production of ferrosilica manganese. However ferrosilica manganese production plants were closed in 2012 and 2013 due to high energy costs. Since then, total ferroalloy production and so the CO_2 emissions showed a decreasing trend and it was 118 kilotons in 2015.

Figure 4.18 CO_2 emissions from ferroalloys production, 1990-2015



Methodological Issues:

Turkey reports CO_2 emissions from ferroalloys production following the IPCC Tier 1 approach, as shown in equation below. Ferroalloys production is not a key category in Turkey.

CO_2 emissions from ferroalloys production

$$ {}_{CO2} = \sum_i (MP_i * EF_i) $$

where;

E_{CO2} = CO_2 emissions, tonnes

MP_i = production of ferroalloy type i, tonnes

EF_i = generic emission factor for ferroalloy type i, tonnes CO_2/tonne specific ferroalloy product

Collection of activity data

Activity data are obtained from the two ferrochrome producers by a production survey on the yearly basis by Turkstat. Both the ferro-chromium production data and the reductant agent consumption data are gathered for all the time series. The ferro silico manganese production between 2011 and 2014 is revealed by the Turkstat's PRODCOM survey which counts every industrial production in Turkey. The coke used in the ferro chromium production is deducted from the total coke consumption of Turkey in the energy sector to avoid a double counting.

Choice of emission factor

Turkey applies the default CO_2 and CH_4 emission factors from the 2006 IPCC Guidelines, as shown in table below.

Table 4.39 Ferroalloys emission factors

Ferro alloy	CO_2 EF (t CO2/t product)
Ferrochromium	1.3
Siliconmanganese	1.4

Table 4.40 Ferroalloys production and emissions, 1990-2015

Years	Total ferroalloy production (1990=100)	CO_2 emission (kt)
1990	100	67
1991	141	94
1992	143	96
1993	159	107
1994	172	115
1995	156	104
1996	179	120
1997	190	127
1998	194	130
1999	193	129
2000	166	111
2001	99	66
2002	22	15
2003	21	14
2004	17	11
2005	49	32
2006	111	74
2007	132	88
2008	137	92
2009	89	59
2010	127	85
2011	189	127
2012	224	153
2013	278	186
2014	193	129
2015	177	118

Source-Specific QA/QC and Verification:

In this inventory report the ferro alloy production data was gathered directly from the plants. Until this report Turkstat's PRODCOM data, which is the yearly industrial production survey, have been used to calculate emissions. Therefore this year the plant specific data and the PRODCOM data are compared. PRODCOM data was found to be between -4% and +8% interval compared with the totalized plant specific annual production data since 2005.

Uncertainties and Time-Series Consistency:

Since the calculations are based on default Tier 1 EFs and company derived production data, uncertainty values of EF are considered 25% and AD are 5% as recommended in Table 4.9 of 2006 IPCC Guideline.

Recalculation:

For this inventory year ferrochromium production data was gathered directly from the companies. In the previous inventories TurkStat's annual industrial production statistics, PRODCOM, data was used. Some ferroalloy shaping processes and trading data were also evaluated as ferroalloy production in the PRODCOM previously. These data were sorted out. The entire time series were recalculated using the plant specific production data. The table below shows the results of the recalculation.

Table 4.41 Comparison on ferroalloy production emissions recalculation in the 2016 and 2017 inventory submissions

Year	Emissions from ferroalloy productions in 2016 submission (kt CO_2)	Emissions from ferroalloy productions in 2017 submission (kt CO_2)	Difference in emissions (kt CO_2)	Percental difference (%)
1990	81.2	66.9	-14.3	-17.6
1991	111.4	94.3	-17.2	-15.4
1992	113.9	95.6	-18.3	-16.1
1993	117.0	106.6	-10.4	-8.9
1994	126.8	115.1	-11.8	-9.3
1995	115.1	104.0	-11.1	-9.7
1996	131.9	119.6	-12.3	-9.3
1997	140.8	126.8	-14.1	-10.0
1998	143.2	130.0	-13.2	-9.2
1999	161.1	128.8	-32.2	-20.0
2000	126.4	110.9	-15.5	-12.3
2001	66.0	66.0	0.0	0.0
2002	14.6	14.6	0.0	0.0
2003	46.0	14.0	-32.0	-69.5
2004	37.3	11.3	-26.0	-69.6
2005	36.9	32.5	-4.4	-11.9
2006	91.7	74.4	-17.2	-18.8
2007	100.6	88.5	-12.2	-12.1
2008	141.9	91.6	-50.3	-35.4
2009	56.7	59.3	2.5	4.5
2010	84.9	85.1	0.2	0.3
2011	142.8	126.8	-16.1	-11.2
2012	240.5	152.8	-87.7	-36.5
2013	191.6	185.9	-5.8	-3.0
2014	131.8	128.9	-2.9	-2.2

Planned Improvements

No further improvements are planned at this time.

4.4.3. Aluminum production (Category 2.C.3)

Source Category Description:

Turkey estimates CO_2 and PFCs (CF_4 and C_2F_6) emissions from primary aluminum production. 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.

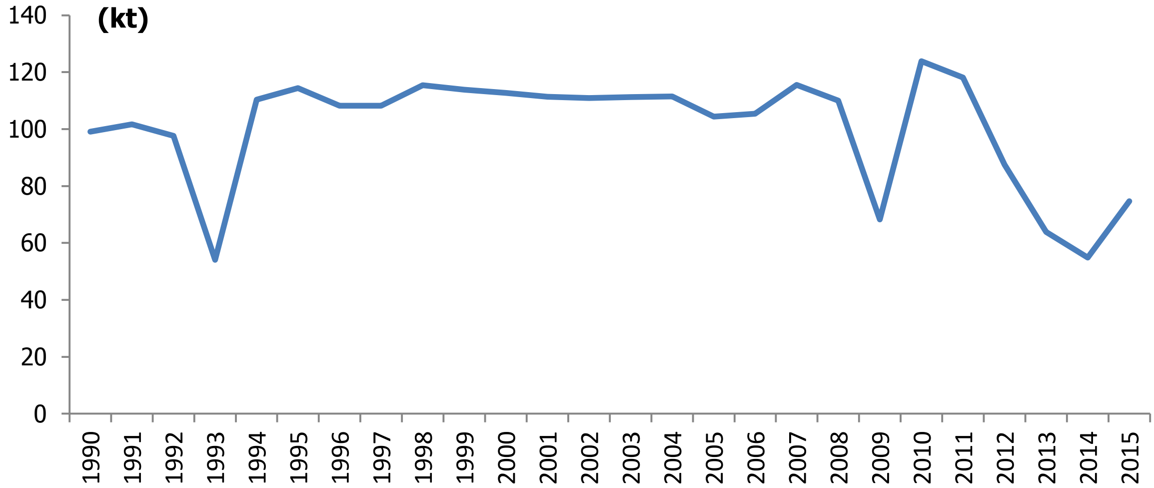
Eti Aluminyum's Seydişehir Aluminum Plant, located in the Central Anatolia region of Turkey, is an integrated primary aluminum production plant. From here the company is able to convert aluminum ore into metallic aluminum by first processing the ore and then shaping it through the use of casting, rolling 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.

Most carbon dioxide emissions result from the electrolysis reaction of the carbon anode with alumina (Al_2O_3). The consumption of prebaked carbon anodes and Søderberg paste is the principal source of process related carbon dioxide emissions from primary aluminium production. PFCs are formed during a phenomenon known as the 'anode effect'.

The CO_2 emissions from aluminum productions is shown in figure 4.18. Overall between 1990 (99 kt CO_2eq) and 2015 (75 kt CO_2eq) emissions have decreased by 25%. This is due to decreasing aluminum production of Turkey. In 1993 aluminum production decreased remarkably. This is because of the excessive world aluminum stocks prior to the world economic recession of 1994. CO_2 emissions remained generally stable until a similar trend was seen in 2008 (110.05 kt), 2009 (68.23 kt) and 2010 (123.91 kt) similarly because of the world economic recession in 2008. Emissions have decreased between 2010 and 2014. In 2015, CO_2 emissions increased 36% with respect to 2014 due to the increasing aluminum production of Turkey.

Figure 4.19 CO_2 emissions from aluminum production, 1990-2015



In the Table 4.42 the emission trend of F-gases from metal production (CRF 2C3 category) 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 4.42.

Data 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 can be seen from the table below, reductions in PFCs emissions have occurred in 2006.

Table 4.42 PFCs, CF_4 and C_2F_6 emissions from primary aluminum production, 1990-2015

Year	PFCs (kt CO_2eq.)	CF_4 (tonnes)	C_2F_6 (tonnes)
1990	692.77	87.38	3.86
1991	854.54	107.78	4.75
1992	781.92	98.62	4.35
1993	786.58	99.21	4.38
1994	693.65	87.49	3.86
1995	592.88	74.78	3.30
1996	597.28	75.34	3.32
1997	593.33	74.84	3.30
1998	593.87	74.91	3.31
1999	591.07	74.55	3.29
2000	591.38	74.59	3.29
2001	592.20	74.70	3.30
2002	595.92	75.16	3.32
2003	595.33	75.09	3.31
2004	600.78	75.78	3.34
2005	559.97	70.63	3.12
2006	460.95	58.59	2.29
2007	574.44	72.45	3.20
2008	527.71	66.56	2.94
2009	259.26	32.70	1.44
2010	513.88	64.82	2.90
2011	480.35	60.59	2.67
2012	359.05	45.29	2.00
2013	270.58	34.13	1.51
2014	255.41	32.21	1.42
2015	120.08	15.14	0.67

Methodological Issues:

Aluminum is a key category by the trend analysis due to the cessation of PFC emissions in the industry. CO_2 emissions from primary aluminum production are calculated by the T2 method for the entire time series. Eti Aluminum, the only primary aluminum producer in Turkey, switched its production process in the mid of 2015. The company is now using Prebaked smelters. Before that Søderberg process was used to produce aluminum. For 1990-2014 CO_2 emissions come from Søderberg cells. However for the year 2015 both Søderberg cells and Prebaked cells were used for production.

CO_2 emissions for Søderberg cells

$$_{CO2} = \left(PC \times MP - \frac{CSM \times MP}{1000} - \frac{BC}{100} \times PC \times MP \times \frac{S_p + Ash_p + H_p}{100} - \frac{100 - BC}{100} \times PC \times MP \times \frac{S_c + Ash_c}{100} - MP \times CD\right) \times \frac{44}{12}$$

where;

E_{CO2} = CO_2 emissions from paste consumption, tonnes CO_2
MP = total metal production, tonnes Al
PC = paste consumption, tonnes/tonne Al
CSM = emissions of cyclohexane soluble matter, kg/tone Al
BC = binder content in paste, wt %
Sp = sulphur content in pitch, wt %
Ashp = ash content in pitch, wt %
Hp = hydrogen content in pitch, wt %
Sc = sulphur content in calcined coke, wt %
Ashc = ash content in calcined coke, wt %
CD = carbon in skimmed dust from Søderberg cells, tonnes C/tonne Al
44/12 = CO_2 molecular mass: carbon atomic mass ratio, dimensionless

CO_2 emissions for Prebaked cells

$$_{CO_2} = NAC \times MP \times \frac{100 - S_a - Ash_a}{100} \times \frac{44}{12}$$

where;

ECO2 = CO2 emissions from paste consumption, tonnes CO2
MP = total metal production, tonnes Al
NAC = net prebaked anode consumption per tonne of aluminum, tonnes C / tone Al
Sa = sulphur content in baked anodes , wt%
Asha = ash content in baked anodes, wt%
44/12 = CO2 molecular mass: carbon atomic mass ratio, dimensionless

PFC emissions

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.

Collection of activity data

To estimate CO_2 emissions, the parameters below are obtained from the single producer. The data are obtained from the producer company by an annual questionnaire. However plant specific data can only be obtained for the years 2005-2015, for 1990-2004 the default parameters are used as the emission factors and national statistics are used as the production data. The paste consumption data for 1990-2004 is assumed to be constant and same with the 2005 data. Total aluminum production and the CO_2 emissions are given in table 4.44 below, however due to confidentiality the production data is given relative to 1990 = 100

Table 4.43 Aluminum production emissions, 1990-2015

Years	Aluminium 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
2015	83.4	74.69

Choice of emission factor

Some of the CO_2 emission factors are provided by the facility while some are used as default values. In the table below the emission factors used in the formula for Søderberg cells can be found.

Table 4.44 Emission factors for aluminum production with Soderberg cells, 2005-2015

Emission factor	Type of data	Value
PC (Paste consumption)	Plant specific	Confidential
CSM (Emissions of cyclohexane soluble matter)	Default	4 kg / tonne Al
BC (Binder content in paste)	Plant specific	Confidential
Sp (Sulphur content in pitch)	Plant specific	Confidential
Ashp (Ash content in pitch)	Plant specific	Confidential
Hp (Hydrogen content in pitch)	Default	3.3 wt%
Sc (Sulphur content in calcined coke)	Plant specific	Confidential
Ashc (Ash content is calcined coke)	Plant specific	Confidential
CD (Carbon in skimmed dust from Søderberg cells)	Plant specific	Confidential

Note: For 1990-2004 PC value assumed to be constant and same with the 2005 data. All other parameters are default for the years 1990-2004

Table 4.45 Emission factors for aluminum production with Prebaked cells

Emission factor	Type of data	Value
NAC (Net Prebaked Anode Consumption)	Plant specific	Confidential
MP(Total Metal Production)	Plant specific	4 kg / tonne Al
Sa (Sulphur content in baked anodes)	Plant specific	Confidential
Asha (Ash content in baked anodes)	Plant specific	Confidential

Note that the company, Eti Aluminyum, switched to the Prebake cells just in 2015 after using Søderberg process for long years. The system is not fully developed yet. NAC value is not measured but it is estimated by the process engineers of the company. In the further years it will be measured.

For the calculation of PFCs emissions, 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_4EF (kg CF_4/tonnes aluminum);
- C_2F_6EF (kg C_2F_6/tonnes aluminum).

In the following Table 4.51, 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 4.46 PFCs emission factor, 1990-2015

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
2015	72.6

Uncertainties and Time-Series Consistency:

For CO_2 emissions, the uncertainty values of the T2 method is considered ±5% for the EF and ±1% for AD, as recommended in 2006 IPCC Guidelines Volume 3 (page 4.56). AD are relatively low as there is very little uncertainty in the data on annual production of aluminum and information is provided directly from the single producer. The CO_2 emission factor is also low as the mechanisms leading to emissions are well known. On the other hand for F gases, 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:

Aggregated national implied emission factors are compared with IPCC default values. Due to the data confidentiality the IEFs cannot be tabulated in here. The production data is gathered from the producer itself and it is compared with TurkStat's national production statistics. Both comparisons are found to be consistent.

Recalculation:

F-gas emissions from primary aluminum production for the years 2007-2014 were not estimated due to confidentiality reasons. In this inventory submission, the emissions for the years 2007-2014 are calculated and included in the inventory.

Planned Improvements

No further improvements are planned at this time.

4.4.4. Magnesium production (Category 2.C.4)

There is no magnesium production in Turkey during period 1990-2015.

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 world-wide 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. However in Turkey there is no primary lead production. Turkey is producing lead by only smelting the recycled lead from vehicles' old batteries. Turkey's highways are developed and there are over 20 million registered highway vehicles and there is huge amount of vehicle batteries to be recycled every year. Therefore there are many lead batteries recycling companies in Turkey.

In lead recycling the batteries are crushed and then the scrap lead and plastic contents are separated by floating. Then the lead is put into a smelting furnace with some reductant agent (natural gas, fuel oil or metalurgical coke), silica, and iron. The furnace is heated up and the lead is melted in the furnace. During this process oxides are carbonated and leave the furnace as CO_2.

Methodological Issues:

Lead production is not a key category in Turkey, and due to lack of data, the Tier 1 is applied to calculate CO_2 emissions by multiplying process specific EF to lead production data, as shown in equation below.

$$_{CO2} = Pb * \quad F_{secondary\ raw\ material\ treatment}$$

where:
E_{CO2} = CO_2 emissions from lead production, tonnes
Pb= quantity of lead produced, tonnes
EF secondary raw material treatment = process specific emission factor, tonnes CO2 / tone lead produced

The lead production data is not known directly for all the years, but for only 1990-1996. However the amount of vehicle batteries recycled is known for the years 2007 and 2015. The specialists from the production field say that lead production amount is 60% of the vehicle batteries recycled by weight and this assumption is used for the estimation of secondary lead production. The amount of lead produced before 2007 is estimated by interpolation.

Collection of activity data

There are many companies in Turkey recycling vehicle batteries to recover lead. Since old batteries are classified as dangerous waste, it is statistically overseen. The amount of vehicle batteries recycled in Turkey is known for the years 2007-2015. The data is gathered from Ministry of Environment and Urbanization - Waste Management Department. It is assumed that 60% of the waste battery weight is recycled as lead. 1990-1996 lead production data is found in the 8th five years development plant of Turkey. The data for the years 1997-2006 are estimated by interpolation. In the table below the amount of vehicle batteries recycled and consequently the amount of lead produced in the smelting process is shown. The emissions from lead production is also shown in the same table.

Table 4.47 Lead production of Turkey and CO_2 emissions from lead production, 1990, 2015

Years	Recycled waste batteries (kt)	Lead production from waste batteries (kt)	CO_2 emissions (kt)
1990	ND	11.0	2.20
1991	ND	8.5	1.70
1992	ND	10.5	2.10
1993	ND	9.6	1.92
1994	ND	8.7	1.75
1995	ND	11.1	2.22
1996	ND	13.4	2.69
1997	ND	14.7	2.94
1998	ND	16.0	3.19
1999	ND	17.2	3.44
2000	ND	18.5	3.70
2001	ND	19.7	3.95
2002	ND	21.0	4.20
2003	ND	22.3	4.45
2004	ND	23.5	4.70
2005	ND	24.8	4.96
2006	ND	26.0	5.21
2007	45.5	27.3	5.46
2008	48.5	29.1	5.82
2009	53.0	31.8	6.37
2010	55.0	33.0	6.60
2011	59.4	35.6	7.13
2012	59.5	35.7	7.14
2013	69.0	41.4	8.28
2014	61.3	36.8	7.36
2015	71.4	42.9	8.57

ND = No Data

Choice of emission factor

Emission factor of 0.20 tonne of CO_2 / tonne of lead produced is used in the calculations. This is the process type specific emission factor for the treatment of secondary raw materials in the 2006 IPCC Guidelines, Table 4.21.

Uncertainties and Time-Series Consistency:

National production data for the amount of vehicle batteries are used as the activity data and it is estimated that 60% by weight of the amount of batteries recycled is recovered as lead. Due to this assumption the activity data has an uncertainty of 25% relying on the experts judgment. The process type emission factor has an uncertainty of 20%.

Source-Specific QA/QC and Verification:

In order to estimate the amount of lead produced using the amount of batteries recycled data, the biggest two lead smelter company are called and the production engineers and environmental responsible gave necessary information. One company responsible declared 55-60% of lead recovery, the other company declared 65% of lead recovery from the old vehicle batteries by weight. Therefore these information is in consistent with the assumption that 60% of lead is recovered by weight.

Recalculation:

In the previous NIR TurkStats national industrial productions statistics were used as the national lead production data and estimates were made accordingly. However this year it is understood that the national data is not lead production data but it is lead ore mining and trading data. Therefore a new approach was developed to estimate the lead production in Turkey and emissions are calculated accordingly. The table below shows the results of the recalculation.

Table 4.48 Comparison on lead production emissions recalculation in the 2016 and 2017 inventory submissions

Years	Lead production emissions in 2016 submission (kt CO_2)	Lead production emissions in 2017 submission (kt CO_2)	Difference in emissions (kt CO_2)	Percental change (%)
1990	1.95	2.20	0.25	13
1991	1.95	1.70	-0.25	-13
1992	1.95	2.10	0.15	8
1993	1.95	1.92	-0.02	-1
1994	1.95	1.75	-0.20	-10
1995	1.95	2.22	0.27	14
1996	1.95	2.69	0.74	38
1997	1.95	2.94	0.99	51
1998	1.95	3.19	1.25	64
1999	1.95	3.44	1.50	77
2000	1.95	3.70	1.75	90
2001	1.95	3.95	2.00	103
2002	1.95	4.20	2.25	116
2003	1.95	4.45	2.51	129
2004	1.95	4.70	2.76	142
2005	1.95	4.96	3.01	155
2006	4.76	5.21	0.44	9
2007	3.86	5.46	1.60	41
2008	14.19	5.82	-8.37	-59
2009	3.71	6.37	2.66	72
2010	11.66	6.60	-5.06	-43
2011	13.51	7.13	-6.39	-47
2012	5.41	7.14	1.73	32
2013	9.48	8.28	-1.20	-13
2014	7.54	7.36	-0.18	-2

Planned Improvements

No further improvements are planned at this time.

4.4.6. Zinc production (Category 2.C.6)

Source Category Description:

In Turkey currently there is no zinc production. In the past, there was a single primary production plant, located in Kayseri, produced zinc until 1999, starting from 1968. The company was closed in 1999. The plant produced zinc by utilizing zincoxide ore by pyrometallurgical (Imperial Smelting Furnace) process. The table below shows the amount of zinc production and CO_2 emissions.

Table 4.49 Zinc productions and emissions, 1990-2015

Years	Zinc Production (tonne)	CO_2 (kt)
1990	22.0	37.84
1991	17.2	29.58
1992	20.8	35.78
1993	20.4	35.09
1994	20.8	35.78
1995	20.4	35.09
1996	20.8	35.78
1997	37.6	64.67
1998	35.6	61.23
1999	31.2	53.66
2000-2015	NO	NO

NO = Not Occurred

In 1996 the production plant was privatized. It is seen that by 1997 the plant increased its production and so its emissions. The plant stopped primary zinc production by December of 1999.

Methodological Issues:

Zinc production is not a key category in Turkey, and due to lack of data Tier 1 is applied. In order to calculate CO_2 emissions, the default EF is multiplied with zinc production data as shown in the equation below.

$$_{CO2} = ZN * \quad F_{default}$$

where:

E_{CO2} = CO_2 emissions from zinc production, tonnes
Zn = quantity of zinc produced, tonnes
EF default = Default emission factor, tonnes CO_2 / tone zinc produced

Collection of activity data

Plant is stopped its primary zinc production activities in 1999. And it changed its owners many times from then. The newest owners of the plant has no information dating back to those years. Fortunately, the capacity utilization rate and the total zinc production capacity of the plant is found in the records of the ministry of state responsible for privatization (2001). By multiplying the production capacity of the plant with the capacity utilization rate, the production data of the plant are estimated for 1990-1999.

Choice of emission factor

Default emission factor of 1.72 tonne of CO_2 / tonne of zinc produced is used in the calculations. This is the default emission factor in the 2006 IPCC Guidelines, Table 4.24. based on weighting of 60% Imperial Smelting and 40% Waelz Kiln.

Uncertainties and Time-Series Consistency:

Uncertainty value for EF is considered 50% as recommended in the 2006 IPCC Guidelines Volume 3 Table 4.25 due to the use of default EF. The capacity data of ÇİNKUR is different in two separate data sources. (33.500 ton/year in the 8th Five Years of Development Plan of Turkey and 40.000 ton/year in our data source). Since the production data is calculated as the capacity of the plant multiplied by the capacity utilization rate, the AD should have a higher uncertainty then the Guideline recommends. Uncertainty value for AD is considered 20% based on the expert judgment.

Source-Specific QA/QC and Verification:

Experts from zinc trader and waelz oxide producer companies in Turkey are personally communicated and by this way it is verified that Turkey's only zinc producer was ÇİNKUR and it was closed in 1999. ÇİNKUR's zinc production data is also found in the 8th five years development plan of Turkey (2001) and it is stated that ÇİNKUR is roughly producing 20.000 tons zinc/year which is in line with our calculated production data for the years between 1990 and 1996.

Recalculation:

In the previous NIR TurkStats national industrial productions statistics were used as the national zinc production data and estimates were made accordingly. However this year it is understood that the national data is not zinc production data but it is zinc ore mining data and possibly zinc oxide production data. In Turkey there is no zinc metal production. However in the past there used to be. A new data source has found revealing the zinc productions of Turkey for 1990-1999 as mentioned in the *Collection of activity data.* So the emission were calculated accordingly. The following table shows the result of the recalculation.

Table 4.50 Comparison on zinc production emissions recalculation in the 2016 and 2017 inventory submissions

Years	Zinc production emissions in 2016 submission (kt CO_2)	Zinc production emissions in 2017 submission (kt CO_2)	Difference in emissions (kt CO_2)
1990	0.2	37.8	37.6
1991	0.2	29.6	29.4
1992	0.4	35.8	35.4
1993	0.4	35.1	34.7
1994	0.5	35.8	35.3
1995	1.4	35.1	33.7
1996	1.3	35.8	34.5
1997	1.4	64.7	63.2
1998	1.6	61.2	59.6
1999	1.9	53.7	51.8
2000	2.0	NO	-2.0
2001	2.2	NO	-2.2
2002	2.4	NO	-2.4
2003	2.6	NO	-2.6
2004	2.8	NO	-2.8
2005	3.2	NO	-3.2
2006	8.6	NO	-8.6
2007	18.3	NO	-18.3
2008	21.9	NO	-21.9
2009	31.8	NO	-31.8
2010	29.8	NO	-29.8
2011	22.8	NO	-22.8
2012	19.5	NO	-19.5
2013	39.6	NO	-39.6
2014	32.9	NO	-32.9

Planned Improvements

No further improvements are planned at this time.

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 obtained from IEA - Eurostat - UNECE Energy Questionnaire - Oil table of Turkey. Having only total consumption data for all lubricants (i.e. no separate data for oil and grease), the weighted average oxidation 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 terms of kt converted to in terms of TJ by multiplying it with a factor (=40.2). The following table shows the amount of lubricant used and the CO_2 emissions, from 1990 to 2015.

Table 4.51 The Amount of lubricant used and CO_2 emissions, 1990-2015

		(kt)
Year	Lubricant	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
2015	432	254.7

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%.

For AD uncertainty value is considered to be 25%.

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.

Recalculation:

No recalculation is made for this category.

Planned Improvements

No further improvements are planned at this time.

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 obtained from IEA - Eurostat - UNECE Energy Questionnaire - Oil table of Turkey. Tier 1 method formulated as Equation 5.4 in 2006 IPCC Guideline is used with default carbon content and ODU factor. The following table shows the amount of paraffin wax used and resulting CO_2 emissions, 1990 to 2015.

Table 4.52 The Amount of paraffin wax used and CO_2 emissions, 1990-2015

(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
2015	20	2.39

Uncertainties and Time-Series Consistency:

Uncertainty values of AD is considered to be 25%, on the other hand since the ODU factor is highly dependent on specific country conditions and policies, the default EF exhibits an uncertainty of 100% according to the 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.

Recalculation:

No recalculation is made for this category.

Planned Improvements

No further improvements are planned at this time.

4.6. Electronics Industry (Category 2.E)

A research for this category has been done by taking into consideration of relevant sectors and gases. According to the results, it has been appeared that f gases have not been used in the manufacturing processes of these sectors. However, it is founded that some gases have been used with the aim of research and development.

Source Category Description

The sub-sector only consists of the following sub-application:
2.E.5- Other, other electronic uses.

Methodological Issues

This section is composed of results of the research which has been conducted by the Ministry of Environment and Urbanization. As it is stated above, results show that f gases are not used in the manufacturing of flat panel display, photovoltaic products and semiconductors. This information has been gathered by contacting with largest companies within the relevant sectors.

However, it is observed that CF_4, CHF_3 and SF_6 are used for the research and development in the area of semiconductor products. Therefore, these gases are reported under the category of 2.E.5 "other electronic uses".

According to the research, these gases were started to be used in 2010. For reporting of emission, it is assumed that same amount of gas were used for each year. This assumption is made by considering the expert judgment.

Table 4.53 shows the consumption amount of each gases which are consumed for the research and development purpose.

Table 4.53 Consumption of each gases, 2010-2015

Years	CF_4 (kg)	CHF_3 (kg)	SF_6 (kg)
2010	1.2	6	1 848
2011	1.2	6	1 848
2012	1.2	6	1 848
2013	1.2	6	1 848
2014	1.2	6	1 848
2015	1.2	6	1 848

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.

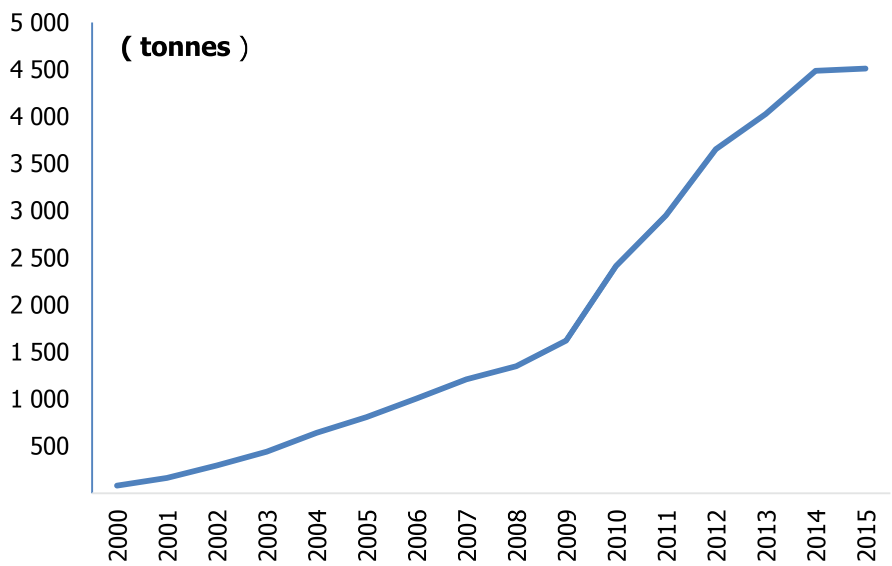
Uncertainties and Time-Series Consistency:

Table 4.54 and Figure 4.20 present total HFCs emissions from 2000 to 2015. 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 4.54 Total HFCs emissions, 2000-2015

Year	HFCs Emissions (tonnes)	HFCs Emissions (kt CO_2eq.)
2000	81.3	115.22
2001	163.4	230.70
2002	293.9	414.58
2003	443.2	624.44
2004	640.8	902.80
2005	808.6	1 137.64
2006	1 004.4	1 411.82
2007	1 208.4	1 697.21
2008	1 348.1	1 873.06
2009	1 621.3	2 080.89
2010	2 412.4	3 013.38
2011	2 949.9	3 379.26
2012	3 654.4	4 190.91
2013	4 029.9	4 386.24
2014	4 489.2	4 820.46
2015	4 511.9	4 678.31

Figure 4.20 Total HFCs emissions, 2000-2015



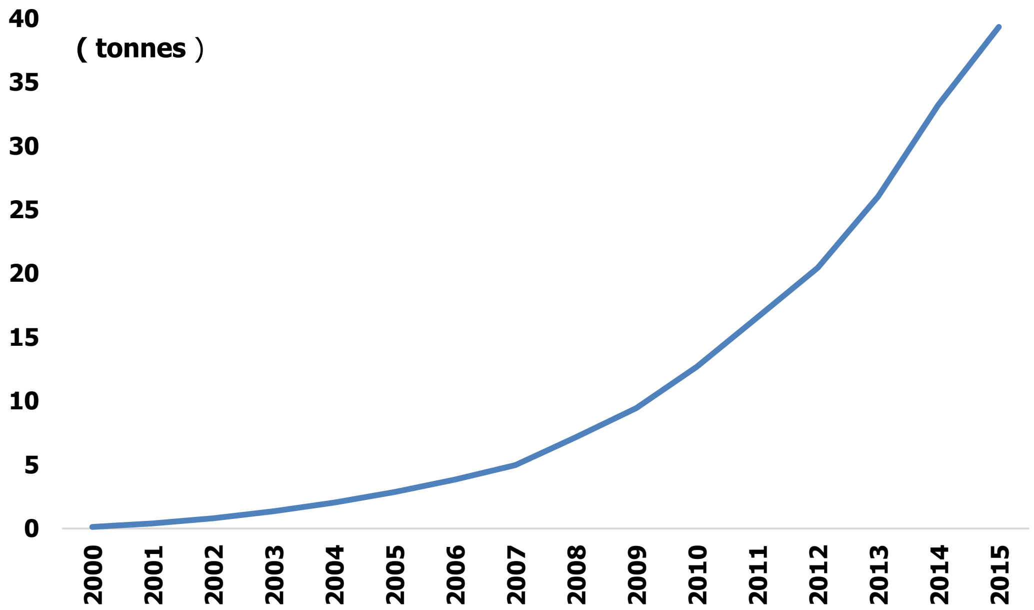
Above presentation shows aggregated emissions caused by HFCs including HFC-23, HFC-32, HFC-41, HFC-43-10mee, HFC-125, HFC-134, HFC-134a, HFC-143, HFC-143a, HFC-152a, HFC-227ea, HFC-236fa, HFC-245ca, and HFC-365mfc. Moreover, table below separately indicates emissions from these gases for specific years. All emission values are presented in tonnes and for each gas emissions are calculated related to Tier 1a/1b method of IPCC.

Table 4.55 HFCs Emissions, 2000-2015

(tonnes)

Substance	2000	2005	2010	2011	2012	2013	2014	2015	Calculation method
HCF-23	0.02	0.29	0.58	0.64	5.41	4.65	4.06	3.63	IPCC T1
HCF-32	-	-	-	-	0.01	0.01	0.48	0.6	IPCC T1
HCF-41	-	-	0.026	0.022	0.03	0.026	0.022	0.09	IPCC T1
HCF-43-10mee	-	-	-	0.04	0.08	0.07	0.15	0.17	IPCC T1
HCF-125	-	-	0.71	1.2	3.55	6.68	15.26	25.53	IPCC T1
HCF-134				0.0002	0.006	0.005	0.005	0.004	IPCC T1
HCF-134a	80.35	791.38	2066.27	2285.44	2270.35	2877.47	3143.27	3000.00	IPCC T1
HCF-143	-	-	0.001	0.001	0.001	0.001	0.001	0.001	IPCC T1
HCF-143a					0.002	0.001	0.001	2.84	IPCC T1
HCF-152a	0.78	14.07	331.36	642.15	849.39	1109.14	1274.49	1418.20	IPCC T1
HCF-236fa	-	-	0.68	1.66	3.07	4.12	4.11	4.09	IPCC T1
HCF-245ca			0.02	1.14	0.97	0.82	2.65	5	IPCC T1
HCF-245fa	-	-	-	-	-	-	10.67	11.81	IPCC T1
HCF-365mfc	-	-	0.12	1.1	1.08	0.92	0.78	0.66	IPCC T1
HCF-227ea	0.13	2.87	12.67	16.55	20.45	26.06	33.23	39.33	IPCC T1

Figure 4.21 HFC-227ea Emissions, 2001-2015



Recalculation:

No recalculation has been done.

Planned Improvements:

For the future inventory submissions, improvements of the data will be done by contacting with sector associations and firms.

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

Methodological Issues:

It is assumed that SF_6 is used only in electrical instruments, mainly in circuit breakers. Emission results are reported based on the import and export data of SF_6. However, custom code for this gas was established in 2013 and trade data is available only for 2013, 2014 and 2015. Therefore, trend of electricity consumption is used for the prediction of imported gas for previous years.

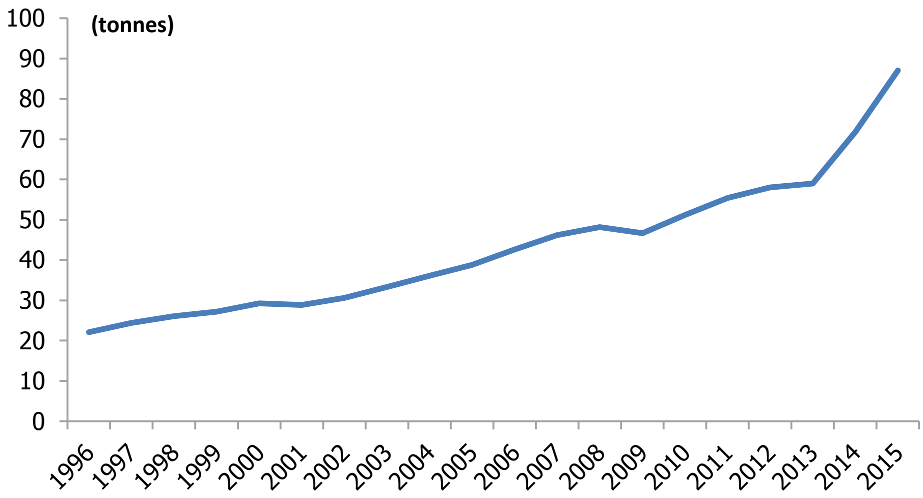
Data for electricity consumption is obtained from the Turkish Electricity Transmission Company and the trade data for SF_6 is provided by the Turkish Statistical Institution.

Table 4.56 SF_6 Consumption and Electricity Consumption

Years	Electricity consumption (GWh)	SF_6 emissions (tonnes)
1996	74 157	22.1
1997	81 885	24.4
1998	87 705	26.1
1999	91 202	27.1
2000	98 296	29.3
2001	97 070	28.9
2002	102 948	30.6
2003	111 766	33.3
2004	121 142	36.1
2005	130 263	38.8
2006	143 071	42.6
2007	155 135	46.2
2008	161 948	48.2
2009	156 894	46.7
2010	172 051	51.2
2011	186 100	55.4
2012	194 923	58.0
2013	198 045	59.0
2014	207 375	71.8
2015	216 233	87.1

There is no information about the number and the capacity of the used, imported or exported equipments and the number of destroyed equipments. The imported gas amount has been assumed as completely emitted in related year. Figure below indicates the trend of SF_6 for years.

Figure 4.22 SF_6 emissions, 1996-2015



Uncertainties and Time-Series Consistency:

Uncertainties of SF_6 was estimated using expert judgment as described in IPCC Good Practice Guidance and Uncertainty Management (2000) Reference.

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.

Recalculation:

Calculation method change for this year, SF_6 emissions are recalculated based on the overall electricity consumption of Turkey. Table below compare the previous calculation results with latest results.

Table 4.57 Comparison on SF6 emissions recalculation in the 2016 and 2017 inventory submissions

(tonnes)

Years	2017 Calculation SF_6 Emission	2016 Calculation SF_6 Emission
1996	22.1	15.6
1997	24.4	25.6
1998	26.1	27.6
1999	27.1	21.6
2000	29.3	13.5
2001	28.9	12.9
2002	30.6	20.0
2003	33.3	20.1
2004	36.1	29.5
2005	38.8	35.9
2006	42.6	38.1
2007	46.2	39.8
2008	48.2	35.3
2009	46.7	33.6
2010	51.2	36.6
2011	55.4	39.8
2012	58.0	40.6
2013	59.0	59.0
2014	71.8	71.8

Planned Improvements:

For the future inventory submissions, improvements of the data will be done by contacting with sector associations and firms.

5. AGRICULTURE (CRF Sector 3)

5.1. Sector Overview

Agricultural activities will most probably coexist with the existence of human beings on this planet, but anthropogenic global warming has many causes identified. It is specified that activities related to food production leads to enhanced global warming. The overall emission value calculated for the agriculture sector is 57.4 Mt CO_2 eq. for the year 2015 which is 14% of the total emission value including LULUCF and 12.1% of all emissions excluding LULUCF for the Republic of Turkey. The agricultural sector is divided into ten categories from 3.A to 3.J in the CRF. These categories were listed below in Table 5.1 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[b]		x[b]	
3.C Rice cultivation		x					
3.D Agricultural soils	x[a]		x	x[b]		x[b]	
3.E Prescribed burning of savannas		x	x	x[c]	x[c]	x[c]	x[c]
3.F Field burning of agricultural residues		x	x	x[b]	x[b]	x[b]	x[b]
3.G Liming	x						
3.H Urea application	x						
3.I Other carbon-containing fertilizers	x						
3.J Other							

[a] to be reported under LULUCF Sector.

[b] Emissions of this gas from this category are likely to be emitted and a methodology is provided in the EMEP/EEA Guidebook.

[c] 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 and 2008, from 20.9% to 10.8%, before levelling off. The following Table 5.2 aims to give a clear view on the weights of the categories within the sector presenting emissions and percentage values for the year 2015. All emission data given in this source category, unless otherwise indicated, are stated either in kt CO_2 equivalent (eq.) or Mt CO_2 equivalent.

Table 5.2 Agriculture sector emissions and overall percentages by categories, 2015

	CH_4 (kt CO_2 eq)	N_2O (kt CO_2 eq)	CO_2 (kt)	Total (kt CO_2 eq)	%
3 Agriculture	**30 509.0**	**26 102.5**	**810.6**	**57 422.1**	**100.0**
A. Enteric fermentation	26 888.0			26 888.0	46.8
B. Manure management	3 159.7	3 144.1		6 303.8	11.0
C. Rice cultivation	199.7			199.7	0.3
D. Agricultural soils		22 877.5		22 877.5	39.8
E. Prescribed Burning of Savannas				NO	
F. Field burning of agricultural residues	261.6	80.9		342.5	0.6
G. Liming				NE	
H. Urea application			810.6	810.6	1.4
I. Other Carbon-containing fertilizers				NE	
J. Other				NO	
GHG Percentage Shares	53.1	45.5	1.4	100.0	

Figures in the table may not add up to the total due to rounding.

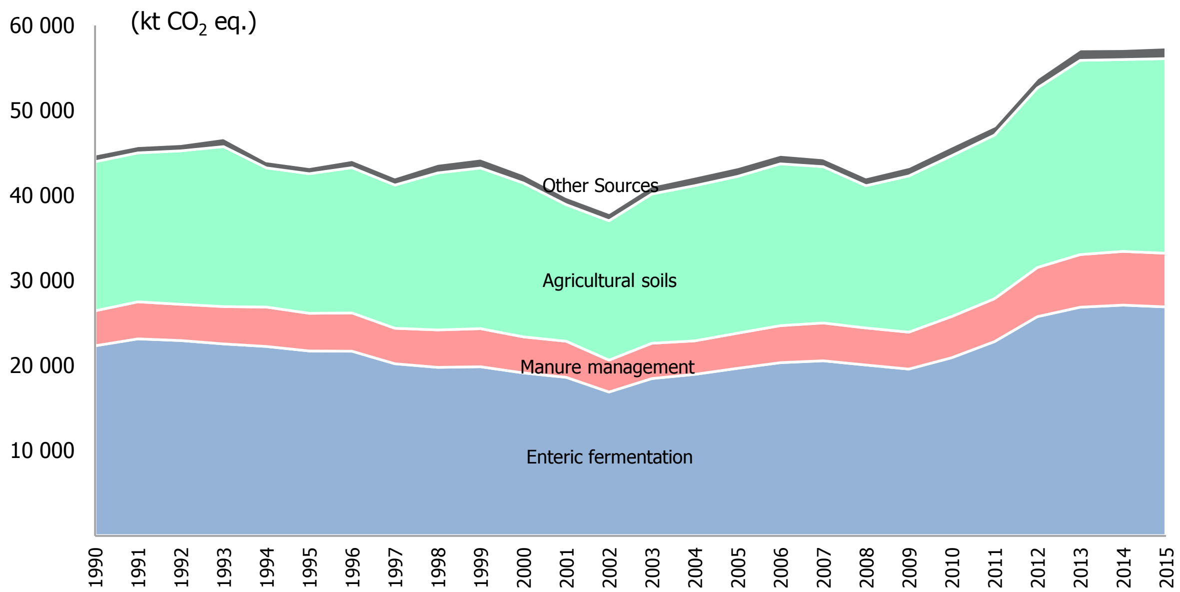
Table 5.3 clearly presents the developments of the emissions for the agriculture sector. The overall emission for the sector increased from 44.8 Mt CO_2 eq. to 57.4 Mt CO_2 eq. during the 26 years after 1990 showing an increase of 28.1%. The biggest increase among the categories in absolute terms for the emissions is observed in the agricultural soils category where the emission increased by around 5.4 Mt CO_2 eq. (30.5%) from 17.5 Mt CO_2 eq. to 22.9 Mt CO_2 eq. for the same period. The primary reason for this increase is the change in activity data. Other significant increases in twenty-six years are seen in enteric fermentation, manure management, and urea application where the figures are 4.6 Mt CO_2 eq. (20.5%), 2.2 Mt CO_2 eq. (53.3%), and 0.4 Mt CO_2 eq. (76.2%) respectively. Increases in emissions from enteric fermentation and manure management are largely a result of activity data developments. Emissions for rice cultivation increased by 0.1 Mt CO_2 eq. (118.6%) whereas the emissions of 1990 and 2015 for field burning of agricultural residues were nearly the same showing only a slight increase of 7.4%.

Table 5.3 Overview of the agriculture sector, 1990-2015

Year	A. Enteric fermentation		B. Manure management		C. Rice cultivation		D. Agricultural soils		F. Field burning of agricultural residues		H. Urea application		Agriculture Total	
	(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	22 314	49.8	4 111	9.2	91	0.2	17 528	39.1	319	0.7	460	1.0	44 824	100
1991	23 129	50.5	4 352	9.5	70	0.2	17 507	38.2	328	0.7	436	1.0	45 822	100
1992	22 929	49.8	4 263	9.3	74	0.2	18 034	39.1	309	0.7	459	1.0	46 069	100
1993	22 536	48.2	4 385	9.4	77	0.2	18 804	40.2	333	0.7	627	1.3	46 762	100
1994	22 235	50.5	4 634	10.5	70	0.2	16 356	37.1	292	0.7	453	1.0	44 040	100
1995	21 705	50.1	4 427	10.2	86	0.2	16 408	37.8	299	0.7	426	1.0	43 351	100
1996	21 677	49.1	4 498	10.2	95	0.2	17 077	38.6	309	0.7	534	1.2	44 190	100
1997	20 205	47.9	4 169	9.9	95	0.2	16 834	39.9	312	0.7	532	1.3	42 146	100
1998	19 781	45.2	4 397	10.1	103	0.2	18 453	42.2	343	0.8	658	1.5	43 735	100
1999	19 850	44.7	4 479	10.1	112	0.3	18 883	42.6	301	0.7	733	1.7	44 360	100
2000	19 124	45.0	4 240	10.0	100	0.2	18 088	42.6	334	0.8	617	1.5	42 504	100
2001	18 606	46.7	4 243	10.6	102	0.3	16 055	40.3	309	0.8	527	1.3	39 842	100
2002	16 878	44.5	3 748	9.9	103	0.3	16 383	43.2	321	0.8	527	1.4	37 961	100
2003	18 464	44.9	4 149	10.1	112	0.3	17 549	42.6	313	0.8	565	1.4	41 152	100
2004	18 957	44.9	3 937	9.3	121	0.3	18 239	43.2	342	0.8	632	1.5	42 228	100
2005	19 663	45.4	4 133	9.5	147	0.3	18 429	42.5	351	0.8	613	1.4	43 335	100
2006	20 331	45.4	4 353	9.7	171	0.4	19 018	42.5	332	0.7	592	1.3	44 797	100
2007	20 552	46.3	4 445	10.0	162	0.4	18 374	41.4	283	0.6	566	1.3	44 383	100
2008	20 057	47.6	4 352	10.3	172	0.4	16 729	39.7	275	0.7	565	1.3	42 149	100
2009	19 576	45.1	4 343	10.0	167	0.4	18 362	42.3	318	0.7	593	1.4	43 359	100
2010	20 912	45.7	4 840	10.6	171	0.4	18 900	41.3	308	0.7	645	1.4	45 776	100
2011	22 806	47.4	5 039	10.5	171	0.4	19 239	40.0	332	0.7	558	1.2	48 145	100
2012	25 740	47.9	5 771	10.7	206	0.4	21 105	39.3	308	0.6	640	1.2	53 770	100
2013	26 850	46.9	6 188	10.8	191	0.3	22 827	39.9	335	0.6	807	1.4	57 198	100
2014	27 094	47.3	6 313	11.0	191	0.3	22 556	39.4	292	0.5	788	1.4	57 233	100
2015	26 888	46.8	6 304	11.0	200	0.3	22 878	39.8	342	0.6	811	1.4	57 422	100

Furthermore, in relative terms, the biggest category in the agriculture sector is enteric fermentation having a 46.8% share for 2015, hence being the dominant category. In all of the reported years, 1990-2015, this category had an average share of 47.1% in the agriculture sector, though the trend clearly indicates a slight decline from 49.8% to 46.8%. The second biggest category is agricultural soils having a proportion of 39.8% for 2015 increased slightly from 39.1% in 1990 while having percentage shares ranging from 37.1% in 1994 and 43.2% in 2004 with an average share of 40.6% for the 26 years. Manure management's share presents somehow a more stable increasing trend, starting from 9.2% in 1990 and reaching 11.0% in 2015 having also an average of 10.1%. The remaining categories rice cultivation, field burning of agricultural residuals, and urea application had emission shares of 0.3%, 0.6%, and 1.4% respectively for 2015. Though the share increased by around 70.6% and 37.6% for rice cultivation and urea application respectively, the absolute terms and relative weights of these two categories are still small for the period 1990-2015. Despite these increasing values, the share for field burning of agricultural residues decreased on the contrary slightly for the reporting period from 0.7% to 0.6%. A graphical representation is given below in Figure 5.1, which displays the overall cumulative distribution and the trend for the reporting period since 1990 until 2015 in the Agriculture sector in four sections, namely enteric fermentation, agricultural soils, manure management, and other sources.

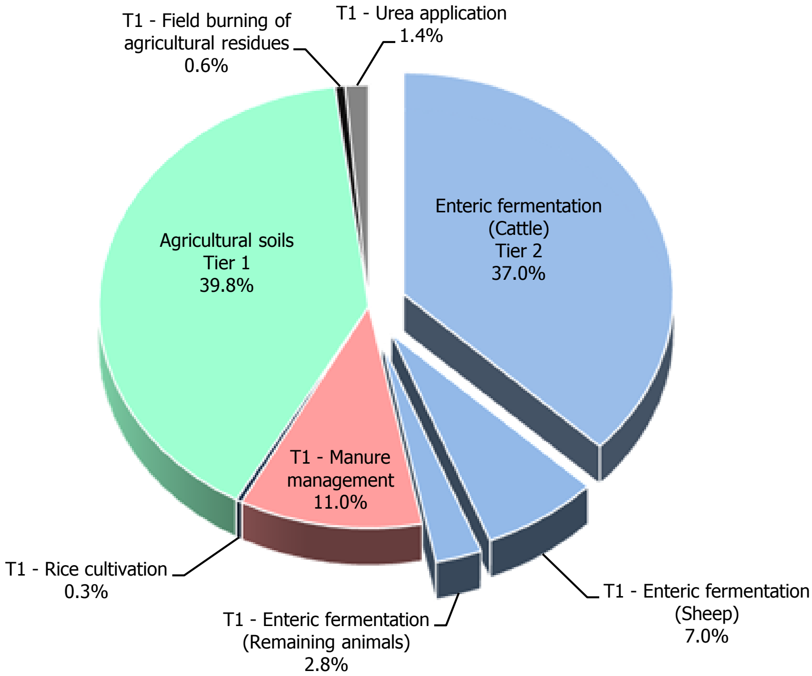
Figure 5.1 Cumulative emissions of agricultural categories, 1990-2015



Additionally, 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 National 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.

A main new development in the current reporting of the agriculture sector is the Tier 2 method used in the calculation of Enteric Fermentation Category for cattle. Figure 5.2 displays a brief overview of the related category shares with respective information on the method used.

Figure 5.2 Methods used in the agriculture sector, 2015



The method used for the emission estimations in the agriculture sector except for cattle in enteric fermentation is the T1 method. The only T2 method used in this sector is related to emissions due to enteric fermentation of cattle which has a value of 21 274.4 kt CO_2 eq. This amount equals to around 37% of total emissions in the agriculture sector and 79.1% of total emissions in enteric fermentation which is the biggest subcategory in enteric fermentation as clearly shown in Figure 5.2.

GHG emission values and their shares in the agriculture sector, CH_4, N_2O and CO_2, are given in Table 5.4. After its initial increase, emission values for CH_4 decreases mainly in the first twelve years period after 1991, but then shows a horizontal trend and thereafter an increasing trend starting around 2010. The percentage share of CH_4 decreased from 55.8% in 1990 to 53.1% in 2015.

The share of N_2O emissions with respect to yearly total values were around 45.5%. The emission values for N_2O were 19 363 kt CO_2 eq. (43.2%) in 1990 whereas it increased to 26 103 kt CO_2 eq. (45.5%) in 2015 nearly entirely as a result of the increase in emissions of manure management and agricultural soils.

CO_2 emissions result only from urea application having the smallest share in this sector and its shares range between 1% and 1.7% for the period 1990-2015. The highest value of CO_2 emissions occurred in 2015 with 811 kt while it has the smallest value in 1995 with 426 kt depending on the amount of urea applied. The corresponding value for the current reporting year has a share of 1.4%.

Table 5.4 Overview of GHGs in the agriculture sector, 1990-2015

	CH_4		N_2O		CO_2		Total
Year	**(kt CO_2 eq.)**	**(%)**	**(kt CO_2 eq.)**	**(%)**	**(kt CO_2 eq.)**	**(%)**	**(kt CO_2 eq.)**
1990	25 001.2	55.8	19 362.8	43.2	459.9	1.0	44 823.9
1991	25 889.9	56.5	19 496.4	42.5	436.2	1.0	45 822.5
1992	25 569.6	55.5	20 040.3	43.5	458.7	1.0	46 068.7
1993	25 288.0	54.1	20 846.9	44.6	626.7	1.3	46 761.6
1994	25 188.8	57.2	18 398.3	41.8	452.6	1.0	44 039.7
1995	24 545.4	56.6	18 379.7	42.4	425.9	1.0	43 351.0
1996	24 562.2	55.6	19 094.0	43.2	534.1	1.2	44 190.4
1997	22 845.5	54.2	18 768.8	44.5	532.0	1.3	42 146.3
1998	22 623.7	51.7	20 453.7	46.8	657.9	1.5	43 735.3
1999	22 746.6	51.3	20 879.6	47.1	733.3	1.7	44 359.6
2000	21 813.0	51.3	20 073.9	47.2	617.5	1.5	42 504.4
2001	21 358.1	53.6	17 956.9	45.1	527.1	1.3	39 842.0
2002	19 244.2	50.7	18 190.3	47.9	526.9	1.4	37 961.5
2003	21 045.1	51.1	19 541.2	47.5	565.4	1.4	41 151.7
2004	21 209.2	50.2	20 386.7	48.3	632.2	1.5	42 228.1
2005	22 036.7	50.9	20 685.5	47.7	613.2	1.4	43 335.4
2006	22 806.3	50.9	21 398.7	47.8	592.3	1.3	44 797.3
2007	23 113.7	52.1	20 702.5	46.6	566.3	1.3	44 382.5
2008	22 546.9	53.5	19 037.1	45.2	564.8	1.3	42 148.8
2009	22 123.6	51.0	20 642.4	47.6	592.7	1.4	43 358.8
2010	23 788.9	52.0	21 341.8	46.6	645.0	1.4	45 775.7
2011	25 683.9	53.3	21 903.6	45.5	557.5	1.2	48 145.1
2012	29 019.0	54.0	24 111.3	44.8	639.8	1.2	53 770.1
2013	30 414.5	53.2	25 976.4	45.4	807.3	1.4	57 198.3
2014	30 687.0	53.6	25 758.8	45.0	787.7	1.4	57 233.5
2015	30 509.0	53.1	26 102.5	45.5	810.6	1.4	57 422.1

Figures in the table may not add up to the total due to rounding.

The AD used for the compilation of the GHG inventory is provided by TurkStat (https://biruni.tuik.gov.tr/hayvancilikapp/hayvancilik_ing.zul).

Livestock population are critical activity data for the 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, 1990-2015. 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. Since 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 final 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 2015 with the population increasing around 3.0 million (54.2%), 1.4 million (161.9%), and 214.1 million (209.4%) respectively. It is remarkable that poultry numbers had more than tripled in 26 years from around 102 million to over 316 million. Contrary to these developments, the livestock categories shown in the remaining columns in the table present decreasing figures ranging from - 4.7% as for goats to - 86.3% as seen in the category swine. Similarly other decreasing percentages observed for categories dairy cattle, camels, domestic sheep, buffalo, horses, and mules and asses are -6.1%, -22.9%, -26.9%, -63.9%, -76.1%, -83.3% respectively. The figures are presenting a trend for the period 1990-2015 and the decreasing livestock population numbers of nearly 10.4 million in domestic sheep, around 0.36 million in dairy cattle, almost a quarter million in buffalo, and little more than a half million in goats have important consequences for the agriculture sector in our country.

Table 5.5 Livestock population numbers in Turkey, 1990-2015

(thousand)

Year	Dairy cattle	Non-Dairy cattle	Sheep domestic	Sheep merinos	Swine	Buffalo	Poultry	Camels	Horses	Mules and asses	Goats
1990	5 893	5 485	39 711	842	12.0	371	102 255	2.0	513	1 187	10 926
1991	6 119	5 854	39 590	842	10.3	366	145 051	1.9	496	1 136	10 764
1992	6 070	5 881	38 576	840	11.8	352	158 770	1.9	483	1 075	10 454
1993	6 032	5 878	36 709	832	9.0	316	184 460	2.0	450	1 013	10 133
1994	6 082	5 819	34 823	823	8.0	305	190 033	2.0	437	978	9 564
1995	5 886	5 903	32 985	806	5.0	255	135 251	2.0	415	900	9 111
1996	5 968	5 918	32 234	838	5.0	235	158 756	2.0	391	843	8 951
1997	5 594	5 596	29 376	862	4.6	194	175 223	1.4	345	782	8 376
1998	5 489	5 542	28 560	875	5.0	176	243 914	1.4	330	736	8 057
1999	5 538	5 516	29 425	831	3.4	165	246 476	1.4	309	680	7 774
2000	5 280	5 481	27 719	773	3.0	146	264 451	1.0	271	588	7 201
2001	5 086	5 462	26 213	759	2.7	138	223 141	0.9	271	559	7 022
2002	4 393	5 411	24 474	700	3.6	121	251 101	0.9	249	512	6 780
2003	5 040	4 748	24 689	742	7.1	113	283 674	0.8	227	490	6 772
2004	3 876	6 194	24 438	763	4.4	104	302 799	0.9	212	452	6 610
2005	3 998	6 528	24 552	752	1.9	105	322 917	0.8	208	423	6 517
2006	4 188	6 683	24 801	815	1.4	101	349 402	1.0	204	404	6 643
2007	4 229	6 807	24 491	971	1.8	85	273 548	1.1	189	364	6 286
2008	4 080	6 780	22 956	1 019	1.7	86	249 044	1.0	180	336	5 594
2009	4 133	6 591	20 722	1 028	1.9	87	234 082	1.0	167	286	5 128
2010	4 362	7 008	22 003	1 086	1.6	85	238 973	1.3	155	260	6 293
2011	4 761	7 625	23 811	1 221	1.8	98	241 499	1.3	151	248	7 278
2012	5 431	8 484	25 893	1 533	3.0	107	257 505	1.3	141	236	8 357
2013	5 607	8 808	27 485	1 799	3.1	118	270 202	1.4	136	227	9 226
2014	5 609	8 614	29 034	2 106	2.7	122	298 030	1.4	131	212	10 345
2015	5 536	8 458	29 302	2 206	1.6	134	316 332	1.5	123	198	10 416

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 cattle are between them. Hybrid cattle is breeds of culture and domestic dairy cattle. 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 1990-2015. For hybrid cattle population there is not a big increase or decrease in the 1990-2015 series. It was around 2.3 million in 2015 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% in 2015. Non-dairy cattle number increased by nearly 3 million from around 5.5 million in 1990 to 8.5 million in 2015 and its share among total cattle increased from 48.2% to 60.4% between 1990 and 2015. Furthermore, Figure 5.3 shows three types of dairy cattle's as well as non-dairy cattle's population numbers for the period 1990-2015 in a straightforward chart.

Figure 5.3 Population numbers for Turkey's cattle categories, 1990-2015

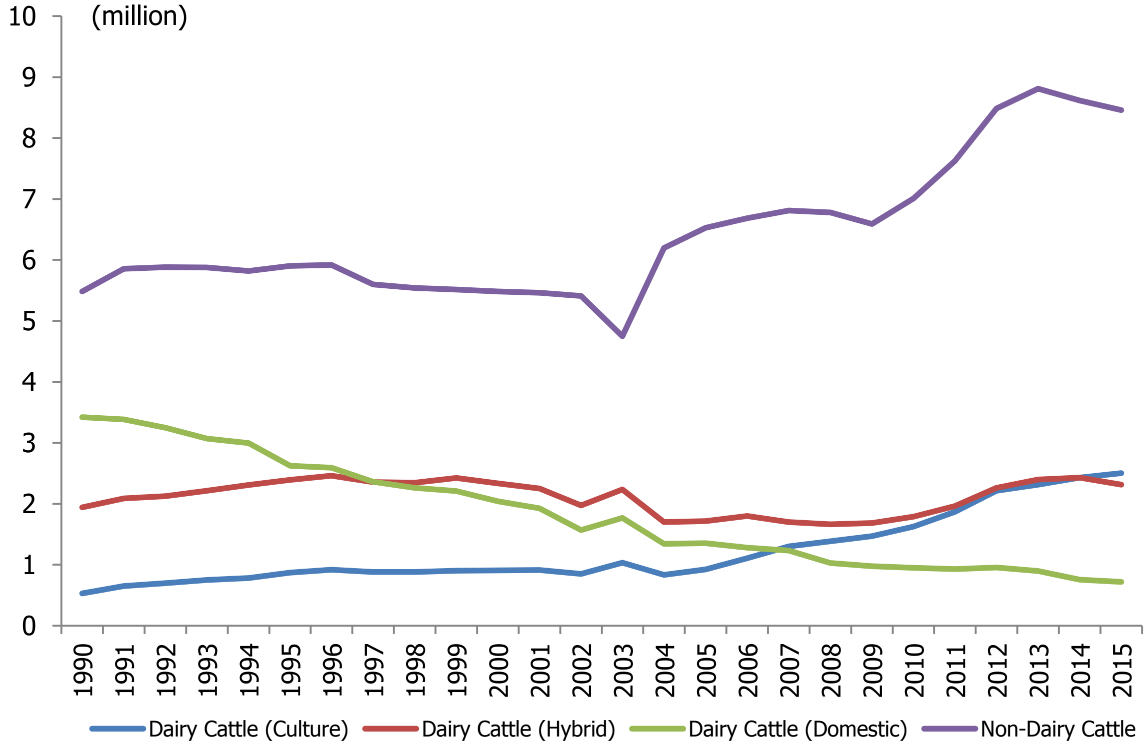


Table 5.6 Subcategories of cattle population in Turkey, 1990-2015

	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	5 594 294	50.0	5 595 643	50.0	11 189 937
1998	879 841	8.0	2 346 093	21.3	2 263 109	20.5	5 489 043	49.8	5 541 957	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	3 875 721	38.5	6 193 625	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	4 361 841	38.4	7 007 959	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	2 314 278	16.1	2 395 897	16.6	897 097	6.2	5 607 272	38.9	8 807 985	61.1	14 415 257
2014	2 427 909	17.1	2 428 708	17.1	752 623	5.3	5 609 240	39.4	8 613 869	60.6	14 223 109
2015	2 500 880	17.9	2 314 061	16.5	720 833	5.2	5 535 774	39.6	8 458 297	60.4	13 994 071

Figures in the table may not add up to the total due to rounding.

Table 5.7 A Detailed perspective on the agriculture sector emissions, 1990-2015

(kt CO_2 eq.)

	Agriculture	A.Enteric fermentation	B.Manure management			C.Rice cultiva-tion	D.Agricultural soils			F.Field burning of agricultural residues			H.Urea applica-tion
Year	Total	CH_4	CH_4	N_2O	Total	CH_4	Direct N_2O	Indirect N_2O	Total	CH_4	N_2O	Total	CO_2
1990	44 824	22 314	2 352	1 759	4 111	91	13 163	4 365	17 528	244	75	319	460
1991	45 822	23 129	2 440	1 912	4 352	70	13 171	4 336	17 507	250	77	328	436
1992	46 069	22 929	2 330	1 933	4 263	74	13 573	4 461	18 034	236	73	309	459
1993	46 762	22 536	2 420	1 965	4 385	77	14 169	4 634	18 804	254	79	333	627
1994	44 040	22 235	2 661	1 973	4 634	70	12 318	4 038	16 356	223	69	292	453
1995	43 351	21 705	2 526	1 901	4 427	86	12 380	4 029	16 408	229	71	299	426
1996	44 190	21 677	2 554	1 944	4 498	95	12 891	4 186	17 077	236	73	309	534
1997	42 146	20 205	2 308	1 861	4 169	95	12 725	4 109	16 834	238	74	312	532
1998	43 735	19 781	2 478	1 920	4 397	103	13 965	4 489	18 453	262	81	343	658
1999	44 360	19 850	2 554	1 925	4 479	112	14 269	4 614	18 883	230	71	301	733
2000	42 504	19 124	2 334	1 907	4 240	100	13 686	4 402	18 088	255	79	334	617
2001	39 842	18 606	2 414	1 829	4 243	102	12 150	3 905	16 055	236	73	309	527
2002	37 961	16 878	2 017	1 731	3 748	103	12 405	3 978	16 383	245	76	321	527
2003	41 152	18 464	2 230	1 919	4 149	112	13 285	4 264	17 549	239	74	313	565
2004	42 228	18 957	1 871	2 067	3 937	121	13 855	4 385	18 239	261	81	342	632
2005	43 335	19 663	1 959	2 174	4 133	147	14 016	4 413	18 429	268	83	351	613
2006	44 797	20 331	2 051	2 302	4 353	171	14 468	4 550	19 018	254	78	332	592
2007	44 383	20 552	2 183	2 262	4 445	162	13 960	4 414	18 374	216	67	283	566
2008	42 149	20 057	2 108	2 244	4 352	172	12 729	3 999	16 729	210	65	275	565
2009	43 359	19 576	2 138	2 206	4 343	167	13 983	4 379	18 362	243	75	318	593
2010	45 776	20 912	2 471	2 370	4 840	171	14 419	4 480	18 900	235	73	308	645
2011	48 145	22 806	2 452	2 587	5 039	171	14 681	4 558	19 239	254	78	332	558
2012	53 770	25 740	2 837	2 934	5 771	206	16 089	5 016	21 105	235	73	308	640
2013	57 198	26 850	3 117	3 070	6 188	191	17 403	5 424	22 827	256	79	335	807
2014	57 233	27 094	3 178	3 134	6 313	191	17 173	5 383	22 556	223	69	292	788
2015	57 422	26 888	3 160	3 144	6 304	200	17 428	5 450	22 878	262	81	342	811

Figures in the table may not add up to the total due to rounding.

Table 5.7 on the previous page presents a detailed perspective on the agriculture sector emissions for the reporting period. 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 our country directly resulting in CO_2 emissions.

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 1 220.36 kt CH_4 (30.5 Mt CO_2 eq.) emissions or 53.1% of agricultural emissions, 59.3% of Turkey's CH_4 emissions and 6.4% of Turkey's total emissions in 2015. CH_4 emissions had increased by 5 508 kt CO_2 eq. (22.03%) from its 1990 level of 25 001 kt CO_2 eq. to 30 509 kt CO_2 eq. This increase is mainly a result of increases of CH_4 emissions in enteric fermentation of 4 574 kt CO_2 eq., in manure management of 808 kt CO_2 eq., and rice cultivation of 108 kt CO_2 eq. This total increase as high as 5 508 kt CO_2 eq. is closely responsible for the 43.7% total increase (12 598 kt CO_2 eq.) in emissions from the agricultural sector between 1990 and 2015.

Enteric fermentation is the single dominant category leading to 89.3% and 88.1% of all CH_4 emissions of agriculture sector for the years 1990 and 2015 respectively. Enteric fermentation was followed by manure management with 9.4% and 10.4%, field burning of agricultural residues with 1% and 0.9% and rice cultivation with 0.4% and 0.7% for 1990 and 2015 respectively.

Nitrous Oxide

Nitrous oxide is a GHG which contributes to global warming and climate change. N_2O emissions accounted for 7% of Turkey's GHG emissions in 2015. Emissions from manure management, agricultural soils, and field burning of agricultural residues include N_2O gas. Agriculture as a sector produced 87.59 kt N_2O emissions (26.1 Mt CO_2 eq.) or 45.5% of agricultural emissions, 78.4% of Turkey's N_2O emissions and 5.5% of Turkey's total emissions in 2015. N_2O emissions have increased by 6 740 kt CO_2 eq. (34.8%) from the 1990 level of 19 363 kt CO_2 eq. to 26 103 kt CO_2 eq.

Agricultural soils as a source category is the dominant source of N_2O emissions, responsible for 90.5% and 87.6% of total agricultural N_2O emissions for the years 1990 and 2015 respectively. Agricultural soils were followed by manure management with 9.1% and 12%, respectively, and field burning of agricultural residues with 0.4% and 0.3%, respectively.

Whereas a percentage as high as 79.4% of this enhancement is a result of increases of N_2O emissions in agricultural soils by 5 349 kt CO_2 eq., manure management is almost responsible for the remaining increase of 20.5% with 1 385 kt CO_2 eq. in N_2O emissions. N_2O emissions of field burning of agricultural residues show a tiny increase of 0.1% (5.57 kt CO_2 eq.) between 1990 and 2015. The net increase of 6 740 kt CO_2 eq. added up to 53.5% of the overall increase of 12 598 kt CO_2 eq. emissions in the agriculture sector between 1990 and 2015. Table 5.7 given before presents a clear view on the distribution of N_2O as well as CH_4 emissions in detail for the sector.

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. Animals produce CH_4 during and/or after feed intake. The largest source of CH_4 emissions in the agricultural sector in our country is enteric fermentation. Enteric fermentation was the biggest source of total carbon equivalent emissions in the agriculture sector with 49.8% (22.3 Mt CO_2 eq.) in 1990 and with 46.8% (26.9 Mt CO_2 eq.) in 2015.

In 2015, enteric fermentation contributed as high as 26 888 kt CO_2 eq., responsible for nearly half of agricultural emissions as stated above and 5.7% of Turkey's total CO_2 eq. emissions. Dairy and non-dairy cattle contributed 21 274 kt CO_2 eq. (79.1%) of emissions from the enteric fermentation category and sheep (domestic and merinos) contributed 4 021 kt CO_2 eq. (15%) of emissions from this category. The increased emissions from the enteric fermentation category in 2015 resulted in a value of 4 574 kt CO_2 eq. (20.5%) compared to 1990 levels (22 314 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 24.4% (5.4 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 many significant animal categories has been increasing in recent years, thereby resulting also in an increase of CH_4 emissions for these subcategories. Between 2002 and 2015, emissions from enteric fermentation increased by 59.3% (10 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 2015 non-dairy cattle were responsible for 10 092 kt CO_2 eq., increased by

4 233 kt CO_2 eq. (72.2%) from the 1990 level of 5 859 kt CO_2 eq. Despite a decrease of 6.1% in dairy cattle population for the period 1990-2015, this subcategory is responsible for 11 182 kt CO_2 eq. in 2015, still an increase of 2 233 kt CO_2 eq. (25%) above its 1990 level of 8 949 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 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 2015 were 5.5 million in total for dairy cattle consisting of culture cattle (2.5 million), hybrid cattle (2.31 million), and domestic cattle (0.72 million). The share of culture dairy cattle type had increased significantly in numbers while domestic dairy cattle 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 1990-2015 as given in Table 5.5. Table 5.8 on the next page shows CH_4 emissions of enteric fermentation in livestock categories.

Table 5.8 CH_4 emissions of enteric fermentation in livestock categories, 1990 - 2015

	Dairy cattle		Non-dairy cattle		Domestic sheep		Merinos sheep	Buffalo	Horses	Goats	Mules& asses	Swine, camels	Total
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.)	(kt CO_2 eq.)	(kt CO_2 eq.)	(kt CO_2 eq.)
1990	8 949	40.1	5 859	26.3	4 964	22.2	137	510	231	1 366	297	3	22 314
1991	9 398	40.6	6 287	27.2	4 949	21.4	137	503	223	1 346	284	2	23 129
1992	9 373	40.9	6 318	27.6	4 822	21.0	137	485	217	1 307	269	2	22 929
1993	9 384	41.6	6 269	27.8	4 589	20.4	135	435	203	1 267	253	3	22 536
1994	9 503	42.7	6 187	27.8	4 353	19.6	134	419	197	1 196	245	3	22 235
1995	9 323	43.0	6 224	28.7	4 123	19.0	131	351	187	1 139	225	2	21 705
1996	9 475	43.7	6 206	28.6	4 029	18.6	136	323	176	1 119	211	2	21 677
1997	8 892	44.0	5 834	28.9	3 672	18.2	140	267	155	1 047	196	2	20 205
1998	8 750	44.2	5 736	29.0	3 570	18.0	142	242	149	1 007	184	2	19 781
1999	8 842	44.5	5 686	28.6	3 678	18.5	135	227	139	972	170	2	19 850
2000	8 484	44.4	5 678	29.7	3 465	18.1	126	201	122	900	147	1	19 124
2001	8 200	44.1	5 676	30.5	3 277	17.6	123	190	122	878	140	1	18 606
2002	7 134	42.3	5 317	31.5	3 059	18.1	114	166	112	848	128	1	16 878
2003	8 464	45.8	5 565	30.1	3 086	16.7	121	156	102	846	122	1	18 464
2004	7 136	37.6	7 464	39.4	3 055	16.1	124	143	96	826	113	1	18 957
2005	7 401	37.6	7 912	40.2	3 069	15.6	122	144	94	815	106	1	19 663
2006	7 862	38.7	8 073	39.7	3 100	15.2	133	138	92	830	101	1	20 331
2007	8 049	39.2	8 205	39.9	3 061	14.9	158	116	85	786	91	1	20 552
2008	7 875	39.3	8 163	40.7	2 869	14.3	166	119	81	699	84	1	20 057
2009	8 032	41.0	7 879	40.2	2 590	13.2	167	120	75	641	71	1	19 576
2010	8 535	40.8	8 411	40.2	2 750	13.2	177	116	70	787	65	1	20 912
2011	9 390	41.2	9 067	39.8	2 976	13.1	198	134	68	910	62	2	22 806
2012	10 779	41.9	10 158	39.5	3 237	12.6	249	148	64	1 045	59	2	25 740
2013	11 169	41.6	10 519	39.2	3 436	12.8	292	162	61	1 153	57	2	26 850
2014	11 271	41.6	10 277	37.9	3 629	13.4	342	168	59	1 293	53	2	27 094
2015	11 182	41.6	10 092	37.5	3 663	13.6	358	184	55	1 302	49	2	26 888

Figures in the table may not add up to the total due to rounding.

Methodological Issues:

Turkey applies a T1 method to estimate CH_4 emissions from enteric fermentation for all animal populations except cattle for which it applies a T2 method. The T2 method is applied by using mainly country specific parameters. 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 for all related animal categories so far.

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 except for cattle. In Turkey there are three dairy cattle types categorized as culture cattle, hybrid cattle and domestic cattle. In 2015, the average milk production of culture cattle is around of 3 868 kg head^{-1} yr^{-1}. Hence, 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 was 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 2 729 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. Since the T1 method regarding cattle still applies for agricultural categories other than enteric fermentation, the explanation given is still valid for other agricultural categories like manure management.

Another animal type sheep is categorized as merinos and domestic sheep for similar reasons like 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 fed for its wool. 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 for the activity data are determined by TurkStat experts and uncertainty values for EFs are taken from the

IPCC Guidelines. The calculated AD uncertainty figure is 12.36% whereas the EF uncertainty value is 12.06% figured out by using Equation 3.2 in the IPCC Guidelines Vol. 1.

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.

Recalculation:

The emissions for cattle have been estimated using T2 method for the first time in this submission. The results for cattle in enteric fermentation are presented both in Figure 5.4 and Table 5.9. Moreover Table 5.10 presents key country specific parameters regarding T2 calculation, except for methane conversion factor which is a default value given in the 2006 IPCC Guidelines.

Figure 5.4 Comparing enteric fermentation emissions for cattle by different tiers

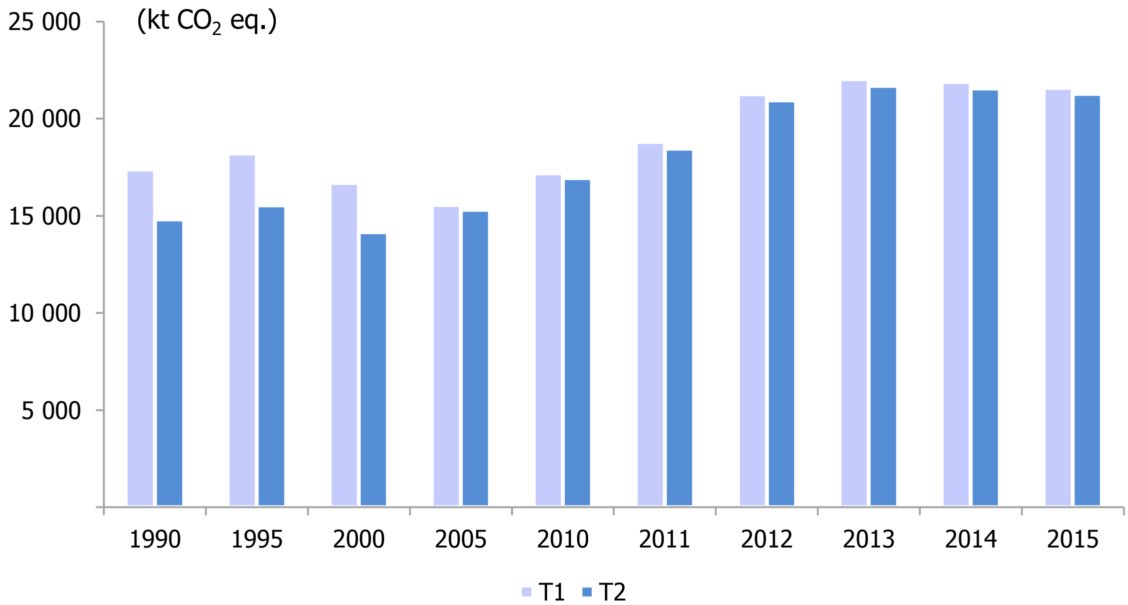


Table 5.9 Enteric fermentation emissions, Cattle, 1990-2015

(kt CO_2 eq.)

	Dairy Cattle		Other Cattle		Total Cattle	
Year	T1	T2	T1	T2	T1	T2
1990	10 937	8 949	6 444	5 859	17 381	14 807
1991	11 440	9 398	6 878	6 287	18 318	15 685
1992	11 397	9 373	6 910	6 318	18 307	15 691
1993	11 392	9 384	6 907	6 269	18 299	15 653
1994	11 524	9 503	6 837	6 187	18 361	15 690
1995	11 271	9 323	6 937	6 224	18 208	15 547
1996	11 462	9 475	6 953	6 206	18 416	15 681
1997	10 771	8 892	6 569	5 834	17 340	14 726
1998	10 589	8 750	6 512	5 736	17 101	14 485
1999	10 710	8 842	6 481	5 686	17 192	14 528
2000	10 245	8 484	6 441	5 678	16 685	14 162
2001	9 893	8 200	6 418	5 676	16 312	13 876
2002	8 592	7 134	6 358	5 317	14 950	12 450
2003	9 887	8 464	5 579	5 565	15 466	14 029
2004	7 619	7 136	7 278	7 464	14 897	14 599
2005	7 890	7 401	7 671	7 912	15 560	15 313
2006	8 348	7 862	7 853	8 073	16 201	15 935
2007	8 506	8 049	7 999	8 205	16 505	16 254
2008	8 295	7 875	7 966	8 163	16 261	16 038
2009	8 444	8 032	7 744	7 879	16 188	15 911
2010	8 959	8 535	8 234	8 411	17 193	16 946
2011	9 839	9 390	8 960	9 067	18 799	18 456
2012	11 281	10 779	9 968	10 158	21 249	20 938
2013	11 684	11 169	10 349	10 519	22 033	21 688
2014	11 767	11 271	10 121	10 277	21 888	21 548
2015	11 651	11 182	9 938	10 092	21 590	21 274

Figures in the table may not add up to the total due to rounding.

Table 5.10 Key T2 parameters used/calculated and estimated emissions for cattle, 1990 - 2015

	Dairy Cattle						Other Cattle				
Year	CH_4 Emissions (kt)	Mass (kg)	GE intake (MJ/head /day)	CH_4 Conversion rates, Y_m (%)	Milk yield (kg/day)	Digestibility of feed (%)	CH_4 Emissions (kt)	Mass (kg)	GE intake (MJ/head/ day)	CH_4 Conversion rates, Y_m (%)	Digestibility of feed (%)
1990	357.9	350.4	478.2	6.50	3.70	64.19	234.4	180.4	297.1	6.50	60.77
1991	375.9	356.6	479.1	6.50	3.86	64.47	251.5	185.1	299.2	6.50	61.13
1992	374.9	360.3	479.1	6.50	3.93	64.65	252.7	186.6	299.4	6.50	61.27
1993	375.4	365.3	479.1	6.50	4.04	64.92	250.8	187.9	297.9	6.50	61.52
1994	380.1	368.1	479.1	6.50	4.11	65.08	247.5	189.9	297.1	6.50	61.80
1995	372.9	377.4	479.1	6.50	4.32	65.54	249.0	192.1	295.6	6.50	62.08
1996	379.0	379.9	478.3	6.50	4.35	65.66	248.3	192.7	294.3	6.50	62.22
1997	355.7	382.1	477.5	6.50	4.37	65.78	233.4	191.9	292.8	6.50	62.23
1998	350.0	383.8	477.3	6.50	4.41	65.88	229.4	191.5	291.0	6.50	62.29
1999	353.7	386.1	476.4	6.50	4.44	66.01	227.4	192.1	289.9	6.50	62.43
2000	339.4	389.0	477.3	6.50	4.53	66.14	227.1	194.3	291.5	6.50	62.54
2001	328.0	391.2	477.2	6.50	4.57	66.22	227.0	195.6	292.2	6.50	62.60
2002	285.3	396.2	476.8	6.50	4.67	66.43	212.7	185.9	277.0	6.50	62.44
2003	338.6	398.7	491.1	6.50	5.17	66.49	222.6	228.7	328.1	6.50	63.66
2004	285.4	400.7	535.8	6.50	6.79	66.53	298.5	251.8	337.2	6.50	64.43
2005	296.0	404.1	535.7	6.50	6.87	66.61	316.5	253.6	339.3	6.50	64.56
2006	314.5	413.3	535.8	6.50	7.11	66.94	322.9	258.9	338.9	6.50	64.84
2007	322.0	421.4	535.9	6.50	7.31	67.09	328.2	265.0	338.9	6.50	65.02
2008	315.0	431.4	535.9	6.50	7.56	67.48	326.5	272.8	339.3	6.50	65.35
2009	321.3	435.9	536.0	6.50	7.68	67.64	315.1	274.1	337.3	6.50	65.53
2010	341.4	440.9	535.9	6.50	7.80	67.83	336.5	278.8	339.2	6.50	65.84
2011	375.6	446.8	535.8	6.50	7.94	68.05	362.7	280.8	336.5	6.50	65.97
2012	431.2	451.5	535.7	6.50	8.06	68.24	406.3	287.0	339.1	6.50	66.23
2013	446.7	454.6	535.6	6.50	8.14	68.40	420.8	288.6	338.3	6.50	66.33
2014	450.8	461.0	535.7	6.50	8.30	68.66	411.1	293.1	339.1	6.50	66.55
2015	447.3	464.2	535.7	6.50	8.38	68.70	403.7	296.0	339.3	6.50	66.61

Planned Improvement:

All data and methodologies are kept under review. It is planned to estimate emissions regarding significant livestock categories (i.e. sheep) using the T2 method with respect to the 2006 IPCC Guidelines. Collaboration with the MFAL is ongoing in particular on the availability of detailed data on the disaggregation of animals by characteristics like age, type etc.

5.3. Manure Management (Category 3.B)

Source Category Description:

In Turkey, representative manure management systems (MMS) distribution data are not available for the entire country. Therefore default distributions for animal types are mainly used regarding this subcategory.

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 2015, emissions including CH_4 and N_2O from the manure management category reached 6 304 kt CO_2 eq. This number represented 11% of emissions of the agriculture sector. Emissions in 2015 from this source category increased by 2 192 kt CO_2 eq., nearly 53.3% above its 1990 level of 4 111 kt CO_2 eq. Similarly, the increase is calculated as nearly 808 kt CO_2 eq. for CH_4 emissions and 1 385 kt CO_2 eq. for N_2O emissions and increasing percentages are 34.3% and 78.7% respectively for the same period, 1990-2015, also shown in Table 5.7.

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 3 160 kt CO_2 eq. (50.1% of the manure management category) which represented 5.5% of agricultural emissions (Table 5.7) in 2015 whereas the respective share in 1990 was 5.2%, around a quarter 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 9.4% and 10.4% for 1990 and 2015 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 3 144 kt CO_2 eq. (49.9% of the manure management category) which represented 5.5% of agricultural emissions in 2015 (Table 5.7) whereas the respective share in 1990 was 3.9%, less than the current reporting percentage of 2015.

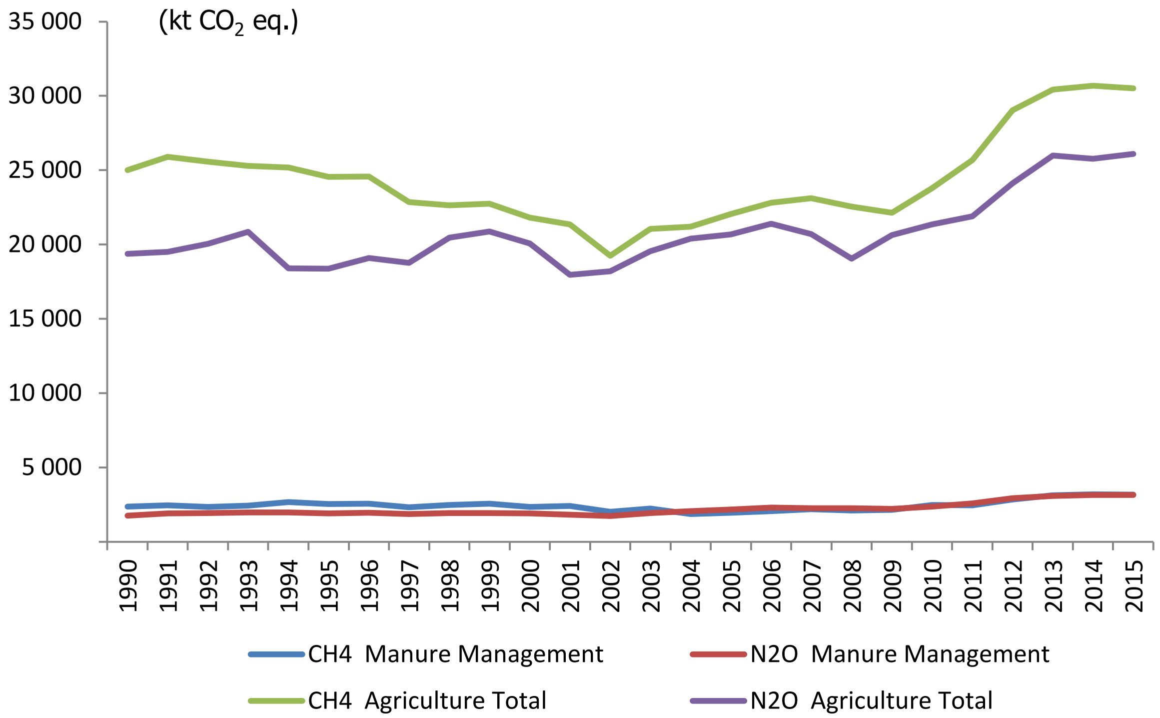
With respect to all N_2O emissions of the agriculture sector, the second highest N_2O emission source category was manure management after agricultural soils category for all reporting years. N_2O emissions of manure management accounted for 9.1% and 12% of all N_2O emissions in the agriculture sector in 1990 and 2015 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 (10.4% and 12%, 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. Figure 5.5 enables a trend comparison of these two gas emissions.

Figure 5.5 Comparing CH_4 and N_2O emission trends, 1990-2015



Typical animal mass values and Nitrogen excretion rates (Nex) are crucial parameters in estimating emissions from manure management. Table 5.11 shows these values for most of the significant animal categories. Typical animal mass values used in the calculations for the remaining animal categories, namely horses, mules & assess, camels, swine are 238 kg, 130 kg, 217 kg, 28 kg respectively whereas Nex values (per head) for these animal categories are 39.96 kg N, 21.83 kg N, 36.43 kg N, 4.11 kg N in the same order for all reporting years.

Table 5.11 Typical animal mass values and nitrogen excretion rates per animal (kg), 1990-2015

	Dairy cattle		Other cattle		Sheep (merinos)		Sheep (domestic)		Goats		Buffalo		Poultry	
Year	(mass)	(Nex)	(mass)	(Nex)	(mass)	(Nex)	(mass)	(Nex)	(mass)	(Nex)	(mass)	(Nex)	(mass)	(Nex)
1990	350.36	60.38	180.43	22.39	38.25	13.50	28	11.96	30	15.00	380	44.38	2.12	0.63
1991	356.58	61.47	185.11	22.97	38.25	13.50	28	11.96	30	15.00	380	44.38	2.08	0.62
1992	360.25	62.11	186.58	23.15	38.25	13.50	28	11.96	30	15.00	380	44.38	2.08	0.62
1993	365.29	62.99	187.92	23.32	38.25	13.50	28	11.96	30	15.00	380	44.38	2.07	0.62
1994	368.09	63.49	189.92	23.57	38.25	13.50	28	11.96	30	15.00	380	44.38	2.07	0.62
1995	377.38	65.12	192.08	23.84	38.25	13.50	28	11.96	30	15.00	380	44.38	2.09	0.62
1996	379.90	65.56	192.67	23.91	38.25	13.50	28	11.96	30	15.00	380	44.38	2.08	0.62
1997	382.06	65.93	191.95	23.82	38.25	13.50	28	11.96	30	15.00	380	44.38	2.11	0.63
1998	383.79	66.24	191.49	23.76	38.25	13.50	28	11.96	30	15.00	380	44.38	2.06	0.61
1999	386.05	66.64	192.15	23.85	38.25	13.50	28	11.96	30	15.00	380	44.38	2.06	0.61
2000	388.99	67.15	194.31	24.11	38.25	13.50	28	11.96	30	15.00	380	44.38	2.05	0.61
2001	391.22	67.54	195.64	24.28	38.25	13.50	28	11.96	30	15.00	380	44.38	2.05	0.61
2002	396.16	68.41	185.89	23.07	38.25	13.50	28	11.96	30	15.00	380	44.38	2.05	0.61
2003	398.71	68.85	228.67	28.38	38.25	13.50	28	11.96	30	15.00	380	44.38	2.05	0.61
2004	400.66	69.19	251.76	31.24	38.25	13.50	28	11.96	30	15.00	380	44.38	2.05	0.61
2005	404.07	69.79	253.61	31.47	38.25	13.50	28	11.96	30	15.00	380	44.38	2.04	0.61
2006	413.27	71.40	258.90	32.13	38.25	13.50	28	11.96	30	15.00	380	44.38	2.03	0.61
2007	421.42	72.83	264.97	32.88	38.25	13.50	28	11.96	30	15.00	380	44.38	2.03	0.61
2008	431.39	74.58	272.78	33.85	38.25	13.50	28	11.96	30	15.00	380	44.38	2.05	0.61
2009	435.92	75.37	274.12	34.02	38.25	13.50	28	11.96	30	15.00	380	44.38	2.04	0.61
2010	440.94	76.25	278.75	34.59	38.25	13.50	28	11.96	30	15.00	380	44.38	2.04	0.61
2011	446.77	77.27	280.78	34.84	38.25	13.50	28	11.96	30	15.00	380	44.38	2.04	0.61
2012	451.53	78.10	287.04	35.62	38.25	13.50	28	11.96	30	15.00	380	44.38	2.04	0.61
2013	454.58	78.64	288.55	35.81	38.25	13.50	28	11.96	30	15.00	380	44.38	2.04	0.61
2014	461.02	79.77	293.07	36.37	38.25	13.50	28	11.96	30	15.00	380	44.38	2.03	0.61
2015	464.23	80.33	295.96	36.73	38.25	13.50	28	11.96	30	15.00	380	44.38	2.03	0.61

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 2006 IPCC 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. Table 5.12 shows default EFs based on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Vol.4 for cattle types and swine for each region according to temperature classification. Considering annual average air temperature, provinces are categorized between cool ($0^{o}C$ - $14^{o}C$) or temperate ($15^{o}C$ - $25^{o}C$) 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 CH_4/head/year, which is the average of 21 kg CH_4/head/year and 9 kg CH_4/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, given in the 2006 IPCC Guidelines, are also broken into two climate regions and shown in Table 5.13. Turkey has not a single province with an annual average temperature above 25°C, therefore the warm climate region is not present.

Table 5.12 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	19.0	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	2	2	2	2	3	3	3	3	4	4	4	5	5	5	6

Table 5.13 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

Furthermore, Table 5.14 presents the Manure Management System (MMS) used based on the default values given in 2006 IPCC Guidelines Vol. 4.

Table 5.14 Manure Management System Distribution, 1990 - 2015

(%)

MS	Anaerobic lagoon	Liquid system	Daily spread	Solid storage	Dry lot	Pasture range and paddock	Composting	Digesters	Burned for fuel or as waste	Other
Dairy Cattle - Culture	2.0	36.9	18.0	18.4		20.0		1.0	3.5	0.3
Dairy Cattle - Hybrid	3.0	37.4	23.5	9.2		20.0		1.5	5.3	0.1
Dairy Cattle - Domestic	4.0	38.0	29.0			20.0		2.0	7.0	
Non Dairy Cattle			2.0		46.0	50.0			2.0	
Swine		40.0			54.0				6.0	
Sheep - Domestic						100.0				
Sheep - Merinos						100.0				
Buffalo			4.0		41.0	50.0			5.0	
Camels						100.0				
Horses						80.0				20.0
Goats						80.0				20.0
Mules and Asses						80.0				20.0
Chickens						20.0				80.0
Ducks & Geese						100.0				
Turkeys						20.0				80.0

Uncertainties and Time-Series Consistency:

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.

The AD for this sector are gathered from agricultural statistics of TurkStat. Uncertainties for activity data are determined by TurkStat experts and uncertainty values for EFs are taken from the IPCC Guidelines. The calculated AD uncertainty figure is 14.1% both for CH_4 and N_2O gases whereas EF uncertainty values are 30% and 50% for CH_4 and N_2O gases respectively, as given in the 2006 IPCC Guidelines.

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.

Recalculation:

As a result of QA/QC activities in this category a series of recalculations were done mainly because of calculation errors. N_2O emissions from manure management have been recalculated for the reporting years. The current reported calculations reflect the up-to-date emission values for all twenty-six reporting years starting from 1990.

Planned Improvement:

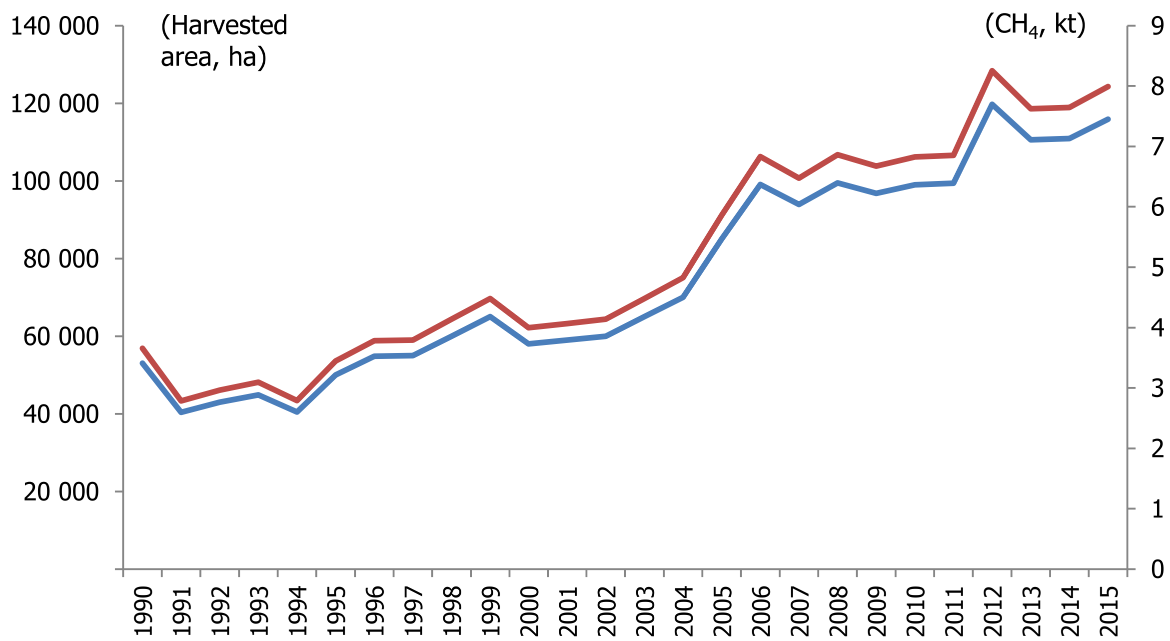
All data and methodologies are kept under review and an upgrade from T1 to T2 might be considered in the future. The prerequisite for such a step in our calculation is the availability of country-specific data on animal waste management system representing our country. Efforts to collect detailed information on manure management systems in Turkey will be undertaken.

5.4. Rice Cultivation (Category 3.C)

Source Category Description:

GHG emissions from rice production are the result of the CH_4 gas being released by anaerobic digestion of organic substances in the paddy fields. Aforementioned CH_4 gas emissions are calculated according to the approach given in the IPCC 2006 Guidelines CH_4 emissions are estimated using the IPCC's default emission factor. 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, fertilizer application, rice cultivar also affect CH_4 emissions. CH_4 emissions from rice cultivation are not a key category. Figure 5.6 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 1990-2015.

Figure 5.6 Harvested area and emitted CH_4 for rice cultivation, 1990-2015



Rice cultivation contributed 7.99 kt CH_4 (199.7 kt CO_2 eq.) emissions or 0.35% of total agricultural emissions in 2015. Emissions have slightly increased by around 4.5% between the years 2014 and 2015. Overall, emissions from rice cultivation increased by 108.4 kt CO_2 eq. (118.6%) for the entire reporting period.

Rice cultivation is the lowest contributor to CH_4 emissions in the agriculture sector for each of the reported twenty-six years, ranging from 0.15% (1991) to 0.41% (2008) respectively. The respective percentage value for 2015 is calculated as 0.35%.

Methodological Issues:

Rice production data are taken from TurkStat agricultural statistics related and area records are available for all districts of Turkey since 1990. A T1 method is used for calculation and the emission factor and the scaling factor are determined by IPCC Guidelines. The cultivation period of rice production in Turkey is 130 days. Irrigated, intermittently flooded with single aeration rice production method is being applied in our country. According to this method, the rice field is intermittently left in the water having only one ventilation. The remainder of the ripening period is the days when water is not retained for 235 days, and since the IPCC threshold value is greater than 180 days, the scaling factor associated with the water regime at maturity is SF_w 0.60. The scaling factor of the water regime before ripening is SF_p 0.68 and the emission factor applied is 1.30 CH_4/ha/day.

Uncertainties and Time-Series Consistency:

The AD for this sector are gathered from agricultural statistics of TurkStat and the related AD uncertainty figure is considered to be 5%. Uncertainty value for the EF is calculated as 33% according to the information given in the 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.

Recalculation:

There is no recalculation.

Planned Improvement:

All data and methodologies are kept under review. We are searching for data in order to reflect our country specific conditions better.

5.5. Agricultural Soils (Category 3.D)

Source Category Description:

This source contains N_2O emissions from synthetic fertilizers, organic fertilizers, and crop residue. This source category is a key category. In this section the N_2O emissions from pasture, range and paddock manure, cultivation of organic soils, and indirect emissions, which consists of atmospheric deposition and nitrogen leaching and run-off, are estimated too. The complete time series regarding emissions are submitted in this submission. Both direct and indirect emissions from this source category are key categories.

Agriculture soils produced 76.8 kt N_2O (22.9 Mt CO_2 eq.) emissions in 2015 and agriculture soils is the largest source category of N_2O emissions in Turkey. This represented 87.6% of N_2O emissions in the Agriculture sector, 68.7% of Turkey's N_2O emissions, and 39.8% of agricultural emissions. Emissions were 5 350 kt CO_2 eq. (30.5%) above the 1990 level of 17 528 kt CO_2 eq. in the year 2015. Direct N_2O emissions increased by 4 265 kt CO_2 eq. whereas indirect N_2O emissions increased by 1 085 kt CO_2 eq. for the given period 1990-2015. The increase is a result of the emission changes of direct and indirect N_2O emissions from managed soils. The total change of direct N_2O emissions is a result of increases in the subcategories inorganic N fertilizers, organic N fertilizers, urine and dung deposited by grazing animals, crop residues, and a decrease in cultivation of organic soils. Direct N_2O emissions due to mineralization/immobilization related to loss/gain of soil organic carbon in the agriculture sector did not occur for the entire reporting period.

Several subcategories contribute to emissions from agricultural soils from direct and indirect pathways (Table 5.15). 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 5.16 for direct and indirect N_2O emissions and the calculated subcategories of organic N fertilizers, including amounts and percentage data.

Table 5.15 Categories of N_2O emissions of agricultural soils, 1990-2015

(kt CO_2 eq.)

Year	Total N_2O emissions from managed soils	Direct N_2O emissions from managed soils						Indirect N_2O emissions from managed soils		
		Total	Inorganic N fertilizers	Organic N fertilizers	Urine and dung deposited by grazing animals	Crop residues	Cultivation of organic soils	Total	Atmospheric deposition	Nitrogen leaching and run-off
1990	17 528	13 163	5 618	1 328	4 521	1 612	84	4 365	1 586	2 779
1991	17 507	13 171	5 169	1 431	4 640	1 848	84	4 336	1 571	2 765
1992	18 034	13 573	5 649	1 446	4 583	1 813	84	4 461	1 608	2 853
1993	18 804	14 169	6 253	1 475	4 480	1 877	84	4 634	1 651	2 983
1994	16 356	12 318	4 714	1 488	4 353	1 679	84	4 038	1 473	2 565
1995	16 408	12 380	4 934	1 397	4 154	1 810	84	4 029	1 443	2 586
1996	17 077	12 891	5 373	1 451	4 136	1 847	84	4 186	1 490	2 696
1997	16 834	12 725	5 465	1 403	3 872	1 901	84	4 109	1 443	2 666
1998	18 453	13 965	6 532	1 446	3 853	2 048	84	4 489	1 550	2 939
1999	18 883	14 269	6 957	1 498	3 884	1 846	85	4 614	1 608	3 006
2000	18 088	13 686	6 456	1 487	3 729	1 930	85	4 402	1 525	2 877
2001	16 055	12 150	5 304	1 403	3 562	1 797	85	3 905	1 367	2 539
2002	16 383	12 405	5 615	1 438	3 350	1 918	84	3 978	1 372	2 606
2003	17 549	13 285	6 279	1 548	3 528	1 845	84	4 264	1 479	2 785
2004	18 239	13 855	6 400	1 485	3 647	2 239	84	4 385	1 487	2 897
2005	18 429	14 016	6 427	1 440	3 741	2 324	84	4 413	1 490	2 922
2006	19 018	14 468	6 587	1 522	3 870	2 405	84	4 550	1 538	3 012
2007	18 374	13 960	6 349	1 564	3 809	2 155	83	4 414	1 513	2 901
2008	16 729	12 729	5 306	1 520	3 677	2 143	83	3 999	1 374	2 625
2009	18 362	13 983	6 621	1 506	3 490	2 283	83	4 379	1 469	2 911
2010	18 900	14 419	6 292	1 555	3 755	2 734	83	4 480	1 486	2 994
2011	19 239	14 681	5 897	1 696	4 098	2 906	83	4 558	1 525	3 033
2012	21 105	16 089	6 706	1 818	4 589	2 894	82	5 016	1 699	3 317
2013	22 827	17 403	7 419	1 881	4 853	3 167	82	5 424	1 824	3 600
2014	22 556	17 173	6 991	1 981	5 056	3 062	82	5 383	1 839	3 544
2015	22 878	17 428	6 961	2 020	5 084	3 280	82	5 450	1 849	3 601

Figures in the table may not add up to the total due to rounding.

Table 5.16 Overview of agricultural soils and organic N fertilizers, 1990 - 2015

		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	44 824	17 528	13 163	75.1	4 365	24.9	1 328	1 196	90.0	133	10.0
1991	45 822	17 507	13 171	75.2	4 336	24.8	1 431	1 299	90.7	133	9.3
1992	46 069	18 034	13 573	75.3	4 461	24.7	1 446	1 313	90.8	133	9.2
1993	46 762	18 804	14 169	75.4	4 634	24.6	1 475	1 342	91.0	133	9.0
1994	44 040	16 356	12 318	75.3	4 038	24.7	1 488	1 355	91.1	133	8.9
1995	43 351	16 408	12 380	75.4	4 029	24.6	1 397	1 288	92.2	110	7.8
1996	44 190	17 077	12 891	75.5	4 186	24.5	1 451	1 328	91.5	123	8.5
1997	42 146	16 834	12 725	75.6	4 109	24.4	1 403	1 279	91.1	124	8.9
1998	43 735	18 453	13 965	75.7	4 489	24.3	1 446	1 332	92.1	115	7.9
1999	44 360	18 883	14 269	75.6	4 614	24.4	1 498	1 342	89.6	156	10.4
2000	42 504	18 088	13 686	75.7	4 402	24.3	1 487	1 322	88.9	165	11.1
2001	39 842	16 055	12 150	75.7	3 905	24.3	1 403	1 252	89.3	151	10.7
2002	37 961	16 383	12 405	75.7	3 978	24.3	1 438	1 173	81.6	264	18.4
2003	41 152	17 549	13 285	75.7	4 264	24.3	1 548	1 323	85.5	225	14.5
2004	42 228	18 239	13 855	76.0	4 385	24.0	1 485	1 243	83.7	242	16.3
2005	43 335	18 429	14 016	76.1	4 413	23.9	1 440	1 303	90.5	137	9.5
2006	44 797	19 018	14 468	76.1	4 550	23.9	1 522	1 388	91.2	134	8.8
2007	44 383	18 374	13 960	76.0	4 414	24.0	1 564	1 334	85.3	230	14.7
2008	42 149	16 729	12 729	76.1	3 999	23.9	1 520	1 301	85.6	219	14.4
2009	43 359	18 362	13 983	76.2	4 379	23.8	1 506	1 289	85.6	217	14.4
2010	45 776	18 900	14 419	76.3	4 480	23.7	1 555	1 375	88.4	180	11.6
2011	48 145	19 239	14 681	76.3	4 558	23.7	1 696	1 495	88.2	201	11.8
2012	53 770	21 105	16 089	76.2	5 016	23.8	1 818	1 695	93.2	124	6.8
2013	57 198	22 827	17 403	76.2	5 424	23.8	1 881	1 771	94.1	110	5.9
2014	57 233	22 556	17 173	76.1	5 383	23.9	1 981	1 823	92.0	159	8.0
2015	57 422	22 878	17 428	76.2	5 450	23.8	2 020	1 834	90.7	187	9.3

Figures in the table may not add up to the total due to rounding.

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-ground 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 17 428 kt CO_2 eq. (76.2%) to emissions from the Agricultural soils category and 30.4% of emissions under the total Agriculture sector in 2015. This is an increase of 4 265 kt CO_2 eq. (32.4%) from the 1990 level of 13 163 kt CO_2 eq.

A major direct source of N_2O emissions from agricultural soils is an outcome of the use of synthetic fertilizer. Almost 31.5% increase in direct emissions from agricultural soils observed between 1990 and 2015 is a result of synthetic fertilizers application. 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 2015, N_2O emissions from synthetic nitrogen fertilizers contributed 6 961 kt CO_2 eq. (39.9%) 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 12.1% to the total emissions under the agriculture sector.

In 2015, N_2O emissions from organic N fertilizers contributed 2 020 kt CO_2 eq. (8.8%) to emissions from the agricultural soils category and 3.5% of emissions under the total agriculture sector. An increase of 692 kt CO_2 eq. (52.1%) is observed from the 1990 level of 1 328 kt CO_2 eq.

As observed from Table 5.15, N_2O emissions from urine and dung deposited by grazing animals contributed 5 084 kt CO_2 eq. (22.2%) to emissions from the agricultural soils category and 8.9% of emissions under the total agriculture sector. This is an increase of 563 kt CO_2 eq. (12.5%) from the 1990 level of 4 521 kt CO_2 eq. Moreover, N_2O emissions from crop residues contributed 3 280 kt CO_2 eq. (14.3%) to emissions from the agricultural soils category and 5.7% of emissions under the total agriculture sector. This is an increase of 1 668 kt CO_2 eq. (103.5%) from the 1990 level of 1 612 kt CO_2 eq.

Indirect N_2O emissions were calculated as 5 450 kt CO_2 eq. for 2015. Indirect N_2O emissions through atmospheric deposition contributed 1 849 kt CO_2 eq. (8.1%) to emissions from the agricultural soils category and 3.2% of emissions under the total agriculture sector in 2015. This is an increase of 263 kt CO_2 eq. (16.6%) from the 1990 level of 1 586 kt CO_2 eq. Indirect N_2O emissions through leaching and runoff added 3 601 kt CO_2 eq. (15.7%) to emissions from the Agricultural soils category in 2015 and 6.3% of emissions under the total Agriculture sector.

Briefly, agricultural soils emissions have increased by 30.5% (around 5.4 Mt CO_2 eq.) between 1990 and 2015. The increase is a result of the emission changes of direct and indirect N_2O emissions from managed soils. The former increased by 4.3 Mt CO_2 eq. and the latter by 1.1 Mt CO_2 eq. for the given period 1990-2015. The total net increase of 4.3 Mt CO_2 eq. of direct N_2O emissions consist of inorganic N fertilizers, organic N fertilizers, urine and dung deposited by grazing animals, crop residues, and cultivation of organic soils. The related figures of changes for 1990-2015 concerning these five subcategories mentioned are 1 344 kt (23.9%), 692 kt (52.1%), 563 kt (12.4%), 1668 kt (103.5%), and -2 kt (-2.2%) respectively. Organic N fertilizers are further subdivided into three groups, namely animal manure, sewage sludge, and other organic fertilizers all applied to soils. Sewage sludge applied to soils, a subcategory of organic N fertilizers, cannot be estimated due to insufficient activity data for the reporting period. Increase in animal manure applied to soils is 638 kt (52.1%) from 1 196 kt to 1 834 kt whereas the increase in other organic fertilizers applied to soils is 54 kt (41%) from 133 kt to 187 kt. On the other hand, the total increase of 1.1 Mt CO_2 eq. of indirect N_2O emissions is divided into two categories, atmospheric deposition and nitrogen leaching and run-off. The related figures of changes for these subcategories are 263 kt (16.6%) and 822 kt (29.6%) for the period 1990-2015 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.

When a crop is harvested, a portion of the crop is left in the field to decompose. The remaining plant matter is a nitrogen source that undergoes nitrification and denitrification and can thus contribute to N_2O production. Crop residue calculation follows in principle the 2006 IPCC Guidelines with small refinements. N_2O emissions are now calculated based on all cultivated plants in Turkey. Both aboveground and belowground crop residues are included. Crop yields vary from year to year, as well as do cultivated area, which cause fluctuations in crop residue emissions. For crop residues N_2O emissions calculations, better data for renewal fraction and fraction removed were asked and received from MFAL. The following table summarizes the crop headings for which N_2O emissions due to crop residues are calculated for in our country.

Table 5.17 Crop data used for crop residue calculations

Major Crop Types	Individual Crops	
Grains	Maize	Sorghum
Beans & Pulses (N fix)	Wheat	Soyabean
Tubers	Rice	Dry bean
Root crops and Other	Barley	Potato
N-fixing forages	Oats	Peanut
Non-N-fixing forages	Millet	Alfalfa
Grass-clover mixtures		

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 except the data on synthetic fertilizer consumption amounts, which is obtained from the MFAL. Uncertainties for the AD are calculated as 55.2% by TurkStat using Equation 3.2 in the IPCC Guidelines Vol. 1 whereas the respective EF uncertainty is figured out as 95.96% after taking the default uncertainties in the IPCC Guidelines into consideration.

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.

Recalculation:

In this source category, a major recalculation was a result of the removal of a main calculation error. There were changes also in the crop production emissions calculation. In this year's submission, changes to calculations of N_2O emissions from crop residue were mainly due to changes in our national database for agricultural statistics by corrections to the classification of data. There are newly added plants under the heading of Crop Production Statistics. Therefore N contributions of these additional crops are also calculated. Furthermore all classifications of major crop types were checked, minor flaws of time series data were audited entirely, and whole data series from 1990 to 2015 were recalculated. Additionally, emissions related to soil organic matter have been divided according to the methodology and updated according to the newly figures submitted in the LULUCF sector. Another subcategory, emissions from cultivation of organic soils, have been added to the Inventory this year.

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 also useful to improve emission estimations from agricultural 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:

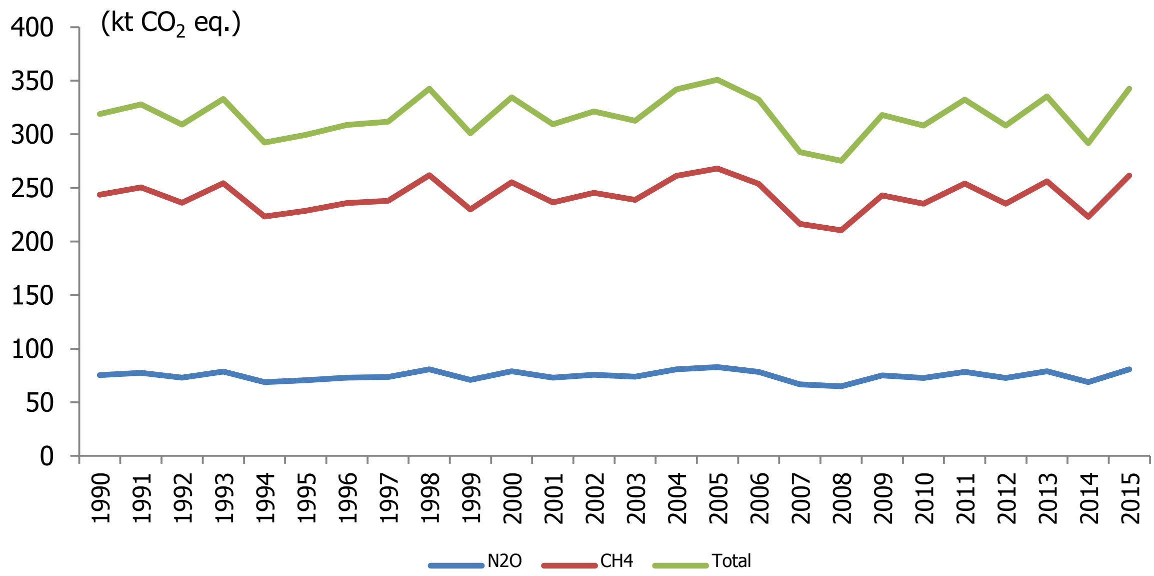
The burning of residual crop material releases CH_4, N_2O, CO, and NO_x emissions where CO and NO_x are indirect greenhouse gases. The resulting atmospheric release of agricultural waste is not considered to be a net carbon dioxide source, as carbon is being absorbed again during the growing season, despite CO_2 emissions. 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-six reporting years. After consultations with the Ministry of Food, Agriculture and Livestock, wheat and barley cultivation areas in Turkey were found to be included in field burning. As field burning is illegal and widely under control, it is becoming rare. Also, the machinery is usually able to manage the excess straw left on fields after harvesting. As shown in detail in Table 5.18, CH_4 and N_2O emissions contributed 262 kt CO_2 eq. and 81 kt CO_2 eq. respectively to this source category in 2015.

Table 5.18 Field burning of agricultural residues emissions, 1990 and 2015

Category	Emission (kt CO_2 eq.) 1990	(%)	2015	(%)	Changes from 1990 to 2015 (kt CO_2 eq.)	(%)	Percentages of agricultural sector (%) 1990	2015
Field burning of agricultural residues	319	100	342	100	23.6	0.1	0.71	0.60
CH_4	244	76	262	76	18.0	0.1	0.54	0.46
N_2O	75	24	81	24	5.6	0.1	0.17	0.14

In 2015, field burning of agricultural residues contributed 342 kt CO_2 eq. This emission value represented 0.6% of all agricultural emissions. Total field burning CO_2 eq. emissions increased by nearly 51 kt in 2015 compared to the previous year because of (mainly) newly added plants and other improvements. For the base year 1990, this total emission was changed to 319 kt with corrections. CH_4 and N_2O emissions from field burning show mostly stable trend except the year 2008. The decline in 2008 is a result of reductions in harvested areas due to natural phenomena such as frost and floods. For the reported years, CH_4 emissions had a minimum value of 210 kt CO_2 eq. in 2008 and a maximum value of 268 CO_2 eq. in 2005 whereas minimum N_2O emissions were 65 kt CO_2 eq. in 2008 and 83 kt CO_2 eq. in 2005. The overall emission trends can also be observed in Figure 5.7. CH_4, N_2O and total emissions from this source category have similar patterns showing ups and downs.

Figure 5.7 Emissions of field burning of agricultural residues, 1990-2015



Total emissions from this source category were highly similar to the level of 1990 showing only a slight increase of 24 kt CO_2 eq. between 1990 and 2015. The respective percentage change is calculated as 7.4%.

Methodological Issues:

Activity data used in the emission estimation are taken from TurkStat agricultural statistics. The emissions are calculated according to the 2006 IPCC Guidelines Equation 2.27 given in Chapter 2. Crop residue per hectare is multiplied with area of both cereal and then with fraction burned, combustion factor and the related emission factor. Both CO_2 and N_2O emissions are calculated using the IPCC Tier 1 approach. 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. 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 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. Uncertainty values concerning AD and EF for two GHG sources under this source category, namely CH_4 and N_2O, are each estimated to be 50% as recommended in the 2006 IPCC Guidelines.

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 in order to attain quality objectives. 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. Calculations are implemented every year during preparation phase of the NIR. If errors or inconsistencies are found, they are documented and corrected accordingly. Regarding field burning of agricultural residues, a more representative data for burned fraction were received from MFAL.

Moreover, annual checks are done whether new scientific articles for updating emission factors have been published in Turkey.

Recalculation:

Field burning of agricultural residues emissions were recalculated because of the removal of maize burning and the modifications undertaken in the calculations for crop production emissions including a change in the combustion factor used for Barley.

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 will consider evaluating possible data sources for this mandatory category.

5.9. Urea Application (Category 3.H)

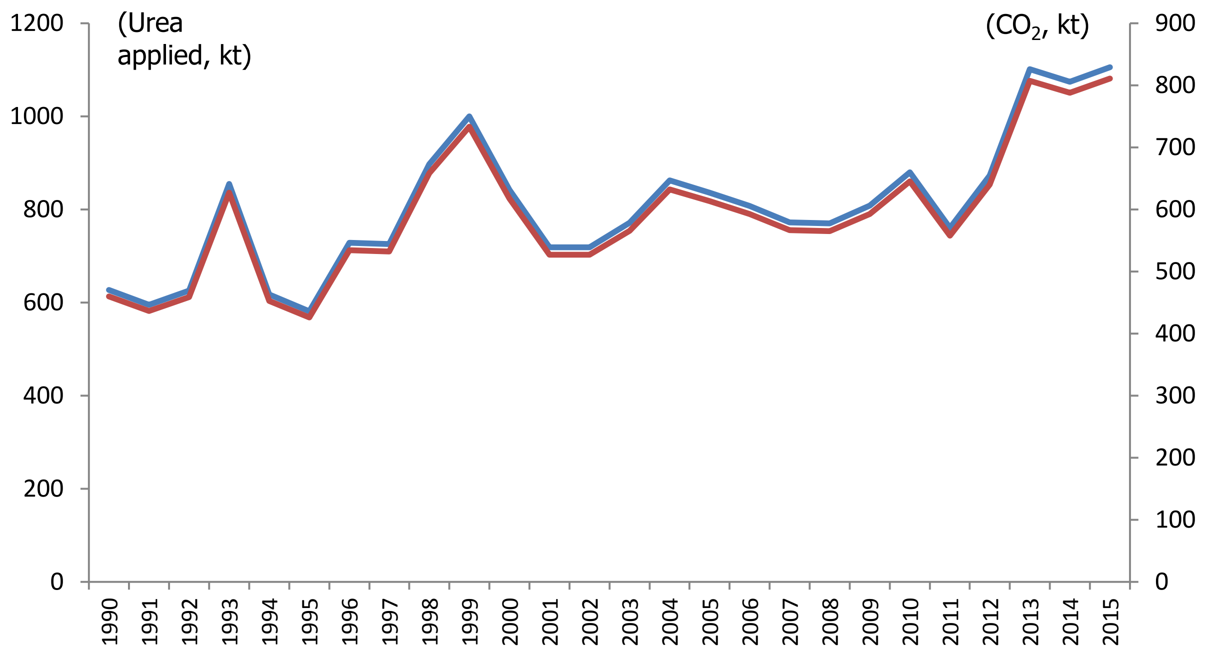
Source Category Description:

Adding urea to soils for fertilization leads to reduction of the CO_2 gas that was fixed during the industrial production process. Urea ($CO(NH_2)_2$) transforms to (NH_4^+), hydroxyl ion (OH^-) and bicarbonate (HCO_3^-) with the presence of urease and water. 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 810.6 kt CO_2 in 2015. This is an amount representing 1.4% of agricultural emissions. Emissions from the urea application in 2015 were 351 kt CO_2 eq. (76.2%) above its 1990 level of 460 kt CO_2 eq. This source category, CO_2 emissions from urea application, is not a key category.

Emissions values due to urea application are given in Table 5.7 for the period 1990-2015. Figure 5.8 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 from the figure as well as a slowly increasing trend for twenty-six reporting years.

Figure 5.8 Urea application and emitted CO_2, 1990-2015



Methodological Issues:

Emissions associated with the application of urea are calculated by using a T1 approach (equation 11.13; IPCC, 2006), using the default EF for carbon conversion of 0.20. This value equals the carbon content of atomic weight of urea. In order to calculate CO_2-C emissions resulting from urea application; the annual total amount of urea applied to the soils in the country is determined. Related AD required for the calculation are taken from the website of MFAL under the title of "Chemical fertilizer production, consumption, import and export statistics" which is updated every year for the subsequent year. Our country uses directly the production data presented as the related activity data.

Uncertainties and Time-Series Consistency:

Under the IPCC (2006) T1 methodologies, the default EFs are used which assume conservatively that all carbon in the urea is emitted as CO_2 into the atmosphere. The default EF is assumed to be certain under this theoretical assumption.

A default 10% uncertainty is applied regarding the AD used in the emission calculation of urea application whereas the uncertainty of the EF is taken as 50% as given in the IPCC Guidelines under the related section.

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 a significant tool for implementing QA/QC principles for the Inventory. AD for this source category is obtained from the MFAL. Data used for calculations are a part of official statistics which have their own QA/QC procedures. Specially, the time series was checked for the consistency. As a general QC check, the multiplication of activity data and emission factor was double checked for CO_2 emissions from urea application. Emission trends are analyzed. If there is a high fluctuation in the series then AD and emission calculation are re-examined.

Recalculation:

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)

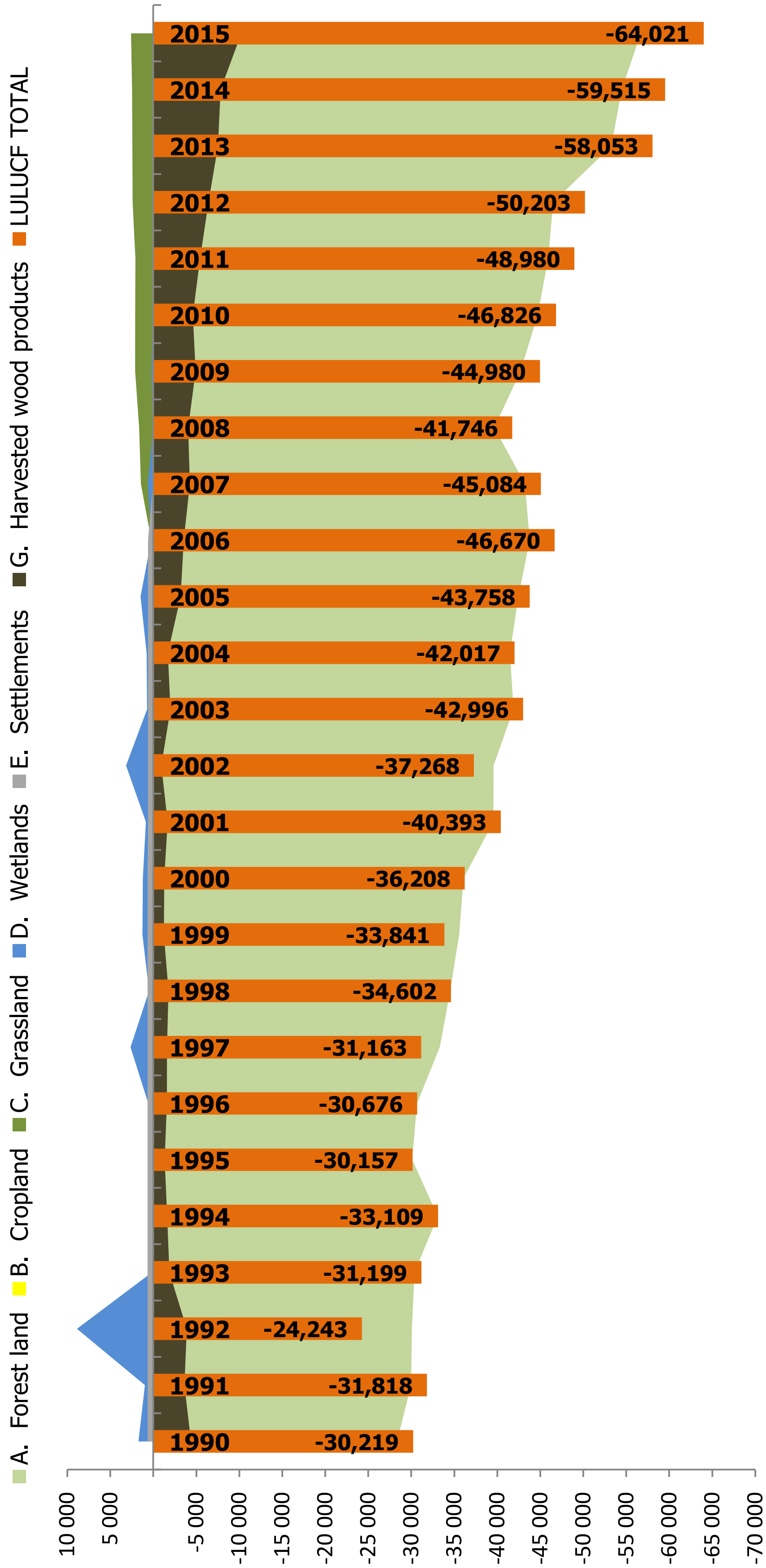
6.1. Sector Overview

This sector comprises GHG emissions and removals arising from land use, land use change and forestry (LULUCF). The Figure 6.1 presents removals/emissions from this sector for the 1990-2015 period by land-use categories.

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, dams) and settlements.

If the rises in removals in the LULUCF sector are analyzed on an annual basis most of them are derived from afforestation and reforestation campaings especially the period between 2008-2015. If the rises in emissions in the LULUCF sector are analyzed on an annual basis, the effects of forest fires (wildfires) and construction of dams are dominated. In 2008 29,749 ha forest area burned; in 1992 the greatest dam of Turkey (Atatürk Dam), in 1997 Dicle Dam and in 2002 Ermenek Dam were constructed.

Figure 6.1 Removals/emissions from LULUCF by land use categories, 1990-2015 (kt CO_2eq.)



The following subcategories have been reported as removals;

- Forest land remaining Forest land
- Land converted to Forestland
- Cropland remaining Cropland
- Harvested Wood Products

And the following subcategories have been reported as emissions;

- Land converted to Cropland
- Grassland remaining Grassland
- Land converted to Grassland
- Land converted to Settlements

The estimations for 1990-2015 were calculated according to equations (which are described in sections) in 2006 IPCC Guidelines for National Greenhouse Gas Inventories-Agriculture, Forestry and Other Land Use (Volume 4).

The outcome of the key category analysis for 2015 is listed in table 6.1.

Table 6.1 Key categories identification in the LULUCF sector (Tier 1)

	CATEGORIES OF EMISSIONS AND REMOVALS	Gas	2015
4.A.1	Forest Land Remaining Forest Land	CO2	Key (L,T)
4.A.2	Land Converted to Forest Land	CO2	Key (L,T)
4.B.2	Land Converted to Cropland	CO2	Key (T)
4.C.2	Land Converted to Grassland	CO2	Key (L,T)
4.D.2	Land Converted to Wetlands	CO2	Key (T)
4.G	Harvested Wood Products	CO2	Key (L,T)

Note: L = Level assessment; T = Trend assessment.

Table 6.2 Total emissions and removals in Turkey, 1990-2015

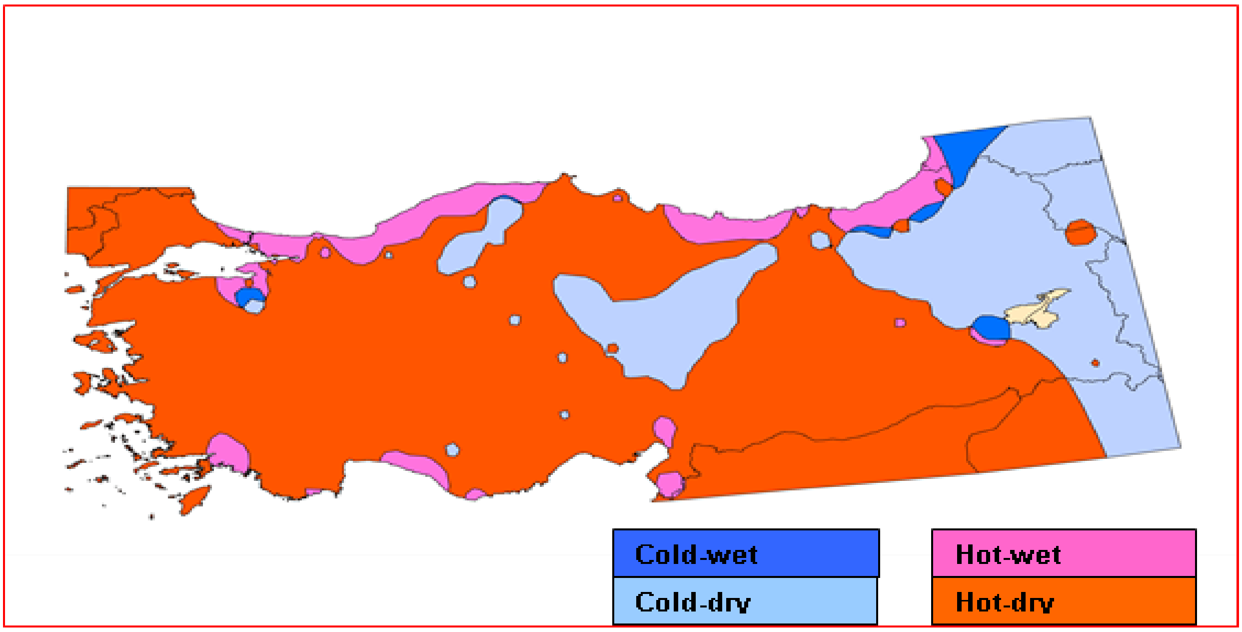
Year	Total greenhouse gases emissions (kt CO_2 eq.)	Removals by LULUCF sector (kt CO_2 eq.)	Share of LULUCF sector in total greenhouse gases emissions (%)
1990	216 636.2	-30 218.7	13.95
1991	223 425.1	-31 817.6	14.24
1992	230 391.9	-24 243.2	10.52
1993	240 264.3	-31 198.8	12.99
1994	233 775.9	-33 108.9	14.16
1995	250 326.3	-30 157.5	12.05
1996	267 926.7	-30 676.0	11.45
1997	279 515.5	-31 163.1	11.15
1998	283 234.3	-34 601.7	12.22
1999	282 975.9	-33 840.7	11.96
2000	310 797.1	-36 208.1	11.65
2001	293 045.0	-40 392.7	13.78
2002	301 380.4	-37 268.0	12.37
2003	320 825.2	-42 995.6	13.40
2004	332 786.4	-42 017.1	12.63
2005	360 390.0	-43 757.7	12.14
2006	382 364.1	-46 669.9	12.21
2007	416 109.3	-45 084.0	10.83
2008	405 990.9	-41 746.2	10.28
2009	406 184.7	-44 979.7	11.07
2010	415 363.7	-46 825.7	11.27
2011	439 520.7	-48 979.6	11.14
2012	459 080.6	-50 202.7	10.94
2013	452 585.8	-58 053.4	12.83
2014	472 847.7	-59 515.4	12.59
2015	474 291.9	-64 021.2	13.50

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 13.50% during the 1990-2015 periods.

Definition and Background Data

The methodology advised in the 2006 IPCC Guidelines for National Greenhouse Gas 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 (Figure 6.2) was prepared and used a base for all land use categories except Forest Land. There are 4 sub-climate types have been identified.

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 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 (threshold for a minimum planning unit) ; 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. There is no threshold for the forests in the definition of the forest.

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 Forest land category is provided from ENVANIS (Inventory Statistical System for Forests) database since 2004. The ENVANIS data base collects and processes data from forest management plans as the plans are renewed (more information on ENVANIS in Forest Land section) . The data for the years between 1990-1999 and 2000-2004 found by interpolation according to 1999 and 1972 forest inventory results. The annual commercial cutting and fuel wood data taken from Forest Production and Marketing Department of GDF. The annual forest fire information (area) taken from Forest Fire Department and the Annual illegal cutting and wood gathering information taken from Combatting Forest Pest Department of GDF.

The lands other than Forestland have been determined via CORINE (CooRdinateINformation on the Environment) land cover maps belonging to years 1990, 2000, 2006, 2012 which are corrected with national . 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 2012. 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. The ENVANIS is a tabular database that uses national forest definition. The land cover classification in CORINE including forest cover is visual. But both systems have integrated for calculating of total land cover.

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:

Table 6.3 Completeness Table

Sink/source category	Pool	GHG	Reported as	Mandatory	Explanation
Forest land remaining forest land	Soil	CO_2	NE	No	Lack of adequate data on annual carbon stock changes in the soil in the Forest Land Remaining Forest Land soil organic matter
Forest land remaining forest land	Dead wood and Litter	CO_2	NE	No	Lack of adequate data on annual carbon stock changes in the litter and deadwood in the Forest Land Remaining Forest Land
Forest land, Biomass Burning-Controlled Burning		CO_2, CH_4 and N_2O	NO	No	Does not occur
Forest land, drained soils		Non-CO_2	NE	No	Drainage does not occur in the forests
Drained wetlands		Non-CO_2	NA	No	No available data
Limestone application in croplands and grasslands		CO_2	NO	No	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	NA	No	No available data
Croplands, disturbance associated with land use conversion to cropland		N_2O	NA	No	No available data
Other land		CO_2	NA	No	No available data

6.2. Forest Land (CRF 4.A)

Source/Sink Category Description

According to the figures given by the Forest Management Planning Department of the GDF, Turkey has 22,343 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 10% 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 2015 year are given in Table 6.4.

Table 6.4 Forest inventory results of Turkey, 2015

	Area				
	High forests (ha)		**Total high forests (ha)**	**Coppices (ha)**	**Total forest area (ha)**
	Coniferous	**Deciduous**			
Productive[1]	8 304 035	3 615 026	11 919 061	785 087	12 704 148
Degraded[2]	5 341 232	2 359 425	7 700 657	1 938 130	9 638 787
Total	13 645 267	5 974 451	19 619 718	2 723 217	22 342 935
	Growing stock				
	High forests (m^3)		**Total high forests (m^3)**	**Coppices[1] (m^3)**	**Total forest growing stock (m^3)**
	Coniferous	**Deciduous**			
Productive[1]	1 078 266 986	474 553 789	1 552 820 775	33 695 388	1 586 516 163
Degraded[2]	43 960 033	16 036 698	59 996 731	11 953 934	71 950 665
Total	1 122 227 019	490 590 487	1 612 817 506	45 649 322	1 658 466 828
	Annual volume increment				
	High forests (m^3)		**Total high forests (m^3)**	**Coppices[1] (m^3)**	**Total forest annual increment (m^3)**
	Coniferous	**Deciduous**			
Productive[1]	32 300 035	13 711 068	46 011 103	1 511 832	47 522 935
Degraded[2]	1 051 470	432 985	1 484 455	585 191	2 069 646
Total	33 351 505	14 144 053	47 495 558	2 097 023	49 592 581

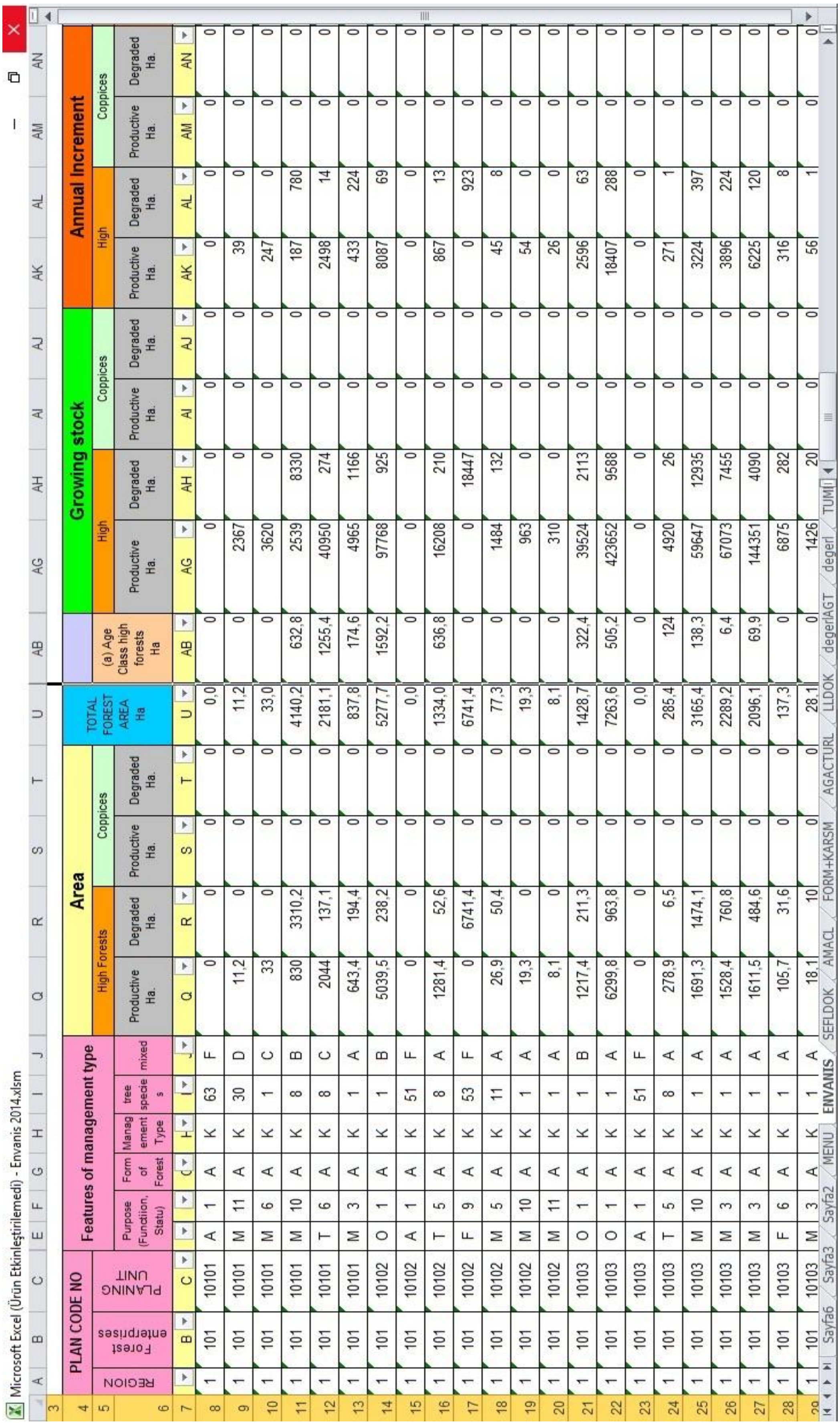
1. 0.75 coefficient was used in order to convert the stere volume into m^3 volume for coppices.

Pinusbrutia, Pinusnigra and, Pinus sylvestris are the most important coniferous species among the other coniferous such as 4 kinds of *Abies spp., Picea orientalis, Cedrus libani* etc. In portion of these three pine species is more than 80% as in totally volume of growing stock. *Fagus orientalis* and 22 *Quercus spp.* have 80% ratio in total volume of the deciduous trees such as *Tilia, Ulmus, Alnus, Castanea* species.

The ENVANIS database (Figure 6.3) collects and processes data from forest management plans as the plans are renewed. Since 2004, the ENVANIS database, a forest resources inventory based on forest management units is used. This database covers the data of areas, annual increment, commercial volume and growing stock of each forest management unit by the spieces, management types, form of stand, purpose, etc. 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 6.5, 6.7 and 6.8.

Figure 6.3 The Envanis Database



PLAN CODE NO			Features of management type					Area				TOTAL FOREST AREA Ha		Growing stock				Annual Increment			
								High Forests		Coppices				High		Coppices		High		Coppices	
REGION	Forest enterprises	PLANING UNIT	Purpose (Functiion, Statu)	Form of Forest	Management Type	tree species	mixed	Productive Ha.	Degraded Ha.	Productive Ha.	Degraded Ha.		(a) Age Class high forests Ha	Productive Ha.	Degraded Ha.	Productive Ha.	Degraded Ha.	Productive Ha.	Degraded Ha.	Productive Ha.	Degraded Ha.
	B	C					J	Q	R	S	T	U	AB	AG	AH	AI	AJ	AK	AL	AM	AN
1	101	10101	A	1	A	K	63	F	0	0	0	0,0	0	0	0	0	0	0	0	0	0
1	101	10101	M	11	A	K	30	D	11,2	0	0	0	11,2	0	2367	0	0	0	39	0	0	0
1	101	10101	M	6	A	K	1	C	33	0	0	0	33,0	0	3620	0	0	0	247	0	0	0
1	101	10101	M	10	A	K	8	B	830	3310,2	0	0	4140,2	632,8	2539	8330	0	0	187	780	0	0
1	101	10101	T	6	A	K	8	C	2044	137,1	0	0	2181,1	1255,4	40950	274	0	0	2498	14	0	0
1	101	10101	M	3	A	K	1	A	643,4	194,4	0	0	837,8	174,6	4965	1166	0	0	433	224	0	0
1	101	10102	O	1	A	K	1	B	5039,5	238,2	0	0	5277,7	1592,2	97768	925	0	0	8087	69	0	0
1	101	10102	A	1	A	K	51	F	0	0	0	0	0,0	0	0	0	0	0	0	0	0	0
1	101	10102	T	5	A	K	8	A	1281,4	52,6	0	0	1334,0	636,8	16208	210	0	0	867	13	0	0
1	101	10102	F	9	A	K	53	F	0	6741,4	0	0	6741,4	0	0	18447	0	0	0	923	0	0
1	101	10102	M	5	A	K	11	A	26,9	50,4	0	0	77,3	0	1484	132	0	0	45	8	0	0
1	101	10102	M	10	A	K	1	A	19,3	0	0	0	19,3	0	963	0	0	0	54	0	0	0
1	101	10102	M	11	A	K	1	A	8,1	0	0	0	8,1	0	310	0	0	0	26	0	0	0
1	101	10103	O	1	A	K	1	B	1217,4	211,3	0	0	1428,7	322,4	39524	2113	0	0	2596	63	0	0
1	101	10103	O	1	A	K	1	A	6299,8	963,8	0	0	7263,6	505,2	423652	9588	0	0	18407	288	0	0
1	101	10103	A	1	A	K	51	F	0	0	0	0	0,0	0	0	0	0	0	0	0	0	0
1	101	10103	T	5	A	K	8	A	278,9	6,5	0	0	285,4	124	4920	26	0	0	271	1	0	0
1	101	10103	M	10	A	K	1	A	1691,3	1474,1	0	0	3165,4	138,3	59647	12935	0	0	3224	397	0	0
1	101	10103	M	3	A	K	1	A	1528,4	760,8	0	0	2289,2	6,4	67073	7455	0	0	3896	224	0	0
1	101	10103	M	3	A	K	1	A	1611,5	484,6	0	0	2096,1	69,9	144351	4090	0	0	6225	120	0	0
1	101	10103	F	6	A	K	1	A	105,7	31,6	0	0	137,3	0	6875	282	0	0	316	8	0	0
1	101	10103	M	3	A	K	1	A	18,1	10	0	0	28,1	0	1426	20	0	0	56	1	0	0

Table 6.5 Forest area changes in Turkey, 1990-2015

(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
2015	8 304	3 615	785	12 704	5 341	2 359	1 938	9 639	22 343

Source: GDF
1) Crown closure between 0.11–1.00.
2) Crown closure between 0.01–0.10.

Total of 1 794 391 ha areas have been converted to forest land between 1990 and 2015 (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 6.6 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

Source: GDF
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 6.7 Growing stock, 1990-2015

(thousand m³)

	Productive[1]			Degraded[2]			
Year	High Forest	Coppices[3]	Productive total	High Forest	Coppices[3]	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
2015	1 552 821	33 695	1 586 516	59 997	11 954	71 951	1 658 467

Source: GDF

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^3volume for coppices.

Table 6.8 Annual volume increment, 1990-2015

(m³)

	Productive[1]			Degraded[2]			
Years	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
2015	46 011 103	1 511 832	47 522 935	1 484 455	585 191	2 069 646	49 592 580

Source: GDF
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 6.5 , 6.7 and 6.8 can be outlined as below:

1. Total amount of areas, growing stocks and annual volume increments of the coppice forests reduced while high forests were increasing. Highest amount of decrease of area/growing stock/annual increment 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 its proportion.

Considerable reasons of these changes are:

1. Moving from the rural to urban areas,
2. 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.
3. Changing considerations on forestry applications towards multi-functional use of forest resources in the framework of sustainable forest management concept,
4. Converting of coppices into high forests,
5. Afforestation activities on the bare lands and degraded forests accomplished by the Forestry Service.
6. 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.

6.2.1 Forest Land Remaining Forestland (Carbon Stock Changes in Productive and Degraded Forests of Turkey between 1990 and 2015)

According to forest inventory data of GDF 2015, 12 704 kha (56.85%) of forests are considered as productive forests and 9 639 kha (43.15%) 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 in normal and degraded forests of Turkey (forestland remaining forestland) were estimated since 1990 (see in Tables 6.9 and 6.10). 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 6.9 Carbon removals (living biomass), 1990-2015

(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 Equivalent
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
2015	10 932	5 601	751	17 284	406	215	291	912	18 196	66 718

1) Crown closure between 0.11–1.00.
2) Crown closure between 0.01–0.10.

Table 6.10 Annual Carbon Stock Changes of forest land remaining forest land category, 1990-2015

(kt)

	Removals	Emissions				
Years	Living biomass	Commercial cutting	Fuel Wood gathering	Other *(Forest fires)	Net carbon sequestration	CO_2 equivalent
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
2015	18 195.6	8 542.8	8.8	47.2	10 197.3	37 390.1

Methodology

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 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

$$\Delta C_G = \sum (Ai,j * G_{TOTAL} * CFi,j)$$

Equation 2.10 (tier 2 and 3)

$$G_{TOTAL} = \sum [(I_V * BCEF_I) * (1+R)]$$

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 (Tier 2).
- Average annual net increment in volume suitable for industrial processing (I_V): It exists for each management class in the forest management plans (Tier 2).
- Average basic wood density (D) and BCEF's factors. It was determined for all fundamental tree species and vegetation types which form a stand in the Turkey's forests (Tolunay,2013) (Table 6.11)(Tier 2).
- 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 6.11 The Average basic wood density and national BCEF's factors

Used for coniferous and deciduous				
Vegetation type	**Basic wood density (tonnes/m^3)**	**$BCEF_I$ (tonnes/m^3)**	**BCEFs (tonnes/m^3)**	**$BCEF_R$ (tonnes/m^3)**
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/cm^3)**	**Deciduous**		**Wood density (g/cm^3)**
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
Cedruslibani	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	*Liquidambar orientalis*	Turkish Sweetgum	0.468
Pinus pinaster	The Maritime Pine	0.440	*Robinia pseudoacaccia*	The Black Locust	0.680
Pinus radiata	The Monterey Pine	0.380		Other Deciduos	0.550
	Other coniferous	0.431			

Tolunay, 2013

- 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 6.12).
- Carbon fraction of dry matter (CF): Default value of IPCC 2006 Guidance Table 4.3 was used for carbon fraction of dry matter (CF) (Table 6.12).

Table 6.12 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	

Soil and Dead Organic Matter

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.

Annual Losses 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 fellings, 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 fellings 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 $\Delta C_L = L_{wood\ removals} + L_{fuelwood} + L_{disturbance}$

Annual Carbon Loss Due to Wood Removals

Equation 2.12. $L_{wood\ removals} = H \bullet BCEF_R \bullet (1+R) \bullet CF$

H: Wood harvesting data includes whole harvested woods as industrial harvesting including planned harvests (m^3/year) (Tier 2).

Annual Carbon Loss Due to Fuelwood Gathering

Equation 2.13. $L_{fuelwood} = [\{FG_{trees} \bullet BCEF_R \bullet (1+R)\} + FG_{part} \bullet D] \bullet CF$

FG:Fuel wood gathering and illegal cutting data obtained from the General Directorate of Forestry (Forestry Statistic 2015) was used here (m^3/year) (Tier 2). 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) (Tier 1).

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) (Tier 1).

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)

6.2.2 Land Converted to Forest Land

Annual changes from lands converted to forest lands can be determine by ENVANIS system. These changes were showed (See table 6.13). We assume these areas are grassland, because most of these areas in Turkey are not owned privately unlike other areas such as cropland. Annual Carbon stock changes (emissions and removals) land converted forestland have been estimated since 1990 in Table 6.14.

Table 6.13 Areas of land converted to forest land in Turkey, 1971-1993

(kha)

Year	Area	Year	Area
1971	0	1994	23 171
1972	0	1995	23 171
1973	20 544	1996	23 171
1974	20 544	1997	29 857
1975	20 544	1998	30 189
1976	20 544	1999	38 789
1977	20 544	2000	107 044
1978	20 544	2001	107 044
1979	20 544	2002	107 728
1980	20 544	2003	78 396
1981	20 544	2004	83 765
1982	20 544	2005	64 335
1983	20 544	2006	50 259
1984	23 171	2007	45 723
1985	23 171	2008	55 678
1986	23 171	2009	71 206
1987	23 171	2010	149 565
1988	23 171	2011	37 861
1989	23 171	2012	134 893
1990	23 171	2013	214 710
1991	23 171	2014	182 430
1992	23 171	2015	292 698
1993	23 171		

Table 6.14 Annual Carbon stock changes of land converted to forest land, 1990-2015

(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 equivalent
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
2015	633.7	220.9	854.6	584.4	7 395.2	8 834.2	177.2	5.7	2 791.3	5 860.0	21 486.7

Methodology

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. $\Delta C_{DOM} = [A* \frac{(DOM_{t2} + DOM_{t1})}{T}]*CF$

T: 20 years according to guidance.

There has been 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. $\Delta C_{Mineral} = \frac{SOC_0 + SOC_{(0-T)}}{D}$

There has been 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)

The carbon stock values of below ground biomass, above ground biomass and dead organic matter of Grassland are described in the table 6.19, the carbon stock values of Grassland's soil is described in the table 6.21.

Net Annual Changes of Carbon Stocks in Forest Areas

Annual Carbon stock change in living biomass and net carbon stock change in dead organic matter in forest areas were evaluated as two categories divided into 4.A.1 Forest remaining Forest Land and 4.A.2 Land Converted to Forest Land but 4.C.2 Forest Land converted to Grass Land was added to table for the net annual carbon stock changes in forest (Table 6.15 and Table 6.16)

Table 6.15 Net annual changes of carbon stocks in forest areas, 2015

Greenhouse gas source 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	22 342.9	-19 072.1	8 869.7	-10 202.4	4 545.9	54 077.1
1. Forest Land remaining Forest Land (removal)	20 209.6	-18 195.7	8 598.9	-9 596.8	0.0	-135 188.4
2. Land converted to Forest Land (removal)	1 905.3	-854.6	177.2	-677.4	5 182.6	-21 486.7
3. Forest Land converted to Grass Land (emission)	-234.2	21.8	-93.7	-71.9	-636.7	-2 598.1

Net carbon sequestration and removals between 1990 and 2015 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, 1990-2015

Year	removals (tonnes C)	emissions (tonnes C)	Net removals (kt)	CO_2 equivalent (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
2015	27 395 573	12 647 256	14 748.3	54 077.2

*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).

Net carbon uptake was calculated by taking commercial cutting, fuel wood gathering and biomass lost from forest fires out the aboveground and belowground living biomass for forestland remain forestland.

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 6.17:

Table 6.17 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 calculated as 23.5% by Equation 3.1.

Time Series Consistency

Since there are two forest inventory carried out by the General Directorate of Forestry for 1972, 1999 before 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 2004-2015 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 (4.B)

Source Category Description:

Cropland remaining Cropland and Land converted to Cropland has been reported under this category.

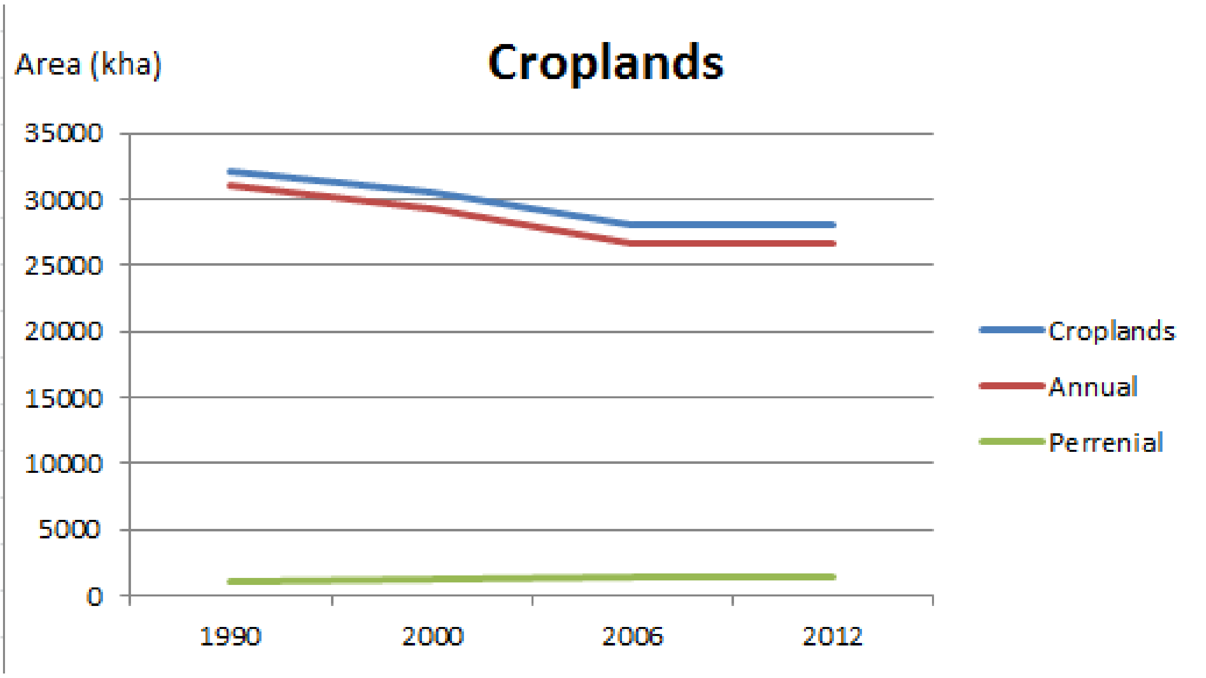
CSC in aboveground, belowground, organic and mineral soil pools have been calculated and reported. The Cropland category was a large source in the last submission but has diminished with the change in emission factors and activity data.

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 Activity data section database we have calculated land use changes based on 4 temporal time points: 1990, 2000, 2006 and 2012. We had a more compatible and consistent monitoring system with this methodology. In Turkey the cropland areas decreased between 1990 and 2012 as seen in Figure 6.4.

Figure 6.4 temporal change in croplands in Turkey between 1990 and 2012.



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 28 080.79 kha in 2012. In 1990 it was 31 259.93 kha.

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 6.18).

Table 6.18 Land use changes between 1990-2000, 2000-2006 and 2006-2012 (w/o Forest land) in Turkey

(ha)

1990-2000

From	To	Croplands		Wetlands	Grasslands				Otherlands	
		Perennial	Annual	Artificial	Green areas	Pastures	Natural grasslands	Settlements	Otherland	Mine areas
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	572.2	1.58
	Pastures	18 346.79	364 130.83	5 724.40	491.7	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	551.9	12 470.79	1 575.40	367	5 729.20	2 944.23	18 376.83	7 034.63	24 593.83

2000-2006

From	To	Perennial	Annual	Artificial	Green areas	Pastures	Natural grasslands	Settlements	Otherland	Mine areas
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	115.1	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

Table 6.18 Land use changes between 1990-2000, 2000-2006 and 2006-2012 (w/o Forest land) in Turkey

2006-2012	From	Croplands		Wetlands	Grasslands			Settlements	Otherlands	
to		Perennial	Annual	Artificial	Green areas	Pastures	Natural grasslands	Settlements	Otherland	Mine areas
Croplands	Perennial	1 434 428.03	471.04	628.01	0.00	29.71	16.33	1 640.70	773.08	319.51
	Annual	16 694.32	26 700 955.49	28 962.05	972.89	6 713.76	839.15	23 186.10	14 451.64	7 776.24
Wetlands	Artificial	0.00	0.00	1 210822.46	809.73	119.97	77.52	31.62	439.65	162.15
	Green areas	0.00	0.00	1 572.76	53 336.75	699.08	0.00	94.63	117.97	25.43
Grasslands	Pastures	812.24	0.00	1 813.47	259.14	36 972.93	9.42	5 345.11	4 878.14	1 998.89
	Natural gr.	1 600.35	9 591.23	4 864.11	73.39	565.59	890 680.42	5 563.82	7 640.67	8 382.12
Settlements	Settlements	28.67	51.67	234.56	0.00	52.99	0.00	804 297.38	1325.51	78.98
Otherlands	Otherland	43.60	281.97	3 745.79	511.71	425.22	1 786.38	26 114.24	10 524 472.45	611.07
	Mine areas	26.18	128.09	626.78	16.08	937.17	900.72	182.71	179.15	76153.32

Methodological Issues:

New emission/removal factors

The TUBITAK (Scientific and Technical Research Council of Turkey) 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 6.19). 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 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 6.19 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 this 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 above values (Table 6.20) 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 percent 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 percent, >40 percent, >60 percent, and >80 percent. The project area has been classified for 4 settlement intensity classes in this way (Table 6.20).

Table 6.20 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 percent was in the 2^{nd} SC, 30 percent in the 3^{rd}, while 60 percent 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)

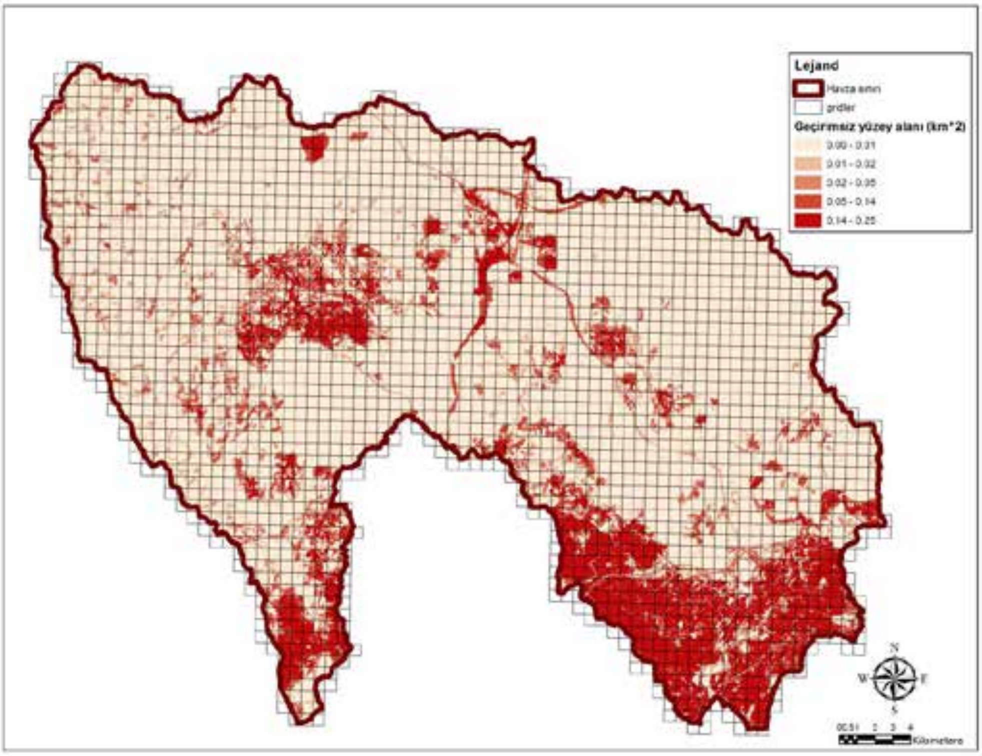
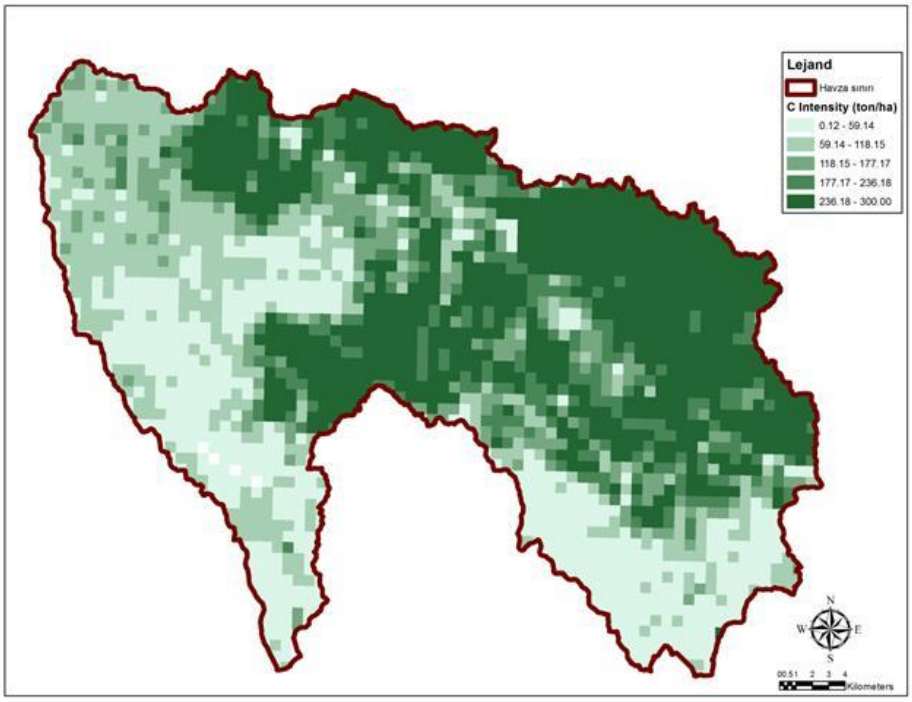


Figure 6.6 Carbon intensity in the study area (Alibeyköy, Sazlıdere and Kağıthane watersheds in Istanbul)



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 under the Ministry of Food, Agriculture and Livestock. The CS values that have been calculated by various studies have been complied as a layer on 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 6.21 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. Activity data 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 Scientific and Technical Research Council of Turkey (TUBITAK) with the project number 112YO96.

A combination of Tier 1 and 2 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 Tier 2 approach was used for the conversions between perennial and annual croplands. Tier 2 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 6.22 Properties of poplar species

Tree	BWD g/cm^3	Plantation Pattern	# of trees per ha	Volume increment m^3/ha yr	Rotation period (years)	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 6.23).

Table 6.23 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	2625.85	1473.80	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 (TUBITAK Project COST 112Y096) 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 6.19 and 6.21)

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 6.19 and 6.21)

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 (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

Annual changes from forest land converted grass land (deforestation) can be monitor by ENVANIS system. These changes were showed (See table 6.24). We assume these areas are grassland. Annual Carbon stock changes (emissions and removals) of forest land converted grass land have been estimated since 1990 in Table 6.25.

Table 6.24 Areas of forest land converted to grass land in Turkey, 1971-2015

(kha)

Year	Area	Year	Area
1971	0	1994	2.6
1972	0	1995	2.6
1973	0	1996	2.6
1974	0	1997	9.3
1975	0	1998	9.3
1976	0	1999	9.3
1977	0	2000	9.3
1978	0	2001	9.3
1979	0	2002	10.0
1980	0	2003	9.8
1981	0	2004	20.1
1982	0	2005	4.6
1983	0	2006	3.6
1984	2.6	2007	12.2
1985	2.6	2008	21.2
1986	2.6	2009	44.6
1987	2.6	2010	2.3
1988	2.6	2011	0
1989	2.6	2012	31.7
1990	2.6	2013	5.9
1991	2.6	2014	5.6
1992	2.6	2015	13.5
1993	2.6		

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 6.25 Annual Carbon stock changes of forest land converted to grass land, 1990-2015

(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 equivalent
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
2015	21.8	0.7	343.1	365.6	93.6	67.4	913.1	1 074.1	708.5	2 597.8

Methodology

Annual removals and emissions from forest land converted to grassland were calculated by the following Equations of IPCC 2006 Guidance Vol 4 AFOLU:

Annual Increment in Carbon Stocks Due to Living Biomass Increment in forest land converted to grassland

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 forest land converted to grassland

Equation 2.19. $$\Delta C_{DOM} = \left[A * \frac{(DOM_{t2} + DOM_{t1})}{T}\right] * CF$$

T: 20 years according to guidance.

There has been used dead organic matter C stock values given by Tolunay and Çömez(2008) of forests :

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 forest land converted to grassland

Equation 2.24. $$\Delta C_{Mineral} = \frac{SOC_0 + SOC_{(0-T)}}{D}$$

There has been used soil carbon stock values given by Tolunay and Çömez (2008) for forests :

Soil organic carbon (tonnes/ha)		
Coniferous	76.37	±51.03 (n=820)
Deciduous	80.40	±58.95 (n=191)

The carbon stock values of below ground biomass, above ground biomass and dead organic matter of Grassland are described in the table 6.19, the carbon stock values of Grassland's soil is described in the table 6.21.

Croplands converted to grassland

CSC in biomass, soils and litter are reported in this category based on the CS values given in Tables 6.19 and 6.21.

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 6.19 and 6.21)

- 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 6.19 and 6.21)

- 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 (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) (Eq2.7) 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 6.19 and 6.21)

- 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 6.19 and 6.21)

- 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 (Eq 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 6.19 and 6.21)

- 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 (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 Tier 3 level. We used the results of a national research project funded by the Scientific and Technical Research Council of Turkey 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 Tier 3 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 Tier 3 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 km2. The accuracy check was done with 1000 points with over 90 percent accuracy. The emission factors were developed based on 59 sample plots. The total C stock (AG, BG, L, S) in the 1st level settlements (>20 percent imperviousness) was 85.27 Mg C/ha (Table 6.20) 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 6.19 and 6.21)

- 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

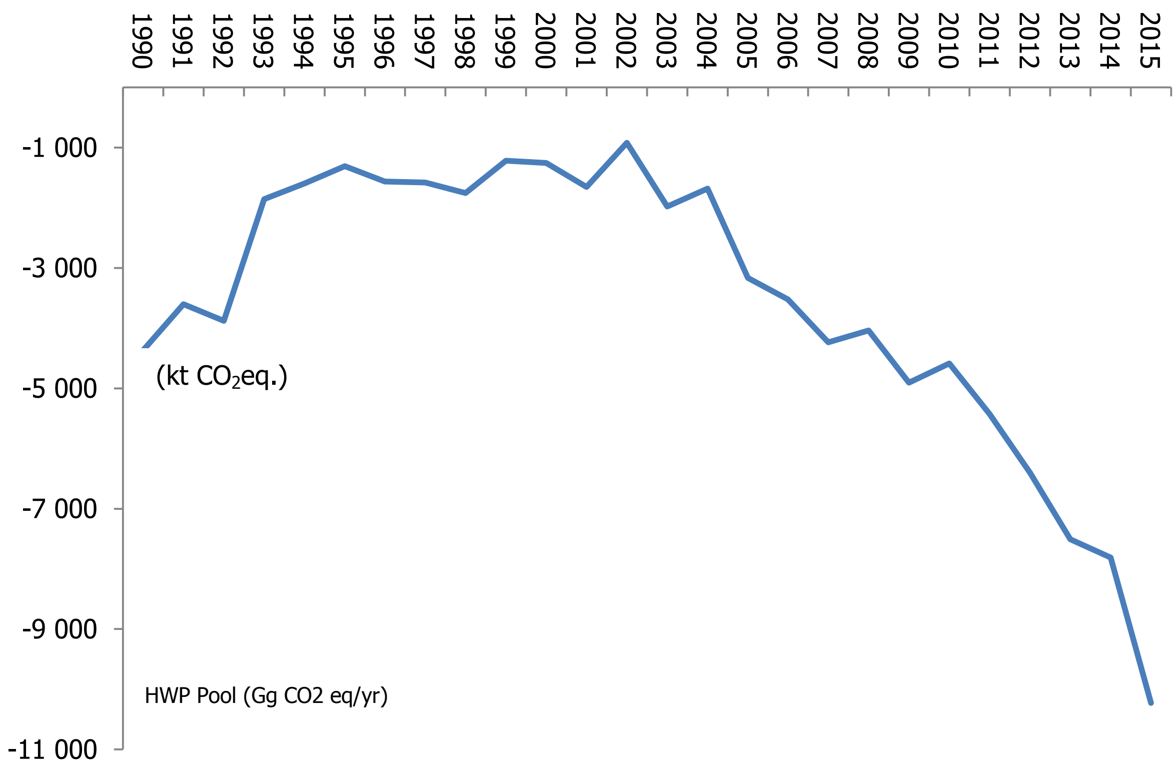
Grassland converted to Settlements (EFs used are from Tables 6.19 and 6.21)

Biomass CSC = AREA for GL-WL* 5.03 Mg C/ha – AREA * 1.86 Mg C/ha

6.7. Harvested Wood Products (4.G)

The CSC of the HWP 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, 1990-2015



The following methodology has been applied in calculations;

- Corrected 1900-2015 data series: the UNECE Timber database gives disaggregated figures for HWP produced in Turkey from 1960 to 2015. 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 1976-2015 (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 1960-2015 data series and we extrapolated the 1900-1960 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 1900-2015 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 CO2 equivalent.
- 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-basedpanels (ExtScen) in '000 tC/yr	125	2 056	=(WP-C)*D*CF
CS-SWint	Carbonstocksawnwood (IntScen) in '000 tC/yr	12 698	44 232	Eq.12.1.(IPCC, 2006)
CS-WPint	Carbonstockwood-basedpanels (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 6.27).

Table 6.27 Annual harvest, 1990-2015 (GDF, 2016)

(thousand m^3)

Year	Industrial wood	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
2015	16 638	3 766	20 404

Source:GDF, 2015

Other Gases (Forest Fire)

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 6.28.

Table 6.28 Forest fires in Turkey, 2015

		Fire types	
Fire number	Total area (ha)	Ground vegetation (ha)	Crown (ha)
2 150	3 219	1 385.0	1 834.0

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 greenhouse gasses emitted by wildfire were 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 (Tier 2 methods) mainly during the calculation of carbon uptake and the other greenhouse gasses inventory. Since there was no adequate and baseline data on land use changes concerning the olden time, first level communication (Tier 1 methods) was applied for the estimation of carbon sequestrations and greenhouse gasses emissions between the years 1990–2015.

The emissions of other greenhouse gasses changed depending on the burned forest areas (see table 6.29). 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 6.29 Changes in the other greenhouse gasses caused by forest fires, 1990-2015

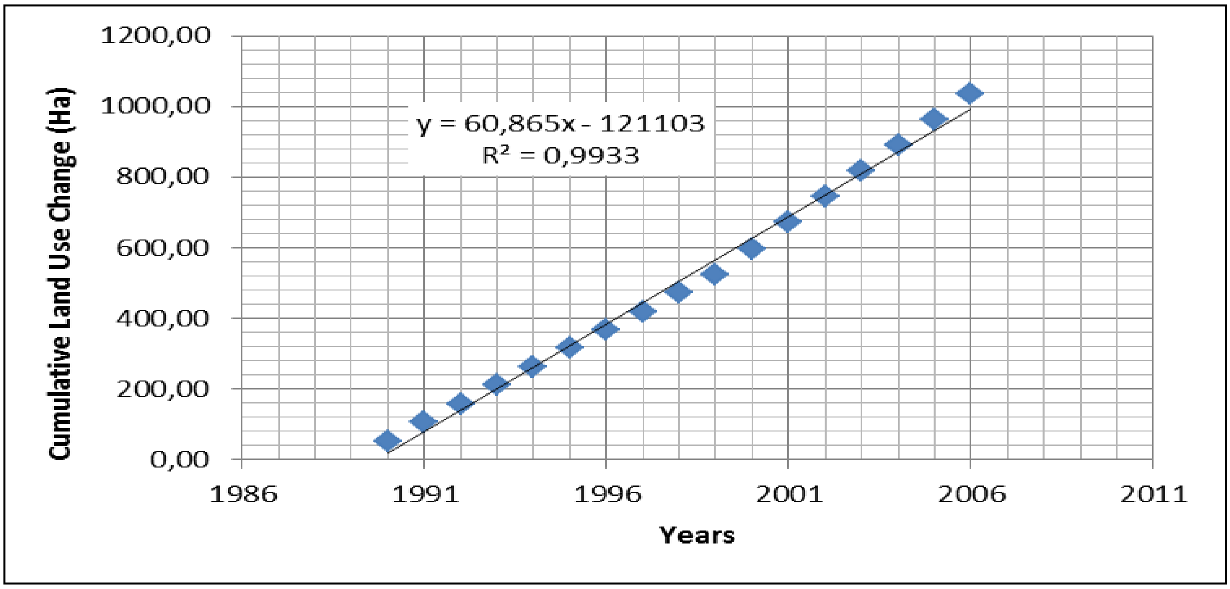
(tonnes)

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
2015	0.00032	0.00002	0.00021	0.00741

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 activity data is around 50% according to expert judgment considering that 3 different Land Use Maps have been used.

The overall uncertainty for land use change 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 Ministry of Food, Agriculture and Livestock. 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 QC mechanism of Forest lands is handled by GDF (General Directorate of Forestry). All the calculations of sector were controlled by both a personnel from Eskişehir Forest Research Institute of GDF for QC.

The QA mechanism of LULUCF is handled by Prof.Dr.Yusuf Serengil from Forest Faculty of Istanbul University.

Category-specific 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.

Cropland:

The emission/removal factors have been modified in most categories. The change in emission factors for all categories croplands had a serious influence on estimations.

The carbon stock changes of the Cropland category have been calculated at sub-regional level in this submission.

Corine maps data updated for 2012, 2006 Corine map and 2012 Corine map data have been compared and land use change has been detected. Therefore calculation for this submission has been recalculated between period 2006 and 2015.

Direct N_2O emissions from N mineralization/immobilization has been in Agriculture (CRF Category 3.) sector, as of this year it is reported in Cropland section. Therefore Cropland emissions differ between 1990 and 2014. The results are shown in Table 6.30.

Grassland:

The carbon stock changes of the Grassland category have been calculated at sub-regional level in this submission

Corine maps data updated for 2012, 2006 Corine map and 2012 Corine map data have been compared and land use change has been detected. Therefore calculation for this submission has been recalculated between period 2006 and 2015.

Settlements:

The carbon stock changes of the Settlements category have been calculated at sub-regional level in this submission.

Corine maps data updated for 2012, 2006 Corine map and 2012 Corine map data have been compared and land use change has been detected. Therefore calculation for this submission has been recalculated between period 2006 and 2015.

Table 6.30 Recalculation Table of Cropland, Grassland and Settlements 1990-2014

	Cropland		Grassland		Settlements	
Year	Without Recalculation (kt CO2 eq.)	With Recalculation (kt CO2 eq.)	Without Recalculation (kt CO2 eq.)	With Recalculation (kt CO2 eq.)	Without Recalculation (kt CO2 eq.)	With Recalculation (kt CO2 eq.)
1990	-47.63	-37.15	84.50	84.50	683.21	683.21
1991	-41.29	-30.81	113.14	113.14	683.21	683.21
1992	-34.94	-24.47	141.75	141.75	683.21	683.21
1993	-28.64	-18.16	170.39	170.39	683.21	683.21
1994	-22.29	-11.82	199.04	199.04	683.21	683.21
1995	-15.99	-5.51	227.68	227.68	683.21	683.21
1996	-9.61	0.87	256.33	256.33	683.21	683.21
1997	-3.26	7.21	359.31	359.31	683.21	683.21
1998	3.01	13.48	462.33	462.33	683.21	683.21
1999	9.39	19.86	946.64	946.64	683.21	683.21
2000	-508.93	-502.18	-304.36	-304.36	629.49	629.49
2001	-516.08	-509.33	-200.87	-200.87	629.49	629.49
2002	-527.23	-520.48	-88.28	-88.28	629.49	629.49
2003	-529.14	-522.39	20.10	20.10	629.49	629.49
2004	-521.88	-515.13	214.25	214.25	629.49	629.49
2005	-517.15	-510.40	235.73	235.73	629.49	629.49
2006	-530.27	-523.52	246.13	246.13	629.49	629.49
2007	-149.31	190.58	923.46	1457.66	570.61	64.29
2008	-144.98	194.90	1129.01	1663.21	570.61	64.29
2009	-155.39	184.45	1595.34	2129.54	570.61	64.29
2010	-145.64	194.24	1589.96	2124.16	570.61	64.29
2011	-148.50	191.38	1561.47	2095.66	570.61	64.29
2012	-142.78	197.07	1883.01	2417.21	570.61	64.29
2013	-137.13	202.71	1915.76	2449.96	570.61	64.29
2014	-131.49	205.50	1948.19	2482.39	570.61	64.29

Category-specific planned improvements

In this submission, the emphasis has been given to the QA/QC of the activity data and emission/factors.

Forest Land:

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 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 two EU project about the LULUCF calculations. The first 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. The second project name is 'Capacity Building in the Field of Climate Change in Turkey' which is tender 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.

Cropland, grasslands and wetlands:

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 activity data 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.

The updated 2012 Corine map has been used in this year's reports. We plan to use national map data of 1/25000 scale more efficiently in order to increase the accuracy of the land use matrix.

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 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 Scientific and Technical Research Council of Turkey (TUBITAK) with a project number of 112Y096. We expect to benefit more from this project findings in the next submission.

A cropland soil organic matter database has been developed under TRGM. The country specific values has been disaggregated for climate and soil types and used in soil CSC estimations of the next submission. The database is going to be expanded with more soil C data.

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 planned 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 2015 were 16.9 Mt CO_2 eq., or 3.6% of total GHG emissions (without LULUCF). Within the sector, 73.80% of the emissions were from solid waste disposal, followed by 26.09% from wastewater treatment and discharge, 0.09% 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 87.9% of total emissions from this sector in 2015, followed by N_2O emissions with 12.1% and a very small per cent of CO_2 as 0.003%.

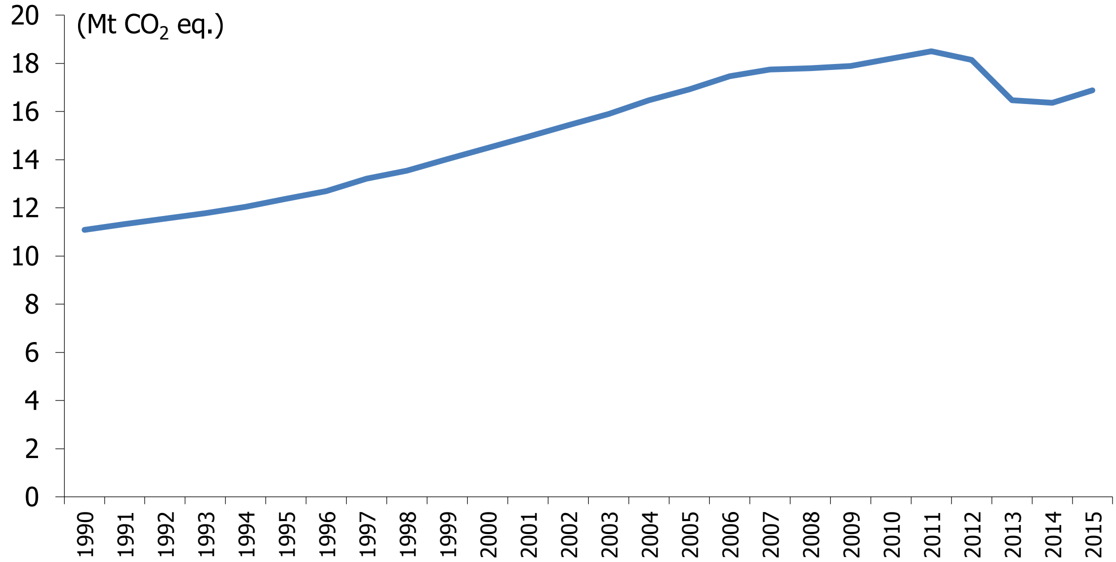
Table 7.1 CO_2 equivalent emissions for the waste sector, 2015

(kt CO_2 eq.)

GHG source and sink categories	CO_2	CH_4	N_2O	Total
5. Waste	0.5	14 836.5	2 039.4	16 876.4
A. Solid waste disposal	NA	12 455.3	NA	12 455.3
B. Biological treatment of solid waste	NA	9.3	6.7	16.0
C. Incineration and open burning of waste	0.5	0.7	0.1	1.4
D. Wastewater treatment and discharge	NA	2 371.2	2 032.6	4 403.8
E. Other	NO	NO	NO	NO

Waste emissions were 52.2% (5.8 Mt CO_2 eq.) higher in 2015 than they were in 1990 and 3.2% (0.5 Mt CO_2 eq.) higher than in 2014 as seen in Figure 7.1.

Figure 7.1 Total GHG emissions of waste sector, 1990-2015



Total emissions in the waste sector gradually increased between 1990 (11 090 kt CO_2 eq.) and 2015 (16 876 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 5.4% (634 kt CO_2 eq.) from 2013 to 2015. Methane recovery is reported as of 2002 (37 kt CO_2 eq.) and increasing to 4 732 kt CO_2 eq. in 2015. 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 source 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 is incinerated or disposed in SWDS by including in the MSW after being sterilized. Hazardous wastes are disposed in separated lots in SWDS. Hazardous 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 in the category of Public Electricity and Heat Production (1.A.1.a).

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 the equation below.

$$CH_4\ Emissions = \left[\sum_x CH_4\ generated_{x,T} - R_T\right] \bullet (1 - OX_T)$$

Where:

CH_4 Emissions = CH_4 emitted in year *T*, Gg

T = inventory year

x = waste category or type/material

R_T = recovered CH_4 in year *T*, Gg

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.

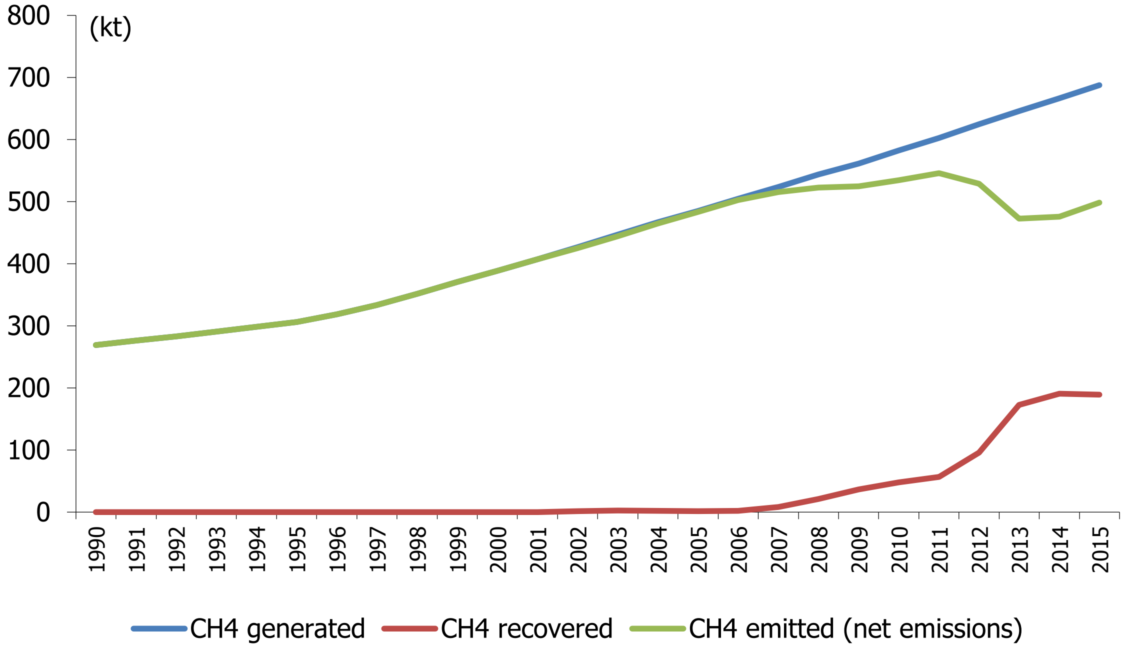
The total amount of CH_4 generated, CH_4 recovered and net CH_4 emissions from solid waste disposal sites are estimated as given in Table 7.3 and Figure 7.2.

Table 7.3 CH_4 generated, recovered and emitted from SWDS, 1990-2015

(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
2015	687.5	189.3	498.2

Figure 7.2 CH_4 emissions from solid waste disposal, 1990-2015



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. 2015 data of MSW disposed in managed SWDS is estimated by trend extrapolation.

Data are generally available from the statistical surveys described above (noting the need to resolving data gaps 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: TurkStat, Municipal Waste Statistics, 1992-2010
TurkStat, Waste Disposal and Recovery Facilities Statistics, 2012-2014

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, 1990-2015

	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
2015	27 415.0	18 969.0	8 446.0	69.2	30.8

Population Data: Historical data are obtained from TurkStat's *Mid-year Population Estimations and Projections* from 1950 onwards as given in Table 7.7. Population estimations are based on General Population Census until 1985. Estimations and projections for the mid-year population size for the 1986-1999 period are based on 2008 Address Based Population Registration System (ABPRS) with Health Surveys and estimations and projections after 2000 are based on 2012 ABPRS and the other administrative sources. Between the years 2007-2015, the annual results of ABPRS are used.

Table 7.7 Mid-year population, 1950-2015

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	76 148 000
1981	45 540 000	2014	77 182 000
1982	46 688 000	2015	78 218 000

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, 2013 and 2015. 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, 1990-2015

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	406.1
2014	31 230.0	77.2	404.6
2015	31 283.0	78.2	399.9

% 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, 2013 and 2015. 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 1990-2015 in Table 7.9.

Table 7.9 Percentage of MSW disposed in the SWDS, 1990-2015

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
2015	31 283.0	27 415.0	87.6

Waste Composition Data: Waste composition data are available for the years 1993, 2006 and 2014. 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*. The source of the 2014 waste composition data is *National Waste Management & Action Plan, Draft Report, 2016-2023; MoEU*.

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 2002-2013. The 2014 waste composition data from *National Waste Management & Action Plan* was used for 2014 and 2015.

Each of national waste composition data are reported in Table 7.10.

Table 7.10 Waste composition data

(%)

Year	Food	Garden	Paper	Textile	Nappies	Plastics, other inert
1990 - 2001	64.0	0.0	6.0	4.0	0.0	26.0
2002 - 2013	34.0	19.0	16.0	0.0	0.0	31.0
2014 - 2015 (1)	47.9	6.7	8.9	3.2	3.0	30.4

(1) Percentages may not add up to 100% due to rounding.

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 2014 are estimated by linear interpolation. Since extrapolation was not applied for 2015 due to the trendline, 2015 data was assumed the same as in 2014.

Data are available from the statistical surveys described above (noting the need to resolving data gaps 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.

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, 1990-2015

	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	4.8	NO	4.8	0.0	100.0
1999	7.3	NO	7.3	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	5.7	NO	5.7	0.0	100.0
2014	6.1	NO	6.1	0.0	100.0
2015	6.6	NO	6.6	0.0	100.0

GDP Data: Historical data for GDP by production approach are obtained from TurkStat's *National Accounts* from 1923 onwards. Between the years 1998-2015, GDP data have been updated by using annual GDP based on 2009. GDP data in current prices used for emission estimations are given in Table 7.12.

Table 7.12 GDP by production approach, 1950-2015

(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	277 468
1966	9 997	1999	253 622
1967	11 144	2000	271 768
1968	18 008	2001	200 998
1969	20 128	2002	236 338
1970	18 825	2003	313 776
1971	16 847	2004	402 952
1972	21 319	2005	499 874
1973	26 854	2006	547 832
1974	36 985	2007	677 438
1975	46 300	2008	776 643
1976	52 996	2009	646 893
1977	60 613	2010	772 365
1978	66 277	2011	831 696
1979	80 960	2012	871 125
1980	67 457	2013	950 355
1981	70 419	2014	934 857
1982	63 485	2015	861 462

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. For 2015, waste generation rate is calculated assuming that IW generated in 2015 is the same as in 2014. 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.* 2015 data is estimated by trend extrapolation. 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 is given in detail in Table 7.13.

Table 7.13 Industrial waste activity data, 1990-2015

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	277 468.4	0.07	20 173.4	0.02	4.8
1999	253 622.3	0.07	17 179.8	0.04	7.3
2000	271 767.8	0.06	17 058.9	0.06	10.4
2001	200 997.6	0.06	11 644.5	0.05	5.6
2002	236 337.8	0.05	12 548.8	0.03	4.4
2003	313 776.3	0.05	15 142.8	0.02	3.3
2004	402 951.6	0.04	17 497.5	0.01	1.6
2005	499 874.0	0.04	18 288.0	0.01	2.7
2006	547 832.4	0.03	16 296.5	0.02	3.3
2007	677 438.2	0.02	15 519.6	0.03	4.0
2008	776 643.4	0.02	12 481.6	0.03	3.9
2009	646 892.7	0.02	10 795.7	0.03	3.4
2010	772 365.0	0.02	13 366.5	0.03	4.2
2011	831 695.6	0.02	14 080.4	0.03	4.5
2012	871 125.0	0.02	14 420.3	0.03	4.7
2013	950 355.3	0.02	15 863.1	0.04	5.7
2014	934 856.8	0.02	15 733.5	0.04	6.1
2015	861 462.1	0.02	15 733.5	0.04	6.6

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, 1990-2015

(kt)

Year	Food	Garden	Paper	Textile	Nappies	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	4.8
1999	14 884.4	-	1 395.4	930.3	-	23 256.9	6 046.8	7.3
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	5.7
2014	13 344.3	1 863.8	2 476.1	880.9	835.9	27 864.2	8 463.2	6.1
2015	13 129.2	1 833.7	2 436.2	866.7	822.5	27 415.0	8 326.8	6.6

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, Turkey has used the average of the default MCFs for unmanaged-deep (0.8) and unmanaged-shallow (0.4) in the absence of country-specific information for unmanaged waste disposal practices (0.6).

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, 1990-2015

(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
2015	0.88	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): Degradable organic carbon (DOC) is the organic carbon in waste that is accessible to biochemical decomposition. IPCC default values for the DOC content of main components (waste types/material) used in the model are listed in Table 7.16.

Table 7.16 DOC values by individual waste type

(weight fraction, wet basis)

Waste Type	DOC
Food waste	0.15
Garden	0.20
Paper	0.40
Textiles	0.24
Nappies	0.24

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 *Table 2.4 in the 2006 IPCC, Volume 5, Chapter2*.

% DOC (by net weight) = (0.15 x A) + (0.20 x B) + (0.40 x C) + (0.24 x D) +(0.24 x E)

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

E = fraction of nappies in MSW

12.96%, 15.30% and 13.55% are the calculated values of DOC by weight for the inventory years of 1990-2001, 2002-2013 and 2014-2015, 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 Dry temperate k values by waste type

	(years^{-1})
Waste Type	**k**
Food waste	0.06
Garden	0.05
Paper	0.04
Textiles	0.04
Nappies	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 IPCC 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 sends 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 every year. 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 (biennial) 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 (1.A.1.a).

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, 1990-2015

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
2015	21	189.3

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 for three years (1993, 2006 and 2014), and these compositions were assumed to apply for the period 1990-2001, 2002-2013 and 2014-2015, respectively, adding to the uncertainty of the activity data.

Combined uncertainty values of EFs are estimated as 30.8% and 38.1% for managed and unmanaged SWDS based on *Table 3.5 in 2006 IPCC, Volume 5, Chapter 3.*

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 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 and 2014 data for mid-year population were updated according to the TurkStat's *Mid-year Population Estimations and Projections* based on the annual results of the Address Based Population Registration System. Therefore, waste per capita data were updated for 2013 and 2014.

Waste composition data for 2014 was updated due to the availability of new country-specific data *(National Waste Management & Action Plan, Draft Report, 2016-2023; MoEU)*.

Between the years 1998-2015, GDP data have been updated by using annual GDP based on 2009. Therefore, waste generation rates were updated for the 1998-2014 period.

Emission estimates from Solid Waste Disposal (CRF Category 5.A) are recalculated over the 1999-2014 time series due to the minor data updates specified above.

In summary, CH_4 emissions from solid waste disposal sites have been recalculated for the years 1999-2014. Compared to the previous inventory submission, CH_4 emissions in 2014 increased by 0.00004 per cent (0.004 kt CO_2 eq.). There is no recalculation for 1990.

Planned Improvement:

As noted above, Turkey has added an additional question on flaring of landfill gas to its *Waste Disposal and Recovery Facilities Survey, 2014*. According to the survey results, it has been determined that there is no flaring on waste disposal sites in Turkey. 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 14.7% (2.77 kt CO_2 eq.) between 1990 (18.79 kt CO_2 eq.) and 2015 (16.02 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. The CH_4 and N_2O emissions of biological treatment can be estimated using the default method based on *Equations 4.1 and 4.2 in 2006 IPCC, Volume 5, Chapter 4* as given below.

$$CH_4\ Emissions = \sum_i (M_i \bullet EF_i) \bullet 10^{-3} - R$$

Where:

CH_4 Emissions = total CH_4 emissions in inventory year, Gg CH_4

M_i = mass of organic waste treated by biological treatment type i, Gg

EF = emission factor for treatment i, g CH_4/kg waste treated

i = composting or anaerobic digestion

R = total amount of CH_4 recovered in inventory year, Gg CH_4

$$N_2O\ Emissions = \sum_i (M_i \bullet EF_i) \bullet 10^{-3}$$

Where:

N_2O Emissions = total N_2O emissions in inventory year, Gg N_2O

Mi = mass of organic waste treated by biological treatment type i, Gg

EF = emission factor for treatment i, g N_2O/kg waste treated

i = composting or anaerobic digestion

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, 2013 and 2015). 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.

For collection of 2015 data, TurkStat sent directly official e-mails to three composting plants in operation in 2015 for requesting the amount of waste composted.

Number of composting plants in Turkey is listed below as a supplementary information.

Table 7.19 Number of composting plants, 1995-2015

1995	2000	2005	2006	2008	2010	2012	2014	2015
1	2	4	4	4	5	6	4	3

Source: TurkStat, Municipal Waste Statistics, 1995-2010

TurkStat, Waste Disposal and Recovery Facilities Statistics, 2012-2015

Choice of Emission Factor

EFs of 4.0 g CH_4/kg waste treated (on a wet weight basis) and 0.24 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 default emission factor for N_2O on a wet weight basis for composting is corrected (0.24 instead of 0.3) according to the *9th Corrigenda for the 2006 IPCC Guidelines* as of July 2015.

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, 1990-2015

(kt)

Year	Amount of waste treated by composting plants	CH_4 Emissions	N_2O Emissions
1990	109.5	0.44	0.026
1991	109.5	0.44	0.026
1992	109.5	0.44	0.026
1993	109.5	0.44	0.026
1994	109.5	0.44	0.026
1995	90.6	0.36	0.022
1996	102.0	0.41	0.024
1997	102.9	0.41	0.025
1998	94.8	0.38	0.023
1999	128.6	0.51	0.031
2000	136.3	0.55	0.033
2001	124.4	0.50	0.030
2002	218.5	0.87	0.052
2003	185.9	0.74	0.045
2004	200.0	0.80	0.048
2005	165.4	0.66	0.040
2006	104.8	0.42	0.025
2007	190.3	0.76	0.046
2008	143.0	0.57	0.034
2009	179.6	0.72	0.043
2010	134.2	0.54	0.032
2011	166.0	0.66	0.040
2012	158.9	0.64	0.038
2013	91.3	0.37	0.022
2014	94.0	0.38	0.023
2015	93.4	0.37	0.022

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 0.052 kt in 2002 while having a minimum value of 0.022 kt in 1995.

Figure 7.3 Amount of waste treated by composting plants, 1990-2015

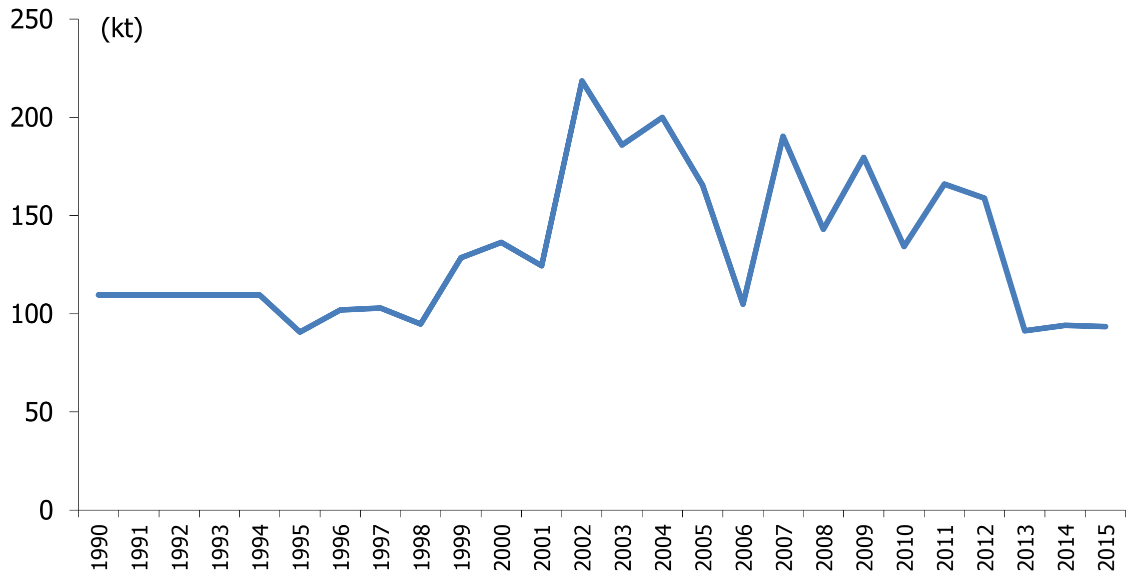


Figure 7.4 CH_4 emissions from composting, 1990-2015

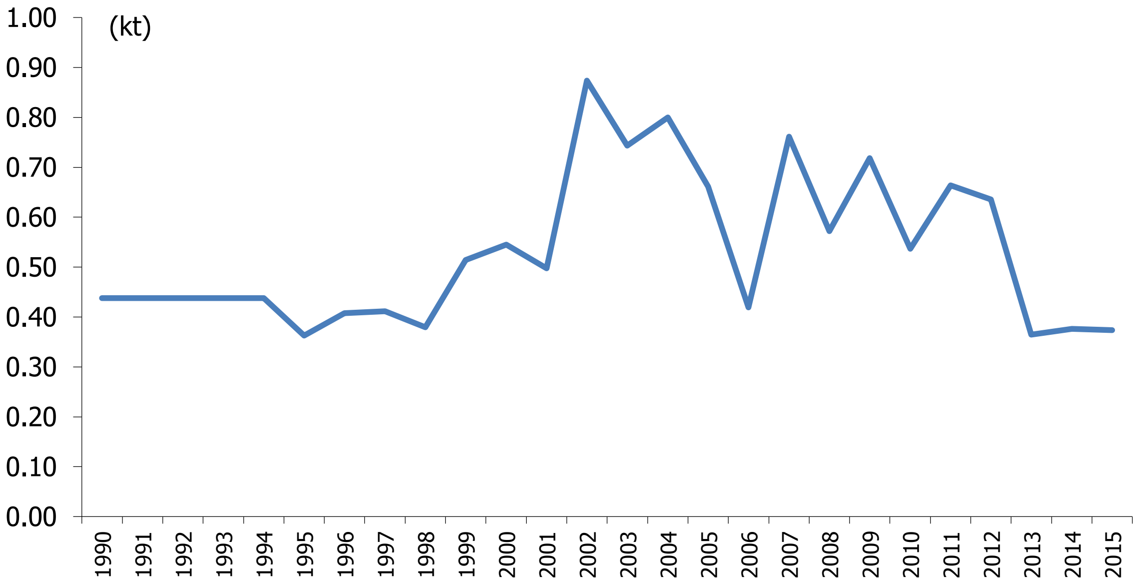
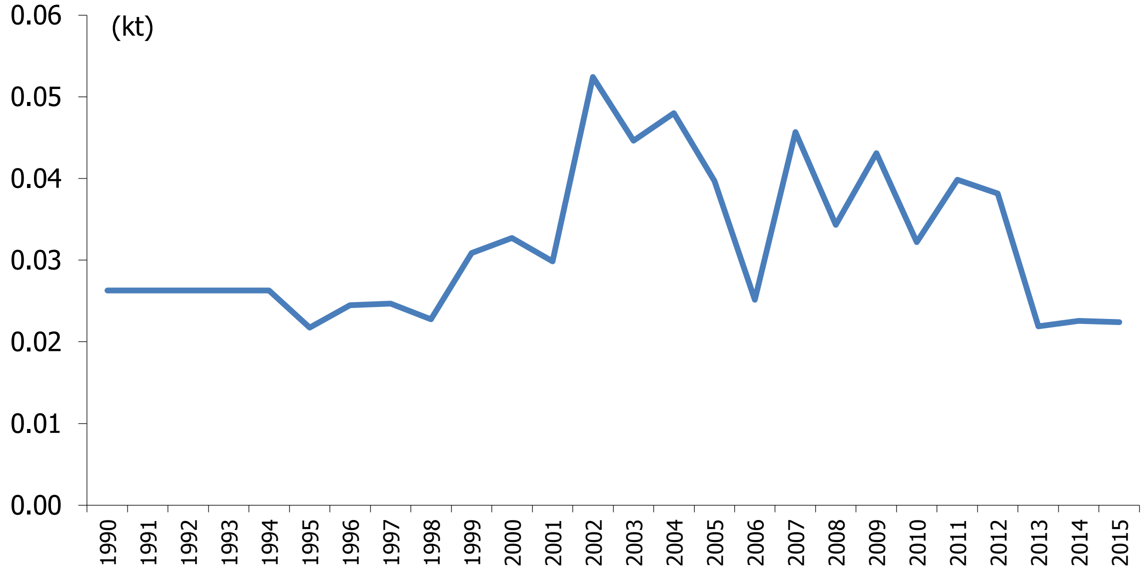


Figure 7.5 N_2O emissions from composting, 1990-2015



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.

Activity data was also calculated using "fraction of waste composted" as in previous years for the year 2015. The figure obtained was not used for calculation but used for verification purposes only.

Recalculation:

Emission estimates from Biological Treatment of Solid Waste (CRF Category 5.B) were recalculated over the 1990-2014 time series due to correcting the default emission factor for N_2O on a wet weight basis for composting as 0.24 instead of 0.3 according to the *9th Corrigenda for the 2006 IPCC Guidelines* as of July 2015. This correction was identified during QC checks.

Overall, recalculations resulted in a decrease in emissions of 1.68 kt CO_2 eq. (20.0%) in 2014 and a decrease in emissions of 1.96 kt CO_2 eq. (20.0%) 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 98.7% (104.1 kt CO_2 eq.) between 1990 to 2015, including no change between 2014 and 2015. The main reason of this trend is the decreasing amount of waste open-burned by years, especially with a sharp decline in 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).

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.*

$$CO_2\ Emissions = MSW \bullet \sum_j \left(WF_j \bullet dm_j \bullet CF_j \bullet FCF_j \bullet OF_j\right) \bullet 44/12$$

Where:

CO_2 Emissions = CO_2 emissions in inventory year, Gg/yr

MSW = total amount of municipal solid waste as wet weight open-burned, Gg/yr

WF_j = fraction of waste type/material of component j in the MSW (as wet weight open-burned)

dm_j = dry matter content in the component j of the MSW open-burned, (fraction)

CF_j = fraction of carbon in the dry matter (i.e., carbon content) of component j

FCF_j = fraction of fossil carbon in the total carbon of component j

OF_j = oxidation factor, (fraction)

44/12 = conversion factor from C to CO_2

j = component of the MSW open-burned such as paper/cardboard, textiles, food waste, wood, garden (yard) and park waste, disposable nappies, rubber and leather, plastics, metal, glass, other inert waste.

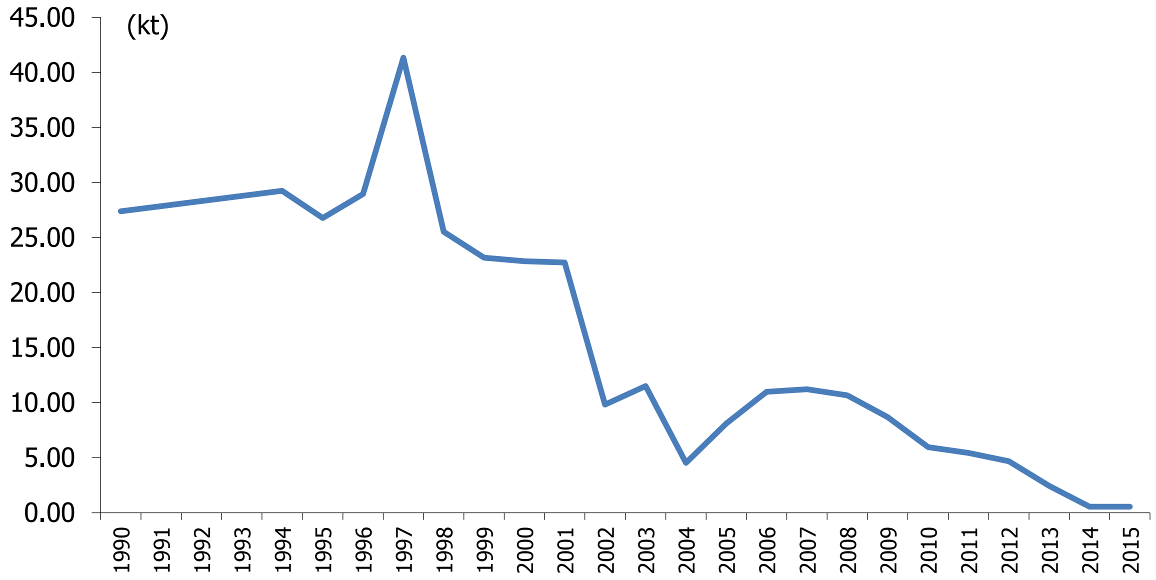
The biogenic CO_2 emissions from open burning should not be included in national total emission estimates according to the information given in *2006 IPCC, Volume 5, Chapter 5, Section 5.1* as in Table 7.21. Total CO_2 emissions from open burning fluctuate between 1990-2015 as shown in Figure 7.6.

Table 7.21 CO_2 emissions from open burning of waste, 1990-2015

(kt)

Year	Total	Biogenic	Non-biogenic
1990	27.396	0.219	27.396
1991	27.861	0.223	27.861
1992	28.323	0.226	28.323
1993	28.784	0.230	28.784
1994	29.243	0.234	29.243
1995	26.788	0.214	26.788
1996	28.963	0.231	28.963
1997	41.347	0.330	41.347
1998	25.539	0.204	25.539
1999	23.171	0.185	23.171
2000	22.853	0.183	22.853
2001	22.725	0.182	22.725
2002	9.822	0.311	9.822
2003	11.513	0.364	11.513
2004	4.526	0.143	4.526
2005	8.107	0.256	8.107
2006	10.979	0.347	10.979
2007	11.228	0.355	11.228
2008	10.656	0.337	10.656
2009	8.682	0.275	8.682
2010	5.962	0.189	5.962
2011	5.432	0.172	5.432
2012	4.665	0.148	4.665
2013	2.437	0.077	2.437
2014	0.544	0.003	0.544
2015	0.544	0.003	0.544

Figure 7.6 CO_2 emissions from open burning of waste, 1990-2015



CH_4 Emissions

The calculation of CH_4 emissions is based on the amount of waste open-burned and on the related emission factor as given in *Equation 5.4 in the 2006 IPCC Guidelines, Volume 5, Chapter 5.*

$$CH_4\ Emissions = \sum_i (IW_i \bullet EF_i) \bullet 10^{-6}$$

Where:

CH_4 Emissions = CH_4 emissions in inventory year, Gg/yr

IW_i = amount of solid waste of type i open-burned, Gg/yr

EF_i = aggregate CH4 emission factor, kg CH_4/Gg of waste

10^{-6} = conversion factor from kilogram to gigagram

i = category or type of waste open-burned, specified as follows:

MSW: municipal solid waste, ISW: industrial solid waste, HW: hazardous waste,

CW: clinical waste, SS: sewage sludge, others (that must be specified)

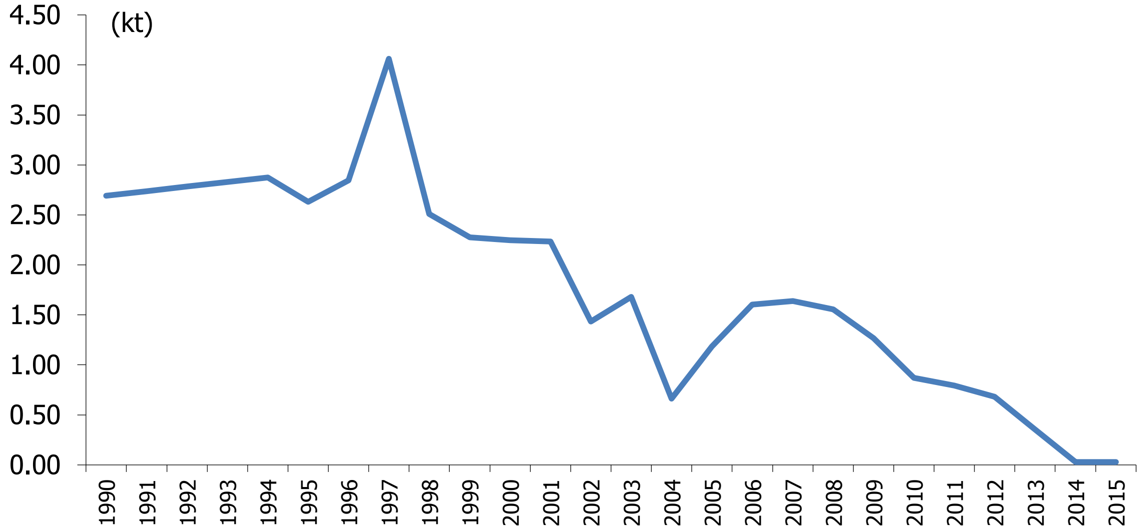
Estimated results of CH_4 emissions are given in Table 7.22 and Figure 7.7. The CH_4 emissions show a decreasing trend with the same fluctuations as with AD between 1990 and 2015 as can be seen in Figure 7.9 below.

Table 7.22 CH_4 emissions from open burning of waste, 1990-2015

(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	0.016	0.012
2015	0.028	0.016	0.012

Figure 7.7 CH_4 emissions from open burning of waste, 1990-2015



N_2O Emissions

The calculation of N_2O emissions is based on the amount of waste open-burned and a default emission factor as given in *Equation 5.5 in the 2006 IPCC Guidelines, Volume 5, Chapter 5.*

$$N_2O\ Emissions = \sum_i (IW_i \bullet EF_i) \bullet 10^{-6}$$

Where:

N_2O Emissions = N_2O emissions in inventory year, Gg/yr

IW_i = amount of open-burned waste of type i , Gg/yr

EF_i = N_2O emission factor (kg N_2O/Gg of waste) for waste of type i

10^{-6} = conversion from kilogram to gigagram

i = category or type of waste open-burned, specified as follows:

MSW: municipal solid waste, ISW: industrial solid waste, HW: hazardous waste,

CW: clinical waste, SS: sewage sludge, others (that must be specified)

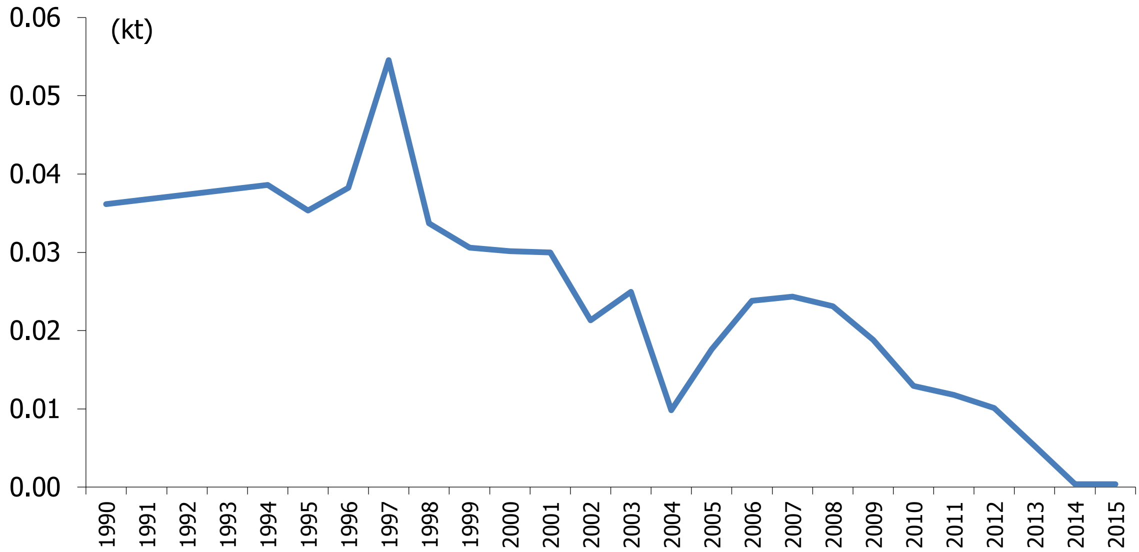
Estimated results of N_2O emissions from open burning of waste are given in Table 7.23 and Figure 7.8. As with CH_4 emissions, N_2O emissions have a decreasing trend with the same fluctuations as of AD between 1990 and 2015 as can be seen in Figure 7.9 below.

Table 7.23 N_2O emissions from open burning of waste, 1990-2015

(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
2015	0.0004	0.0002	0.0002

Figure 7.8 N_2O emissions from open burning of waste, 1990-2015



Collection of Activity Data

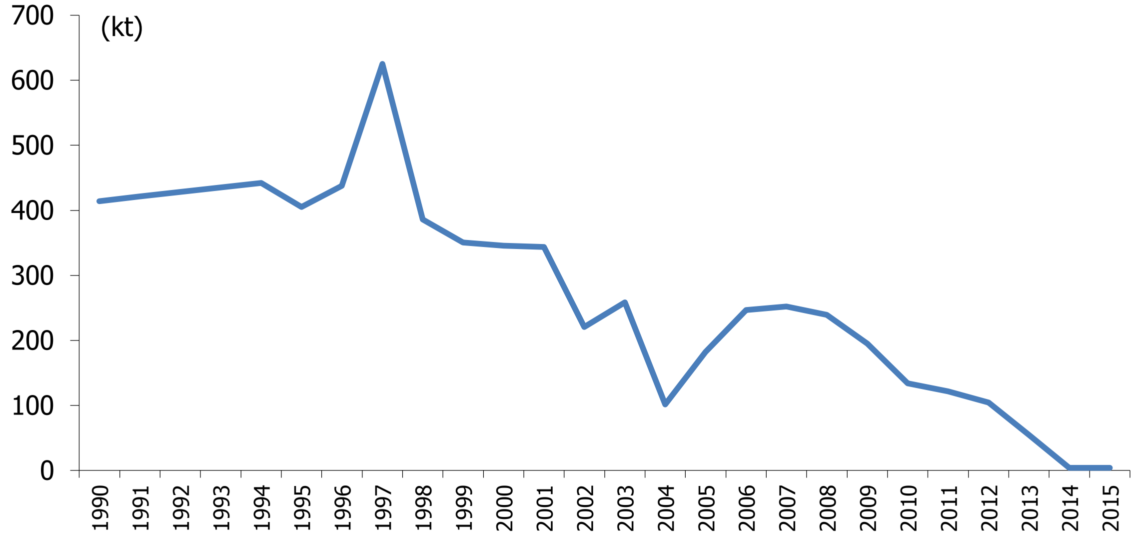
Activity data for open burning of MSW are estimated using the total amount of MSW open-burned (1994-1998, 2001-2004, 2006, 2008, 2010, 2012 and 2014) as obtained from TurkStat's *Municipal Waste Statistics Survey* as given in Table 7.5 and applying an estimate of the composition of MSW.

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, 2011 and 2013 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. Since extrapolation was not applied for 2015 due to the trendline, 2015 data for total amount of waste open-burned was assumed the same as in 2014. 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, 1990-2015

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
2015	0.01	4.28

Figure 7.9 Total amount of MSW open-burned, 1990-2015



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)	2002-2013 (2)	2014-2015 (3),(4)
Paper/cardboard	Biogenic	6.0	16.0	8.9
Textiles	Non-biogenic	4.0	0.0	3.2
Food waste	Biogenic	64.0	34.0	47.9
Garden and Park waste	Non-biogenic	0.0	19.0	6.7
Nappies	Non-biogenic	0.0	0.0	3.0
Plastics	Non-biogenic	3.0	2.0	6.9
Metal	Non-biogenic	1.0	1.0	1.9
Glass	Non-biogenic	2.0	6.0	3.8
Other, inert waste	Non-biogenic	20.0	22.0	17.8

(1) TurkStat, Environmental Statistics, Household Solid Waste Composition and Tendency Survey Results, 1993

(2) MoEF, Waste Management Action Plan, 2008-2012

(3) MoEU, National Waste Management & Action Plan, Draft Report, 2016-2023

(4) Percentages may not add up to 100% due to rounding.

Table 7.26 Default dry matter content, total carbon content and fossil carbon fraction

(%)

MSW Component	Origin	Dry matter content in % of wet waste	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	-
Garden and Park waste	Non-biogenic	40.0	49.0	0.0
Nappies	Non-biogenic	40.0	70.0	10.0
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 using *Equations 5.8, 5.9 and 5.10* respectively as given in the *2006 IPCC Guidelines, Volume 5, Chapter 5.* Three different waste fractions (WF) of 1990-2001, 2002-2013 and 2014-2015 given in Table 7.25 and the fractions of carbon content given in Table 7.26 above are used related to CO_2 emission factors*.* A default oxidation factor in % of carbon input (OF) is selected for MSW as 58.0% based on *Table 5.2 in 2006 IPCC, Volume 5, Chapter 5*.

The CH_4 emissions from open burning of waste are estimated using an 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 using an 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_2 EF is considered as 40.0%. 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:

According to the findings made by the ERT during the technical review of the 2016 inventory submission of Turkey, the equation regarding the CO_2 emissions from open burning of waste was misapplied by Turkey. Turkey examined the emission estimates and corrected the aggregation error. Consequently, CO_2 emissions from Incineration and Open Burning of Waste (CRF Category 5.C) have been recalculated for the years 1990-2014.

Compared to the previous inventory submission, CO_2 emissions in 2014 increased by 496.30% (0.45 kt CO_2 eq.) and increased in 1990 by 890.54% (24.63 kt CO_2 eq.).

Waste composition data for 2014 was updated due to the availability of new country-specific data *(National Waste Management & Action Plan, Draft Report, 2016-2023; MoEU)*. This update resulted as a decrease of 3.49% (0.004 kt CO_2 eq.) in N_2O emissions in 2014.

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 4.0% (167.5 kt CO_2 eq.) for the period 1990-2015, but decreased by 1.0% (46.5 kt CO_2 eq.) between 2014 and 2015. 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 593.5 per cent (815 kt CO_2 eq.) between 1998 (137 kt CO_2 eq.) and 2015 (952 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 using *Equation 6.1 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.*

$$CH_4\ Emissions = \left[\sum_{i,j}\left(U_i \bullet T_{i,j} \bullet EF_j\right)\right]\left(TOW - S\right) - R$$

Where:

CH_4 Emissions = CH_4 emissions in inventory year, kg CH_4/yr

TOW = total organics in wastewater in inventory year, kg BOD/yr

S = organic component removed as sludge in inventory year, kg BOD/yr

U_i = fraction of population in income group i in inventory year,

$T_{i,j}$ = degree of utilisation of treatment/discharge pathway or system, j, for each income group fraction i in inventory year,

i = income group: rural, urban high income and urban low income

j = each treatment/discharge pathway or system

EF_j = emission factor, kg CH_4 / kg BOD

R = amount of CH_4 recovered in inventory year, kg CH_4/yr

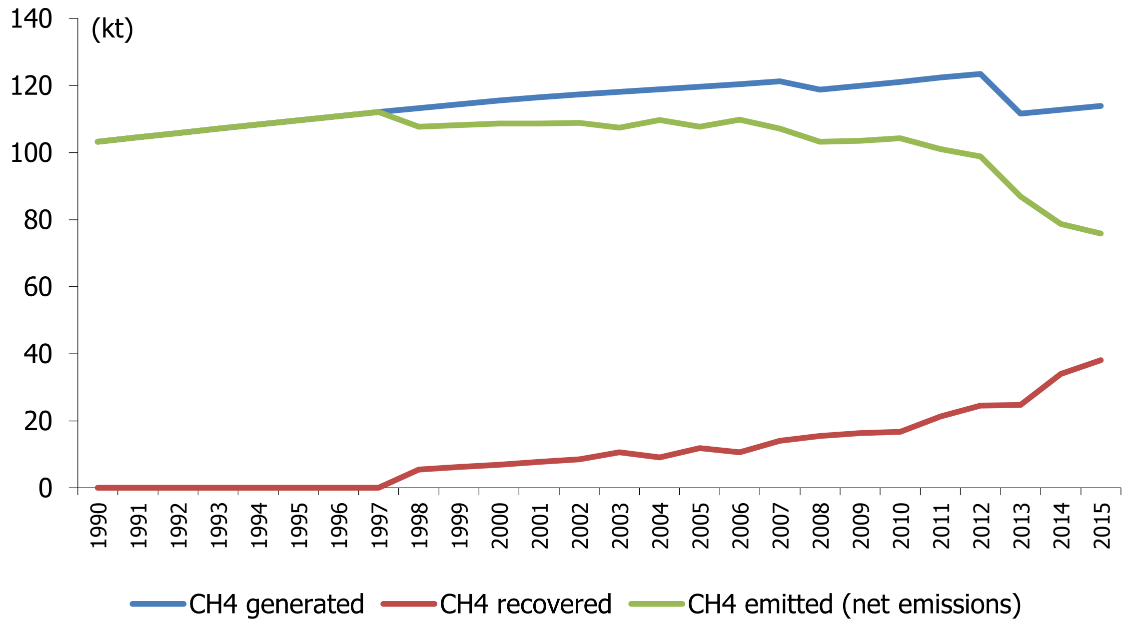
Total CH_4 emissions are estimated based on country-specific information on the total organics in wastewater minus the total amount of sludge and multiplying by the IPCC default emission factor, corrected for country-specific fractions of urban/rural populations and the fraction of the wastewater utilizing the various discharge pathways. The amount of methane generated, methane recovered and net methane emissions are estimated as given in Table 7.27 and Figure 7.10.

Table 7.27 CH_4 generated, recovered and emitted from domestic wastewater, 1990-2015

(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	16.8	104.3
2011	122.4	21.3	101.1
2012	123.5	24.6	98.9
2013	111.6	24.7	86.9
2014	112.7	34.0	78.8
2015	113.9	38.1	75.8

Figure 7.10 CH_4 emissions from domestic wastewater, 1990-2015



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 using *Equation 6.3 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.*

$$TOW = P \bullet BOD \bullet 0.001 \bullet I \bullet 365$$

Where:

TOW = total organics in wastewater in inventory year, kg BOD/yr

P = country population in inventory year, (person)

BOD = country-specific per capita BOD in inventory year, g/person/day,

0.001 = conversion from grams BOD to kg BOD

I = correction factor for additional industrial BOD discharged into sewers (for collected the default is 1.25, for uncollected the default is 1.00.)

The total population is used to calculate TOW and S values. For the entire time series, the total population is taken from Turkstat's *Mid-year Population Estimations and Projections*. 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 2015 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 7.28.

Table 7.28 Fraction of population and total, rural, urban population, 1990-2015

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	76 148 000	6 588 471	69 559 529
2014	8.2	91.8	77 182 000	6 367 326	70 814 674
2015	7.9	92.1	78 218 000	6 176 615	72 041 385

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, 91.8% in 2014 and 92.1% in 2015, 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 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 7.29.

Table 7.29 TOW and S for domestic wastewater, 1990-2015

		(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	1 473.1	778.2
2014	1 493.1	788.8
2015	1 513.1	799.4

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*.

$$EF_j = B_o \bullet MCF_j$$

Where:

EF_j = emission factor, kg CH_4/kg BOD

j = each treatment/discharge pathway or system

B_o = maximum CH_4 producing capacity, kg CH_4/kg BOD

MCF_j = methane correction factor (fraction)

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 7.30.

Table 7.30 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 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 7.31.

Table 7.31 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 sends 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 every year. 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 (biennial) 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 7.32.

Table 7.32 Methane recovery, 1990-2015

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	16.8
2011	12	21.3
2012	13	24.6
2013	17	24.7
2014	18	34.0
2015	19	38.1

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 using *Equation 6.4 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.*

$$CH_4\ Emissions = \sum_i \left[\left(TOW_i - S_i \right) EF_i - R_i \right]$$

Where:

CH_4 Emissions = CH_4 emissions in inventory year, kg CH_4/yr

TOW_i = total organically degradable material in wastewater from industry i in inventory year, kg COD/yr

i = industrial sector

S_i = organic component removed as sludge in inventory year, kg COD/yr

EF_i = emission factor for industry i, kg CH_4/kg COD

for treatment/discharge pathway or system(s) used in inventory year

R_i = amount of CH_4 recovered in inventory year, kg CH_4/yr

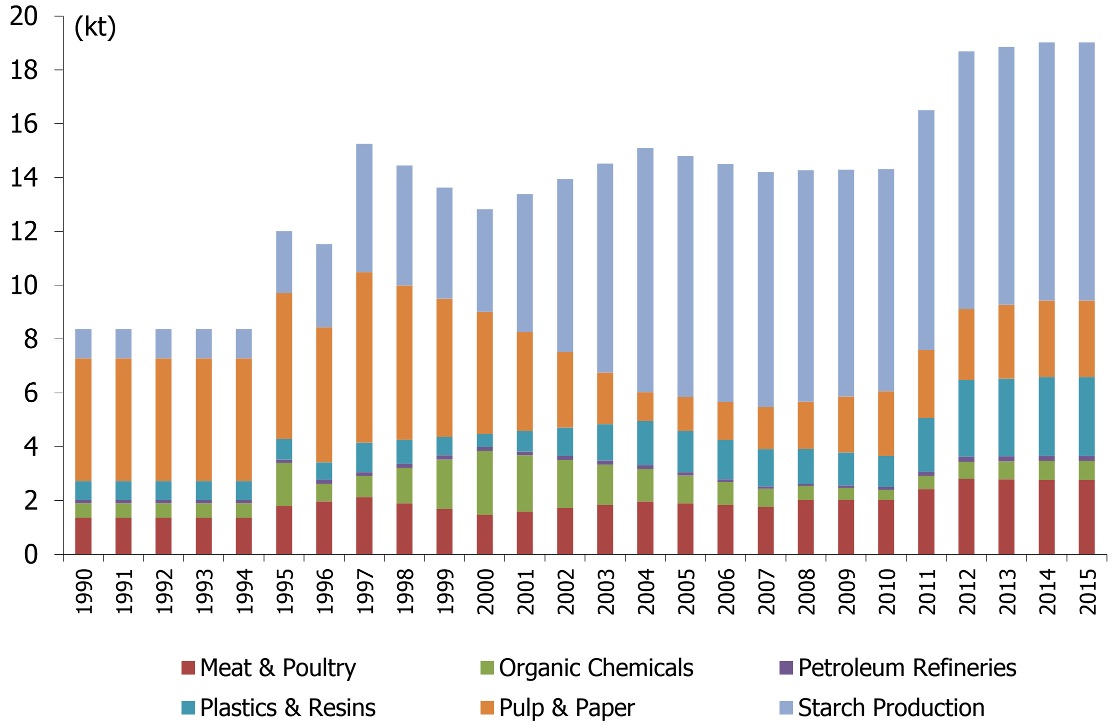
Specifically, the country-specific information on the total organically degradable material in wastewater, by industry, is multiplied by a specific emission factor that takes into account the relative use of various treatment/discharge pathways. There is no recovery of methane from industrial wastewater and sludge removal is assumed to be zero. Amount of methane emissions, by industry, are estimated as given in Table 7.33 and Figure 7.11.

Table 7.33 CH_4 emissions from industrial wastewater by industry, 1990-2015

(kt)

Year	Total	Meat & poultry	Organic chemicals	Petroleum refineries	Plastics & resins	Pulp & paper (combined)	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
2015	19.02	2.76	0.71	0.19	2.92	2.85	9.60

Figure 7.11 CH_4 emissions from industrial wastewater, 1990-2015



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.*

$$TOW_i = P_i \bullet W_i \bullet COD_i$$

Where:

TOW_i = total organically degradable material in wastewater for industry i, kg COD/yr

i = industrial sector

P_i = total industrial product for industrial sector i, t/yr

W_i = wastewater generated, $m^3/t_{product}$

COD_i = chemical oxygen demand (industrial degradable organic component in wastewater), kg COD/m^3

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, 2011 and 2013) are estimated by linear interpolation. In the current inventory, TOW_i and emissions for 2015 were assumed the same as in 2014 due to the lack of data. The amount of industrial wastewater treated by industrial sectors are given in Table 7.34.

Table 7.34 Amount of industrial wastewater treated by sector, 1990-2015

(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
2015	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 7.35, that are based on *Table 6.9 in the 2006 IPCC Guidelines, Volume 5, Chapter 6* and the results are given in Table 7.36.

Table 7.35 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 7.36 TOW$_i$ in wastewater by industry sector, 1990-2015

(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	1 177.2	163.7	60.4	11.7	85.1	487.6	368.6
1998	1 114.5	146.9	101.4	11.6	69.1	442.1	343.4
1999	1 051.8	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	1 032.9	122.7	160.9	11.4	59.2	283.7	394.9
2002	1 076.6	132.4	138.4	11.3	81.4	216.4	496.8
2003	1 120.3	142.0	115.8	11.2	103.5	149.0	598.7
2004	1 165.5	151.6	93.3	11.2	125.7	83.2	700.6
2005	1 142.5	146.6	79.5	9.7	119.1	96.2	691.3
2006	1 119.4	141.6	65.7	8.3	112.6	109.3	682.0
2007	1 096.4	136.7	51.9	6.9	106.0	122.3	672.6
2008	1 101.0	156.0	40.5	5.5	100.2	135.4	663.3
2009	1 102.9	156.5	34.3	6.9	94.3	160.5	650.4
2010	1 104.9	157.0	28.1	8.4	88.3	185.7	637.5
2011	1 273.4	187.1	38.4	11.6	153.6	194.8	687.9
2012	1 441.8	217.2	48.6	14.8	218.8	204.0	738.3
2013	1 454.9	215.2	51.8	14.6	222.0	211.8	739.4
2014	1 468.0	213.3	55.0	14.5	225.1	219.6	740.5
2015	1 468.0	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_4 EFs 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*.

$$EF_j = B_o \bullet MCF_j$$

Where:

EF_j = emission factor for each treatment/discharge pathway or system, kg CH_4/kg COD,

j = each treatment/discharge pathway or system

B_o = maximum CH_4 producing capacity, kg CH_4/kg COD

MCF_j = methane correction factor (fraction)

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 7.37.

Table 7.37 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 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.

$$N_2O\ Emissions = N_{EFFLUENT} \bullet EF_{EFFLUENT} \bullet 44/28$$

Where:

N_2O emissions = N_2O emissions in inventory year, kg N_2O/yr

$N_{EFFLUENT}$ = nitrogen in the effluent discharged to aquatic environments, kg N/yr

$EF_{EFFLUENT}$ = emission factor for N_2O emissions from discharged to wastewater, kg N_2O-N/kg N

The factor 44/28 is the conversion of kg N_2O-N into kg N_2O.

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 using *Equation 6.9 in 2006 IPCC, Volume 5, Chapter 6.*

$$N_2O_{PLANTS} = P \bullet T_{PLANT} \bullet F_{IND-COM} \bullet EF_{PLANT}$$

Where:

N_2O_{PLANTS} = total N_2O emissions from plants in inventory year, kg N_2O/yr

P = human population

T_{PLANT} = degree of utilization of modern, centralized WWT plants, %

$F_{IND-COM}$ = fraction of industrial and commercial co-discharged protein (default = 1.25),

EF_{PLANT} = emission factor, 3.2 g N_2O/person/year

The estimation results are given in Table 7.38 and Figure 7.12.

There has been a steady increase in N_2O emissions from wastewater during the period 1990-2015, as shown in Figure 7.12. N_2O emissions increase of 40.4% since 1990.

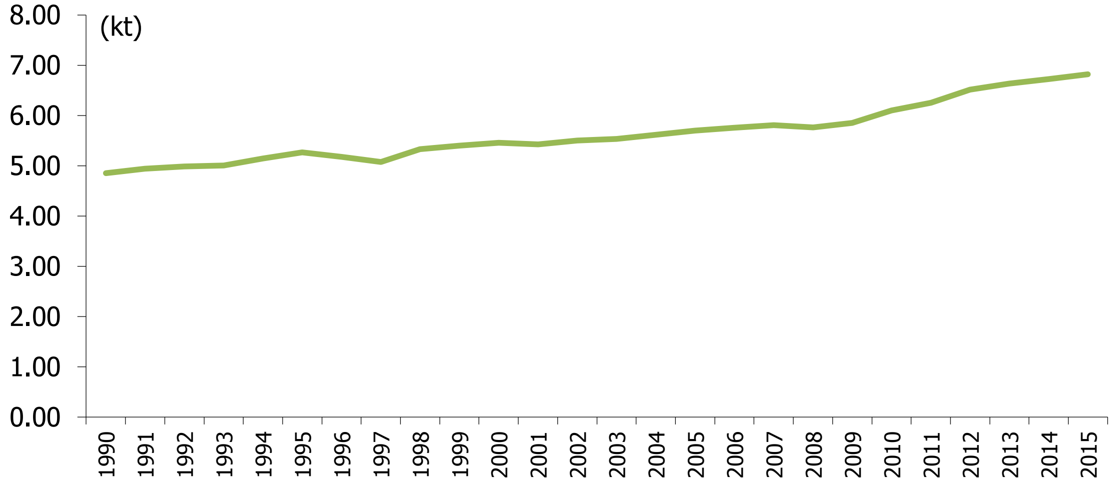
Turkey reports N_2O emissions from industrial wastewater as "IE" in CRF table 5.D. As discussed further below, N_2O emissions from industrial wastewater (category 5.D.2) discharged into sewers is included in the N_2O emissions from domestic wastewater (category 5.D.1).

Table 7.38 N_2O emissions from wastewater, 1990-2015

(kt)

Year	N_2O emissions from wastewater effluent	N_2O emissions from centralized WWT plants	N_2O emissions
1990	4.84	0.02	4.86
1991	4.92	0.02	4.94
1992	4.97	0.02	4.99
1993	4.99	0.02	5.01
1994	5.13	0.02	5.15
1995	5.24	0.02	5.27
1996	5.16	0.02	5.18
1997	5.05	0.02	5.08
1998	5.31	0.02	5.33
1999	5.38	0.02	5.40
2000	5.44	0.02	5.46
2001	5.40	0.02	5.43
2002	5.48	0.03	5.51
2003	5.51	0.03	5.53
2004	5.59	0.03	5.62
2005	5.68	0.03	5.70
2006	5.73	0.03	5.76
2007	5.78	0.03	5.81
2008	5.74	0.03	5.76
2009	5.83	0.03	5.85
2010	6.08	0.03	6.11
2011	6.23	0.03	6.25
2012	6.49	0.03	6.52
2013	6.61	0.03	6.64
2014	6.70	0.03	6.73
2015	6.79	0.03	6.82

Figure 7.12 N_2O emissions from wastewater, 1990-2015



Collection of Activity Data

The activity data that are needed for estimating N_2O emissions are nitrogen content in the wastewater effluent, country population and average annual per capita protein generation (kg/person/yr).

The total nitrogen in the effluent is estimated using *Equation 6.8 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.*

$$N_{EFFLUENT} = \left(P \bullet Protein \bullet F_{NPR} \bullet F_{NON-CON} \bullet F_{IND-COM} \right) - N_{SLUDGE}$$

Where:

$N_{EFFLUENT}$ = total annual amount of nitrogen in the wastewater effluent, kg N/yr

P = human population

Protein = annual per capita protein consumption, kg/person/yr

F_{NPR} = fraction of nitrogen in protein, kg N/kg protein

$F_{NON-CON}$ = factor for non-consumed protein added to the wastewater

$F_{IND-COM}$ = factor for industrial and commercial co-discharged protein into the sewer system

N_{SLUDGE} = nitrogen removed with sludge, kg N/yr

Per capita protein generation consists of intake (consumption) which is available from the FAOSTAT *(http://www.fao.org/faostat/en/#data/FBS/visualize)*. Data can be obtained for Turkey between the years 1990-2013. 2014 and 2015 data were assumed the same as in 2013 due to the lack of data. Population data is available from the TurkStat *(http://www.turkstat.gov.tr/PreTablo.do?alt_id=1027)* and can be accessed under the *Mid-year Population Statistical Table*. Population and annual per capita protein consumption data are given in Table 7.39.

Table 7.39 Population and per capita protein consumption, 1990-2015

Year	Population (1) (1000's persons)	Per capita protein consumption (2) (kg/person/yr)
1990	55 120	39.88
1991	56 055	39.90
1992	56 986	39.62
1993	57 913	39.16
1994	58 837	39.62
1995	59 756	39.89
1996	60 671	38.64
1997	61 582	37.30
1998	62 464	38.64
1999	63 364	38.57
2000	64 269	38.44
2001	65 166	37.68
2002	66 003	37.75
2003	66 795	37.49
2004	67 599	37.60
2005	68 435	37.70
2006	69 295	37.60
2007	70 158	37.47
2008	71 052	36.69
2009	72 039	36.76
2010	73 142	37.77
2011	74 224	38.13
2012	75 176	39.25
2013	76 148	39.46
2014	77 182	39.46
2015	78 218	39.46

Source: (1) TurkStat, Mid-year Population Estimations and Projections

(2) FAOSTAT, Food Balance Sheets

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, 2015

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)
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 and 2014 data for mid-year population were updated according to the TurkStat's *Mid-year Population Estimations and Projections* based on the annual results of the Address Based Population Registration System. Therefore, population data were updated for 2013 and 2014. In addition, as a result of QC checks, methane recovery data for 2010-2014 are recalculated for some biogas facilities.

Consequently, CH_4 emissions from wastewater have been recalculated for the years 2010-2014. Recalculations resulted in an increase in emissions of 89.74 kt CO_2 eq. (3.81%) in 2014.

Turkey was using a constant value (36.83 kg/person/year) of protein consumption for the whole time series. The constant value of protein consumption was the average of the available years provided by the FAO. Based on the ERT recommendation made during the 2016 technical review of the annual submission of Turkey, Turkey reported N_2O emissions using annual per capita protein consumption data originates from the *FAOSTAT (Food Balance Sheets)* for corresponding years of the inventory.

In summary, N_2O emissions from wastewater have been recalculated for the years 1990-2014. Recalculations resulted in an increase in emissions of 157.59 kt CO_2 eq. (8.53%) in 2014 and an increase in emissions of 122.66 kt CO_2 eq. (9.26%) in 1990.

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;

Every year the inventory team reviews the latest inventory and tries 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 2015 inventory.

Also desk review held in October 2016 for both 2015 and 2016 GHG inventory submissions of Turkey. Based on the ERT recommendations for some categories, recalculations were made. All kind of recalculations were described in the chapters 3-7 in detail, and the reasons for recalculations were also summarized below;

In energy sector;

In light of the recommendations addressed by ERT in annual review process and in order for the international data to be convenient and comparable with that of General Energy Balance Sheets, it is decided with TurkStat to disaggregate GHG emissions of 1.A.1.a sector under electricity and combined heat production nodes, using the same data source, TEİAŞ. Since disaggregated data was available for the years 2000-2015, aforementioned breakdown applied for those years.

It is decided to allocate all autoproducers to include under 1.A.1.a category. Formerly whole activity data of autoproducers had been accounted under the industry branch in which they operate. Therefore GHG emissions from 1A1a, all sub sectors of 1A2 and 1a4b based on the reallocation of autoproducers.

Country specific carbon contents for lignite, hard coal, diesel and natural gas for 1990-2014 were revised. Also country specific oxidation rate of hard coal and lignite was determined. So based on revised EFs, CO_2 emissions from 1A1a, and all subcategories of 1A2, 1A3 and 1A4 were re calculated for 1990-2014 period. Also CH_4 and N_2O EFs for 1.A.1.a category were revised and technology specific EFs from 2006 IPCC guidelines are used for the years 2003-2015 since information technology classification was available only for those years.

Also in pipeline transport data correction was made for 2008 AD. Moreover, CH_4 and N_2O emissions resulting from pipeline transport were recalculated due to the correction of EFs for CH_4, and N_2O.

A carbon mass balance study was performed in integrated iron and steel facilities, therefore emissions from 1A1c, 1A2a and 2.C.1 was recalculated based on results of carbon balance study.

GHG emissions from off road vehicles in agricultural sector and abondened underground coal mines are estimated for the first time in this submission.

In IPPU sector;

For cement production; country specific EF were calculated by using data from only 12-14 plants in previous inventory report. In this inventory all the plants are asked for their CaO content between 1990 and 2015. The country specific emission factor was revised and accordingly emissions were recalculated.

For lime production the activity data was revised and it is found that some of the lime production data was double counted. Besides that the lime produced for sugar refining and synthetic soda ash production is deducted from the national lime production data because the CO_2 is reabsorbed and processed in these industries. Moreover in 2016 the dolomitic lime production was not covered.

For the glass production; in the previous inventory the amount of final glass product was used as the activity data. However, in this inventory report molten glass production data is used as the activity data which is compulsory for tier 2 methodology. Secondly, in this inventory report country specific cullet ratios for each type of glass for each year in the time series are used for emission calculations. Lastly, a different approach is applied in this inventory report in order to estimate the 1990-2009 total glass production. For this estimation it is assumed that Şişecam Company produced 90% of all the glasses in Turkey between 1990 and 2009.

For the other use of soda ash category; There is recalculations of CO_2 emissions from other uses of soda ash in the all time series due to recalculation in the glass industry and more over for the years 2013 and 2014 one of the soda ash producers revised its own production data. Furthermore soda ash trading data is also revised.

For the non-metallurgical magnesia production; Previously PRODCOM (Industrial Production Survey of TurkStat) data were used as the activity data of magnesia production. The PRODCOM data classifies magnesia products as sinter and calcined according to degree of calcination. Both of them emissive magnesia products. However in the previous submission sinter magnesia did not taken into account. Moreover in this report the production data is asked to magnesia producers and emissions are calculated accordingly. The PRODCOM data is not available before 2005 whereas companies supplied data for the full time series.

In ammonia production; the carbon oxidation factor was taken as 0.9 in the previous submission. It is corrected with 1.0. Moreover carbon content of the natural gas between 1990 and 2014 was revised.

In the nitric acid production, in the previous NIR the nitric acid production data of one of the plant before 2004 was not available. In this inventory the data is accessed and the time series between 1990 and 2004 is recalculated.

In the carbide production; calcium carbide emission factor is revised due to the assumption that all the produced carbide is used for acetylene production.

In the petrochemical and carbon black production; PRODCOM (Industrial Production Survey of TurkStat) data were used as the activity data of carbon black production. However in this report the production data is asked to PETKİM and emissions are calculated by using the PETKİM data due to plant level data is appropriately more disaggregated.

For the iron and steel production; integrated facilities are begun to provide their energy balance tables which are more reliable sources of data. The tables go back to 5-10 years at most. Therefore the earlier years were adjusted with the previous data set accordingly. Moreover this year it is realized that the steel furnace gas is double counted in the both IPPU and Energy sectors. The steel furnace gas emissions are deducted from the IPPU category since all the steel furnace gas is recovered and used for heat production. In addition this year emissions from the pellet production are calculated for the first time. Despite a major recalculation made in the integrated iron and steel facilities no recalculation is made for the EAF steel production plants.

In ferroalloy production; For this inventory year ferrochromium production data was gathered directly from the companies. In the previous inventories TurkStat's annual industrial production statistics, PRODCOM, data was used. Some ferroalloy shaping processes and trading data were also evaluated as ferroalloy production in the PRODCOM previously. These data were sorted out. The entire time series were recalculated using the plant specific production data due to plant level data is appropriately more disaggregated

In lead production; in the previous NIR, TurkStat’s national industrial productions statistics were used as the national lead production data and estimates were made accordingly. However this year it is understood that the national data is not lead production data but it is lead ore mining and trading data. Therefore a new approach developed to estimate the lead production in Turkey and emissions are calculated accordingly.

In zinc production; in the previous NIR, TurkStat’s national industrial productions statistics were used as the national zinc production data and estimates were made accordingly. However this year it is understood that the national data is not zinc production data but it is zinc ore mining data and possibly zinc oxide production data. In Turkey there is no zinc metal production. However in the past there used to be. A new data source has found revealing the zinc productions of Turkey for 1990-1999 and the emission calculation was done accordingly.

Emission of SF_6 gas was recalculated in accordance with the overall electricity consumption.

In agriculture sector;

Animal population data, the main activity data for Enteric Fermentation, Manure Management, and to an extent for Agricultural Soils, were updated accordingly mainly for the years 1994 and 1997 for some animal categories in small amounts.

Tier 2 method was used to calculate enteric fermentation emissions of cattle for 1990-2015 leading to overall new series. Updating Animal Waste Management Systems percentage distribution and implementing calculation corrections, the entire Manure Mangement N_2O emissions and related Agricultural Soils emissions were recalculated in this submission.

In this source category, a major recalculation was a result of the removal of a main calculation error. The classification of crop residues and the related activity data were updated and corrections were undertaken in time series mistakes leading to a new 1990-2015 series. Newly added plants under the heading of Crop Production Statistics in TurkStat's database were also calculated to the N contributions under this category and reflected in the Inventory.

After consultations with the MFAL, it was determined that maize residues were not burned in our country overall. Hence, the calculation for maize burning was taken out of the inventory entirely. In addition, the combustion factor update of barley and the recalculation for biomass available led to new series for 1990-2014 in the emission category Field Burning.

In LULUCF sector;

Corine data updated for 2012, 2006 Corine and 2012 Corine data have been compared and land use change has been detected.

The carbon stock changes between 2006-2015 of the Cropland (CRF Category 4.B), Grassland (CRF Category 4.C) and Settlements (CRF Category 4.E) have been recalculated.

The difference between previous calculations and recalculations has been shown İn Table (10.1).

In waste sector;

Emission estimates from Solid Waste Disposal (CRF Category 5.A) are recalculated over the 1999-2014 time series due to the minor data updates regarding waste per capita data, waste composition data and GDP data.

Emission estimates from Biological Treatment of Solid Waste (CRF Category 5.B) are recalculated over the 1990-2014 time series due to correcting the default emission factor of N_2O for composting according to the *9th Corrigenda for the 2006 IPCC Guidelines* as of July 2015.

CO_2 emissions from Incineration and Open Burning of Waste (CRF Category 5.C) have been recalculated for the years 1990-2014 because of the aggregation error in the emissions for open burning of waste determined by the ERT during the technical review of the 2016 inventory submission of Turkey. N_2O emissions are recalculated due to updated waste composition data for 2014.

Methane recovery data from some biogas facilities for 2010-2014 and mid-year population data were updated for 2013 and 2014. Consequently, CH_4 emissions from Wastewater Treatment and Discharge (CRF Category 5.D) have been recalculated for the years 2010-2014. N_2O emissions from wastewater have been recalculated for the years 1990-2014 due to the updating of protein consumption data based on the ERT recommendation made during the 2016 technical review of the annual submission of Turkey.

The reasons and the implications of recalculations by CRF category are given in the below table for 1990 and 2014.

Table 10.1 Recalculations made in 2014 inventory and implications to the emission level, 1990 and 2014

CRF category	Reasons for recalculation	Implication to the CRF category level (kt CO_2 eq.)		Implication to the total emission w/o LULUCF (%)	
		1990	2014	1990	2014
1. Energy		**1 881**	**-17 863**	**2.90**	**-2.54**
A.1 Energy industries	Reallocation of autoproducers under 1A1a category, Revision of CS CO_2 EFs for liquid, solid and gaseous fuels, Carbon mass balance in the integrated iron and steel facilities, Use of technology specific CH_4 and N_2O EFs in 1A1a category	1 855	-17 862	0.42	-0.26
A.2. Manufacturing industries and construction	Reallocation of autoproducers under 1A1a category, Revision of CS CO_2 EFs for liquid, solid and gaseous fuels, Carbon mass balance in the integrated iron and steel facilities,	-2 760	-17 790	-1.29	-3.90
A.3. Transport	Revision of country specific carbon contents for diesel oil, and natural gas, Correction of 2008 natural gas consumption data in pipeline transport, Revision of default emission factors for CH_4 and N_2O in pipeline transport	-35	-141	-0.02	-0.03
A.4. Other sectors	Reallocation of autoproducers under 1A1a category, Revision of CS CO_2 EFs for liquid, solid and gaseous fuels, Inclusion of off road vehicles in agricultural sector,	601	-872	0.28	-0.19
B.1 Fugitive emissions from solid fuels	Inclusion of abondened underground coal mines	26	83	0.01	0.02

Table 10.1 Recalculations made in 2014 inventory and implications to the emission level, 1990 and 2014 (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	2014	1990	2014
2. Industrial Processes		**575**	**-2 031**	**0.27**	**-0.45**
A. Mineral industry	Country specific emission factor for clinker production have been revised. A double count in the lime production has been avoided. Molten glass data have been used instead of the final product data. Export/import data for soda ash production and so the activity data have been changed. The source of activity data for the magnesite production has been changed and emissions have recalculated accordingly.	- 1 485	-3 290	-0.69	-0.72
B. Chemical industry	Carbon oxidation factor have been revised and so the ammonia production emissions have been recalculated. Nitric acid production data have been corrected. The emission factor for the carbide production emssions has been revised. carbon black production data have been corrected.	977	203	0.46	0.04
C. Metal industry	The source of activity data for the iron and steel production, ferroalloy production, lead production, zinc production has been changed and emission have recalculated accordingly.	1 082	-592	0.51	-0.13
E. Electronic industry	Each gases are calculated based on the consumption for the research and development purpose.	NO	0.14	NO	0.00
F. Product uses as ODS substitutes		NO	11	NO	0.00
G. Other product manufacture and use	SF6 emissions are recalculated based on the overall electricity consumption of Turkey.	NO	1 638	NO	0.36
3. Agriculture		**3 597**	**7 712**	**1.68**	**1.69**
A. Enteric fermentation	Revision of enteric fermentation mainly because of Tier 2 method used for cattle.	- 2 574	-340	-1.20	-0.07
B. Manure management	Updating Tier 1 animal waste management system distribution because of calculation errors.	6 004	7 466	2.81	1.64

Table 10.1 Recalculations made in 2014 inventory and implications to the emission level, 1990 and 2014 (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	2014	1990	2014
D. Agricultural soils	Correction of a main calculation error. An extensive update for crop residues. Newly submitted emissions for a new subcategory (cultivation of organic soils). Revision of a subcategory related to soil organic matter by applying the methodology correctly.	6 004	7 466	2.81	1.64
F. Field burning of agricultural residues	Removal of maize from the accounts, modifications of calculations, and an updating of the emission factor for barley.	-8	-35	0.00	0.08
4. Land use, land-use change and forestry(2)		**10**	**365**	**0.00**	**0.08**
B. Cropland	Corine maps data updated for 2012, 2006 Corine map and 2012 Corine map data have been compared and land use change has been detected. Therefore calculation for this submission has been recalculated between period 2006 and 2015.Direct N_2O emissions from N mineralization/immobilization have been in Agriculture (CRF Category 3.) sector, as of this year it is reported in Cropland section. Therefore Cropland emissions differ between 1990 and 2014.	10	337	0.00	0.07
C. Grassland	Corine maps data updated for 2012, 2006 Corine map and 2012 Corine map data have been compared and land use change has been detected. Therefore calculation for this submission has been recalculated between period 2006 and 2015.	NO	534	NO	0.12
E. Settlements	Corine maps data updated for 2012, 2006 Corine map and 2012 Corine map data have been compared and land use change has been detected. Therefore calculation for this submission has been recalculated between period 2006 and 2015.	NO	-506	NO	-0.11
5. Waste		**-2 978**	**-9 773**	**-1.36**	**-2.13**
A. Solid waste disposal	Revisions of waste per capita data (2013-2014), waste composition data (2014) and GDP data (1998-2014).	NO	0.00	NO	0.00
B. Biological treatment of solid waste	Correction of the default emission factor of N2O for composting according to the 9th Corrigenda for the 2006 IPCC Guidelines.	-1.96	-1.68	-0.0	-0.00

Table 10.1 Recalculations made in 2014 inventory and implications to the emission level, 1990 and 2014 (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	2014	1990	2014
C. Incineration and open burning of waste	Correction of aggregation error for CO_2 emissions from open-burning over the 1990-2014 time series. For N_2O emissions, revision of 2014 waste composition data.	24.6	0.45	0.01	0.00
D. Waste water treatment and discharge	For CH_4 emissions, revisions in population data (2013-2014) and methane recovery data (2010-2014). For N_2O emissions, revision of the protein consumption data between 1990-2014.	123	247	0.06	0.05
International marine bunkers	Revision of country specific carbon contents for diesel oil, and residual fuel oil.	-0.45	-0.64	0.00	0.00
Total CO2 equivalent emissions without land use, land-use change and forestry		6 199	-11 935	2.90	-2.62
Total CO2 equivalent emissions with land use, land-use change and forestry		6 209	-11 571	2.90	-2.54

Planned improvements

Considerable improvements have been made in the 2015 inventory (2017 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.

Regarding civil aviation, work on data quality regarding fuel consumption and air traffic will be continued in cooperation with experts from related institutions.

Regarding road transportation, since the category is key category, Tiers used in emission estimation needs to be increased. The data availability required for Tier 2 have been searched. Vehicle-km travelled is registered by the vehicle inspection stations during the periodical inspection of vehicles.

TurkStat have been working on the data. It is planned to use vehicle km travelled data in estimations in the next submissions.

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;

In cement production, Turkey recently made improvements in the representativeness of the country specific carbonate content of the clinker. It is planned to collect data on plant specific CKD for the next submissions.

For lime production; it is planned to obtain the amount of dolomitic lime production by survey in Turkey. Therefore the uncertainty in the emission factor can be decreased. Moreover it is planned to obtain a country specific emission factor for dolomitic lime.

In ceramics; although there is a significant amount of roof tiles and bricks production in Turkey, these type of ceramics production is not taken into account, because there is no available data. In the next years it is aimed to gather production data for the mentioned type of ceramics.

In magnesia production; small scale magnesia producers will be investigated for improving completeness.

In nitric acid production; as a legislative obligation nitric acid producers should install a N_2O gas monitoring device. These devices measure the N_2O content of the flue gas instantaneously. Using the instant measurements and the working hours, companies estimated their own annual N_2O release. In the next years, the companies estimations depending on the measuring device will be compared to emissions calculated depending on the nitric acid production data and emission factors.

In petrochemical and carbon black production; recently Turkey started to use the activity data of the manufacturer instead of national statistics due to plant level data is appropriately more disaggregated. Beside that emission factors are selected according to the process type and the feedstock utilized instead of using default values. In 2017; site visit was made to PETKİM and the emission sources of PETKİM were discussed with plant operators and information about the chemical processes of the plant were gathered. In the next years it is planned to calculate CO_2 emissions by gathering the flaring data. The producer will be asked for the necessary activity data required.

In agriculture sector;

It is planned to use Tier 2 method for estimating enteric fermentation emissions of another important animal category (sheep) in the next submissions.

Turkey searches also for country specific parameters related to using Tier 2 method in manure management.

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 two EU project about the LULUCF calculations. The first 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. The second project name is 'Capacity Building in the Field of Climate Change in Turkey' which is tender 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;

In the scope of TurkStat's Waste Disposal and Recovery Facilities Survey, it will be determined whether there is any flaring on waste disposal sites (CRF Category 5.A). Based on the gathered information, flaring would be included in next submission.

Emissions and amount of methane for energy recovery from anaerobic digestion at biogas facilities (CRF Category 5.B.2) will be included in next inventory submissions depending on the availability of such treatment processes.

Desk review of Turkey’s 2015 and 2016 inventory submissions was held in October 2016. Our comments/actions for ERT recommendations are given below in tables 10.2-10.4.

Table 10.2 Status of implementation of issues raised in the previous review report of Turkey for issues assessed as "not resolved" by the ERT

ID#	Issue classification	Recommendation made in previous review report	ERT assessment and rationale	Party Comment/Action
General				
G.11	Uncertainty analysis (17, 2014) Adherence to UNFCCC Annex I inventory reporting guidelines	Use the results of its uncertainty analysis to prioritize the improvements of the inventory	Not resolved. There is no information in the NIR on how Turkey uses the results of the uncertainty analysis to prioritize improvements of the inventory	Information on this issue is given in NIR section 1.6
Energy				
E.1	1. General (energy sector) – (24, 2014) Transparency	Address the problem of the unrecorded recalculation on marine bunkers by revising the CRF tables, providing sufficient explanation in the NIR and further checking the impact of this recalculation on the emission estimates for navigation and total GHG emissions	Not resolved. There is no information in the NIR on recalculations made for marine bunkers	It is noticed by MoTMAC that there is no sufficient information about recalculation made for marine bunkers in NIR. MoTMAC made recalculations in 2015 for marine bunkers owing to revised country specific carbon content. In this context, Turkey is making necessary explanation regarding in this submission.
E.34	1.A.2 Manufacturing industries and construction – liquid, solid and gaseous fuels – CO2 (51, 2014) Transparency	Provide sufficient information on the inter-annual changes in the CO_2 EFs in the NIR	Not resolved. There is insufficient information provided in the NIR on the inter-annual changes in the CO_2 EFs	Inter-annual changes eliminated in this submission.

Table 10.2 Status of implementation of issues raised in the previous review report of Turkey for issues assessed as "not resolved" by the ERT (cont'd)

ID#	Issue classification	Recommendation made in previous review report	ERT assessment and rationale	Party Comment/Action
E.37	1.A.4 Other sectors – liquid, solid and gaseous fuels – CO_2 (54, 2014) Comparability	Revise the emission estimates by reallocating the diesel oil used for agricultural purposes to this subcategory by using assumptions based on the historical trend of the ratio of diesel oil used for agriculture against the total diesel oil used in the country and provide clear explanations in the NIR	Not resolved. The Party informed the ERT that there are problems with disaggregating diesel oil and that part of off-road diesel is still reported under road ttransportation	The Ministry of Energy and Natural Resources (MENR) worked on agricultural association for modelling the agricultural diesel oil consumption some improvemnt was allready achieved in 2015 national energy balance tables. MENR will work on further improvement for dissaggregation of diesel oil consumption.
E.44	1.A.3.b Road transportation – liquid fuels – CO_2, CH_4, N_2O (58, 2014) (30, 2013)(50, 2012)(44, 2011) Transparency	Improve the transparency of the NIR on the methods applied for road transportation	Not resolved. The NIR (section 3.2.6.2) does not provide enough detail on the approach applied for the category, indicating only that tier 1 and 2 methods are used for the category without providing further information per gas or subcategory	Turkey will provide enough detail on the approach applied for the road transportation from in this submission.

Table 10.2 Status of implementation of issues raised in the previous review report of Turkey for issues assessed as "not resolved" by the ERT (cont'd)

ID#	Issue classification	Recommendation made in previous review report	ERT assessment and rationale	Party Comment/Action
IPPU				
I.10	2.A.2 Lime production – CO_2 (66 and 72, 2014) Completeness	Include captive lime production emissions in the estimates of this category	Not resolved. In Turkey, lime is produced in the sugar industry and the CO_2 is used for refining sugar. It is assumed that no CO_2 is released to the atmosphere from lime production in sugar production plants. Similarly,the lime produced for soda ash production is also assumed to be non-emissive as all the CO_2 produced in the lime production is used in the process. The ERT considers that the approach is not in line with the 2006 IPCC Guidelines (see I.47). The Party informed the ERT that in its next inventory submission, it plans to separate captive lime and marketed lime data and calculate the emissions accordingly	Marketed and non marketed lime data are gathered separately. Assumption of using 100% of CO_2 in sugar refinement is validated only based on experts in sugar plant. Studies on validation with scientific research are going on.
I.28	2.B.10 Other (chemical industry) – CH_4 (92, 2014) Accuracy	Validate and double check the AD on styrene production for the complete time series, provide the missing estimates if they occurred in the country and include explanations for the trend of emissions in the NIR	Not resolved. The ERT notes that the 2006 IPCC Guidelines do not provide a methodology for styrene production. However, the Party has to continue reporting the CH_4 emissions reported in previous inventories	CH_4 emissions from styrene production will be reported in the next submission.
I.39	2.C.4 Magnesium production – SF_6 (95, 2014) Adherence to UNFCCC Annex I inventory reporting guidelines	Correct the notation key for SF_6 emissions from magnesium foundries from "NA" to "NE	Not resolved. There is no magnesium production in Turkey. However, the relevant cells for SF_6 emissions in CRF tables 2(I) and 2(II) are left blank rather than using the notation key "NO"	
I.40	2.F. Product uses as substitutes for ozone depleting substances – HFCs (66 and 96, 2014) (43, 2013)(67, 2012) Accuracy	Establish sound data-collection methods to estimate and report actual emission estimates of different F-gas applications under this category and investigate the possibility of moving to a higher-tier method (only potential emissions calculated) for refrigeration and air-conditioning equipment	Not resolved. Import and export data on HFCs are available, but they are not distinguished between final uses (refrigeration and air conditioning, aerosols and foam blowing). For this reason, emissions have been estimated and reported under category 2.F.6 other	For the future inventory submissions, improvements and distinguishment of the data will be done by contacting with sector associations and firms. Accordingly moving to higher-tier method will be possible.

Table 10.2 Status of implementation of issues raised in the previous review report of Turkey for issues assessed as "not resolved" by the ERT (cont'd)

ID#	Issue classification	Recommendation made in previous review report	ERT assessment and rationale	Party Comment/Action
Agriculture				
A.3	3. General (agriculture) – (105, 2014) (65, 2013) (90, 2012)(72, 2011) Accuracy	Use the national data on milk productivity, gross energy intake and average animal mass Not resolved. Turkey uses atier 1 method for its estimation of CH_4 emissions from enteric fermentation. Turkey informed the ERT that as of the next submission, it will use a tier 2 method, which includes use of milk production data and gross energy intake		Emissions from cattle have been calculated using Tier 2 method. (NIR Section 5.2)
A.4	3. General (agriculture) – (106, 2014) (61, 2013) (88, 2012) Transparency	Provide more transparent information in annexes 3 and 7 to the NIR (including information on the sources of the uncertainties, any issues affecting time series consistency and category specific QA/QC and verification procedures) and provide tables showing the time series for the EFs and AD by category, as well as detailed documentation supporting the choice of EFs, including when default EFs are applied	Not resolved. The required information is not included in the NIR	Information on time series of AD is mainly provided in the relevant section of the NIR. Since all agricultural categories except for cattle in enteric fermentation are calculated using T1 methods, EFS are default ones provided in the 2006 IPCC Guidelines.
A.6	3.A Enteric fermentation – CH_4 (108, 2014) (64, 2013)(89, 2012)(71, 2011) Accuracy	Estimate emissions from significant livestock categories using the tier 2 method, including enhanced livestock population characterization, taking into account the relevant IPCC guidance or, if not possible, provide	Not resolved. Turkey informed the ERT that it will use a tier 2 method in the next submission documentation supporting any expert judgment regarding estimation assumptions, taking into account that this category is key	Emissions from cattle have been calculated using tier 2 method. (NIR Section 5.2)
A.8	3.B Manure management – CH_4 (109, 2014) (67, 2013) Accuracy	Estimate the emissions from significant livestock categories using the tier 2 method with country-specific EFs, including enhanced livestock population characterization, and taking into account the relevant IPCC guidance	Not resolved. Although a key category, Turkey has not implemented a tier 2 methodology for significant livestock categories. Turkey has informed the ERT that it is working on more suitable data sources concerning the distribution of manure management systems	Not resolved since gathering representative country-specific activity data and related EF was not possible.
A.10	3.B Manure management – N_2O (110, 2014) (68, 2013) Accuracy	Revise the emission estimates by applying national values of Nex and AWMS distribution	Not resolved. Turkey uses average default tier 1 Nex values for Western Europe and Asia, from the 2006 IPCC Guidelines, to estimate national Nex values. During the review Turkey clarified that the information would be requested in the upcoming agricultural survey implemented till the end of 2016	The results of a related agricultural survey will be published on 1 December 2017 and Turkey also looks for other possible data sources.

Table 10.2 Status of implementation of issues raised in the previous review report of Turkey for issues assessed as "not resolved" by the ERT (cont'd)

ID#	Issue classification	Recommendation made in previous review report	ERT assessment and rationale	Party Comment/Action
A.11	3.B Manure management – N_2O (110, 2014) (68, 2013) Transparency	Include documentation on Nex per AWMS, or information on the distribution of AWMS used for the different animal groups	Not resolved. CRF table 3.B(b) does not include all the required information. In response to a question raised by the ERT, Turkey provided data on Nex per AWMS. These data indicate that anaerobic lagoons, daily spread and anaerobic digesters are used in Turkey (see A.14)	Submitted in this submission. (NIR Section 5.3)
LULUCF				
L.1	4. General (LULUCF) – (table 3, 2014) (72, 2013)(105, 2012)(91, 2011) Completeness	b) Carbon stock changes in mineral soils from grassland; d) Carbon stock changes from wetlands converted to grassland (biomass and mineral soils pools);	Not resolved. The CSC in mineral soils in grassland remaining grassland is reported as "NE Not resolved. CSC from wetland convered to grassland are reported as "NE"	Not resolved. Grasland remaining grassland data is not available. It is planned to provide provision of area data for pasture improvement from related institutions in next submissions.
L.3	4. General (LULUCF) – (115, 2014) Adherence to UNFCCC Annex I inventory reporting guidelines	Strengthen the institutional arrangements to improve the inventory preparation process, specifically the integration of the data and information in the LULUCF sector	Not resolved. Turkey reports in the NIR (pages 282–284) that improvements in the working procedure for production of the LULUCF reporting have been made and improvements are planned. However, the Party stressed that the integration of land-use data remains an unresolved question. There is still a need to improve the coherence of the LULUCF chapter	Resolved. Land use matrix has been established by using ENVANIS, Corine maps and national data for 2017 National Inventory Report
L.5	4. General (LULUCF) – (117, 2014)(74 and 75, 2013) Accuracy	Clarify the description of land categories, check the integrity of the total land area over the entire time series and report on the findings	Not resolved. Turkey has, in its 2015 and 2016 NIRs, improved the description of land categories (chapter 6). However, it does not provide complete reporting of land areas over the time series (see L.16)	Resolved. The descriptions of land use categories are improved in 2017 National Inventory Report.

Table 10.2 Status of implementation of issues raised in the previous review report of Turkey for issues assessed as "not resolved" by the ERT (cont'd)

ID#	Issue classification	Recommendation made in previous review report	ERT assessment and rationale	Party Comment/Action
L.6	4. General (LULUCF) – (117, 2014) (73, 2013) Accuracy	Using domestic data and information, undertake the necessary work to develop an internally consistent land framework and harmonize the two major data sources in order to produce a spatially consistent breakdown of land-use categories for the whole country, over time, and report on progress	Not resolved. According to the NIR (section 6.2) and the responses provided during the review, Turkey cannot produce consistent reporting of land use because the two major data sources for land-use area determination, ENVANIS and CORINE, have not been integrated. The Party further reports that the integration of ENVANIS and CORINE is included in its improvement plans	Resolved. Land use matrix has been established by using ENVANIS, Corine maps and national data for 2017 National Inventory Report.
L.7	4. General (LULUCF) – (119, 2014) (72, 2013) Comparability	Consistently use the notation key "NO" when an activity does not occur, and the notation key "NE" when an activity occurs but emissions are not estimated	Not resolved. The ERT noted improvements in the use of the notation keys (e.g. in CRFtable 4 where "NA" has been replaced by more appropriate use of "NO" or "NE"). However, the proper use of some notation keys is still questionable. As Turkey, in most cases, did not provide any support for categorizing a category as "NO" or "NE", it is difficult to judge if the notation keys are correctly used. For example, forest converted to settlements is reported as "NO". It is difficult to conceive that forests that occupy areas greater than 20 Mha have no areas that are converted to settlements in any way, for example through road construction, over a 20 year period	Resolved. The using of the notation keys is improved in 2017 submission

Table 10.2 Status of implementation of issues raised in the previous review report of Turkey for issues assessed as "not resolved" by the ERT (cont'd)

ID#	Issue classification	Recommendation made in previous review report	ERT assessment and rationale	Party Comment/Action
L.9	4.A Forest land – CO2 (122, 2014) Accuracy	Conduct a thorough scientific assessment of the estimation methods used for forest land, ensuring a comprehensive and balanced approach to calculating carbon inputs and outputs in each pool; revise the estimates if needed	Not resolved. The uptake of CO_2 in forest land is the second most important key category in the NIR of Turkey with an uptake of 54 458.43 kt CO_2 in 2014. The net uptake has increased at an almost constant rate from 28 322.86 kt CO_2 in 1990, an increase of 92.3% till 2014, while forest land area has increased by 7.3% during the same time period. This implies a continuously increasing gap between forest growth and removals, which is somewhat difficult to reconcile, especially as the sink in harvested wood products has also been increasing rapidly since 2002 (chapter 6, figure 6.7). The rate of change and size of the sink motivates a scientific validation of the methodology behind the forest increment and removal estimates	Resolved. The increasing of the carbon uptake has not been sourcing only from the growth of the forest areas. The key drivers for the rise of carbon uptake in Forest Land 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 etc. Due to rise of the using of HWP in Turkey, the carbon uptake of HWP has been increasing since 2002. This information is given in 2014,2015,2016,2017 submissions.
L.12	4.B Cropland – CO2 (123, 2014) (83, 2013) Accuracy	Assume biomass carbon stocks of 0 Mt/ha (tier 1) for annual crops unless sufficient evidence is obtained to support a revision of this assumption	Not resolved. Turkey has assumed biomass stocks on annual cropland as 0.75 Mg/ha based on a study referenced in the NIR (chapter 6, p. 270). However, there is no explanation on how the study arrived at the value of 0.75 Mg/ha and what type of biomass this stock consists of. According to the 2006 IPCC Guidelines, it is good practice to assume living biomass carbon stocks to be zero on annual cropland	Resolved. By The TUBITAK (Scientificand Technical ResearchCouncil of Turkey) Project (COST 112Y096)revealed that biomass above ground was 0.75 mg c / ha in annual on annual cropland.This information is given in 2017 submission.
L.13	4.D. Wetlands – CO2 (124, 2014) Transparency	Explain the trends in AD, taking into consideration the recommendations on consistent land-use information and on the proper use of notation keys	Not resolved. There is no explanation of trends in the NIR. Since 2012, the category has been reported as "NE", "NO" without rationale for the use of the notation keys, except for lack of data	Resolved. The trends of wetlands are given in 2017 submission.
Waste				
		No "not resolved" issues for the waste sector were identified		

Table 10.3 Issues identified in three successive reviews and not addressed by Turkey

ID#[a]	*Previous recommendation for the issue identified*	*Number of successive reviews issue not addressed*	*Party Comment/Action*
General	No such general issues were identified		
Energy			
E.44	Improve the transparency of the NIR on the methods applied for road transportation	5 (2011 - 2015/2016)	Turkey will provide enough detail on the approach applied for the road transportation in this submission.
IPPU			
I.36.b	Allocate PFC emissions for the whole time series under the category other (metal production) to maintain confidentiality	3 (2013-2015/2016)	PFC emissions have been already allocated under metal production category.
I.40*	Establish sound data-collection methods to estimate and report actual emission estimates of different F-gas applications under this category and investigate the possibility of moving to a higher-tier method (only potential emissions calculated) for refrigeration and air-conditioning equipment	4 (2012-2015/2016)	Improvements will be made in the next submissions.
Agriculture			
A.3*	Use the national data on milk productivity, gross energy intake and average animal mass	5 (2011-2015/2016)	Resolved. Emissions from cattle have been calculated using Tier 2 method. (NIR Section 5.2)
A.4	Provide more transparent information in annexes 3 and 7 to the NIR and provide tables showing the time series for the EFs and AD by category, as well as detailed documentation supporting the choice of EFs, including when default EFs are applied	4 (2012-2015/2016)	Information on time series of AD is mainly provided in the relevant section of the NIR. Since all agricultural categories except for cattle in enteric fermentation are calculated using T1 methods, EFs are default ones provided in the 2006 IPCC Guidelines.

Table 10.3 Issues identified in three successive reviews and not addressed by Turkey (cont'd)

ID#[a]	*Previous recommendation for the issue identified*	*Number of successive reviews issue not addressed*	*Party Comment/Action*
A.6*	Estimate the CH4 emissions from significant livestock categories for enteric fermentation using the tier 2 method, including enhanced livestock population characterization, taking into account the relevant IPCC guidance or, if not possible, provide documentation supporting any expert judgment regarding estimation assumptions	6 (2010-2015/2016)	Resolved. Emissions from cattle have been calculated using Tier 2 method. (NIR Section 5.2)
A.8*	Estimate the CH4 emissions from significant livestock for manure management categories using the tier 2 method with country-specific EFs, including enhanced livestock population characterization, and taking into account the relevant IPCC guidance	3 (2013-2015/2016)	Not resolved since gathering representative country-specific activity data and related EF was not possible.
A.10*	Revise the emission estimates by applying national values of Nex and AWMS distribution	3 (2013-2015/2016)	Partially resolved only for cattle since country-specific values for other animal categories were not found. (NIR Section 5.3)
A.11	Include documentation on Nex per AWMS, or information on the distribution of AWMS used for the different animal groups	3 (2013-2015/2016)	Resolved. Information on the distribution of AWMS used for the different animal groups is presented. (NIR Section 5.3)
LULUCF			
L.1*	Use existing data, make all the necessary efforts to collect new data and report estimates for the mandatory categories, subcategories and pools: (b) Carbon stock changes in mineral soils from grassland	5 (2011-2015/2016)	Grasland remainin ggrass land data is not available. It is planned to provide provision of area data for pasture improvement from related institutions.
L.5	Clarify the description of land categories, check the integrity of the total land area over the entire time series and report on the findings	3 (2013-2015/2016)	Corinemap 2012 is used in calculation of 2017 in the NIR.
L.6	Using domestic data and information, undertake the necessary work to develop an internally consistent land framework and harmonize the two major data sources in order to produce a spatially consistent breakdown of land-use categories for the whole country, over time, and report on progress	3 (2013-2015/2016)	Land use matrix has been established by using ENVANIS, Corine maps and national data for 2017 National Inventory Report.
L.7	Consistently use the notation key "NO" when an activity does not occur, and the notation key "NE" when an activity occurs but emissions are not estimated	3 (2013-2015/2016)	Using of notation keys is improved.

Table 10.3 Issues identified in three successive reviews and not addressed by Turkey (cont'd)

***ID#*[a]**	***Previous recommendation for the issue identified***	***Number of successive reviews issue not addressed***	***Party Comment/Action***
L.12*	Assume biomass carbon stocks of 0 Mt/ha (tier 1) for annual crops unless sufficient evidence is obtained to support a revision of this assumption	3 (2013-2015/2016)	By The TUBITAK (Scientific and Technical Research Council of Turkey) Project (COST 112Y096) revealed that biomass above ground was 0.75 mg c / ha in annual on annual cropland.
Waste	No such issues for the waste sector were identified		

Abbreviations: AD = activity data, AWMS = animal waste management system, EF = emission factor, IPCC = Intergovernmental Panel on Climate Change, IPPU = industrial processes and product use, LULUCF = land use, land-use change and forestry, NE = not estimated, Nex = nitrogen excretion, NIR = national inventory report, NO = not occurring.

[a] An asterisk is included after any issue ID# where the underlying issue is related to accuracy or completeness of a key category, a missing category or a potential key category, as indicated in decision 13/CP.20, annex, paragraph 83.

[b] For Turkey, the review of the 2016 inventory submission is being held in conjunction with the review of the 2015 inventory submission. Since the reviews of the 2015 and 2016 inventory submissions are not "successive" reviews, but are rather being h eld in conjunction, for the purpose of counting successive years in table 4, 2015-2016 is considered as one year. The ERT noted that this table 4 is the same as that in the 2015 annual review report for Turkey, modified to reflect the combined 2015/2016 review.

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
General				
G.12	Key category analysis	In Turkey's key category analysis, some categories are more disaggregated than suggested in table 4.1 of the 2006 IPCC Guidelines (e.g. categories 1.A.1, 1.A.2 and 1.A.4 in the energy sector), while other categories are less disaggregated than suggested in the same table (e.g. category 2.F). The fact that the uncertainty analysis is performed in a more disaggregated level is not in itself a reason to perform the key category analysis tier 1 at the same disaggregated level The ERT encourages Turkey to perform the key category analysis with the level of disaggregation suggested in table 4.1 of the 2006 IPCC Guidelines, further disaggregating only when subcategories are particularly significant. In the case where a category cannot be disaggregated to the recommended level,a qualitative approach may also be applied	Not an issue	Key category analysis is was performed in line with the disaggregation suggested in table 4.1 of the 2006 IPCC Guidelines
G.13	Annual submission	The UNFCCC Annex I inventory reporting guidelines state that the Party shall include in its NIR an assessment of completeness, including information and explanations in relation to categories reported as "NE" or "IE", and information related to the geograp hical scope. The section on completeness in the body of the NIR is quite short just referring to table A7 in annex 5. Table A7 lists the categories reported as "NE", but does not show an explanation for not estimating as it was done in the 2014 submission. Furthermore, the table does not show the category reported as "IE", although CRF table 9 provides such information The ERT recommends that Turkey further develop the assessment of completeness in the NIR, providing more information in the body of the NIR on the categories reported as "NE" and "IE", as well as improving the information presented in the annex on completeness including explanations for the use of the notation keys	Yes. Transparency	Detailed information on the assessment of completeness is given in NIR section 1.7

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
Energy				
E.49	Fuel combustion-reference approach – gaseous, liquid, solid and other fuels – CO_2	The ERT noted that the previous annual review report investigated the differences between the sectoral and reference approaches and suggested that the Party make necessary efforts to understand all the reasons for the differences in the estimates between the sectoral and reference approaches and correct these estimates where necessary, ensuring that the sectoral approach estimates are complete, consistent and accurate. In the current submission, there are still important differences between the reference and sectoral approaches (above 5%) for some of the years at the beginning of the time series (1990 –2007), which the Party reports it is still investigating (section 3.2.1 of the NIR). These seem to stem in part from differences between the NCVs used for CRF table AD and those used in the national energy balance. However, improvements have been made over time in the comparison, with the difference for the CO_2 emissions significantly reduced in recent years (for 2014 being 1.25%) The ERT encourages the Party to continue investigating the differences between the CO_2 emissions calculated by the reference and sectoral approaches as a verification tool for the accuracy and completeness of the estimates from the sector	Not an issue	Investigation on the differences between the CO_2 emissions calculated by the reference and sectoral approaches is continuing.
E.50	Comparison with international data – gaseous, liquid, solid and other fuels – CO_2	The ERT noted that for many years, the apparent consumption comparison between the CRF tables and IEA data for liquid fuels seems problematic, particularly for fuels such as other kerosene (more than 100% difference), refinery feedstocks (more than 100% difference) and other oil (more than 300% difference). There is also a significant difference for coal tar, where the IEA reports exports and Turkey does not, and for jet kerosene and petroleum coke for some years. In addition, the CRF crude oil production data are generally higher and always different to the amounts reported to the IEA, with differences observed in NCVs and for physical units. The ERT noted that production of electricity of waste (non-biomass fraction) is reported to the IEA from 2000 onwards, but is not shown in the CRF tables. During the review, the Party informed the ERT that work is ongoing into the harmonization of the national energy balance (which is the main source of inventory AD for the energy sector) with IEA and Eurostat data sets. On the basis of the output of the harmonization work, the national energy balance is expected to be revised by the end of 2016 in order to minimize differences between those data sets The ERT welcomes this information and encourages Turkey to work to understand the reasons for the differences in the reported data between the CRF tables and IEA data and to recalculate emission estimates as necessary in order to improve the accuracy and comparability of the estimates	Not an issue	MENR has still been working on harmonization of the data national energy balance and the data reported to IEA. Revision of national energy balance couldn't be completed yet.

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
E.51	Comparison with international data – liquid, solid fuels – CO_2	The ERT noted that the stock change data comparison between the CRF tables and IEA data for crude oil shows large differences for many years. In some cases, stock draws may be shown in one data source, while stock builds are shown in another. This is shown particularly for residual fuel oil and for refinery feedstocks; therefore, the differences may be mainly for the facility-level reporting from refineries. The ERT also noted that the stock change data comparison between the CRF tables and IEA data for almost all solid fuels have been of opposite signs for many years. This indicates there is a difference in methodology for reporting of stock changes between Turkey's statistical office and the reporting under the facility-level reporting system for power generation facilities and refineries. Fluctuations in these data can lead to significantly different emission calculations for liquid fuels and also differences in comparability of these data compared to other countries The ERT encourages Turkey to work to understand the reasons for the differences in the reported data for stock changes for liquid and solid fuels between the CRF tables and IEA data and to recalculate emission estimates as necessary in order to improve the accuracy and comparability of the estimates	Not an issue	There is some classification and definition problem with National Energy Balance Tables and international questionnaires. It is realized that the sign of stock change in national energy balance table and IEA data set used differently. All the signs are corrected in this submission.
E.52	International aviation – liquid fuels – general	The ERT noted that, due to differences in NCVs, consumption of jet kerosene in international aviation is 3% higher in the CRF tables than that reported to the IEA for 1990–2006. However, from 2007 onwards, CRF table values are up to 150% higher due to additional discrepancies in physical unit data. The consumption of jet kerosene for international aviation in 2014 is reported as 138 775 TJ in the CRF tables and as 109 220 TJ in IEA data (difference of 21.3%) The ERT encourages Turkey to investigate the reasons for the differences between the CRF tables and IEA data and to include an explanation in the NIR, as well as to revise its definitions and estimates for international aviation, if found necessary	Not an issue	All relevant institutions are working together to eliminate the reasons causing the differences between the CRF tables and IEA data. National Energy Balance Tables are incompatible with the international questionnaires due the differences in some definitions especially for the international marine bunkers and jet kerosene. The international oil questionnaire is more detailed than the Energy Balance tables. So the calculation of some figures different between each other and this caused a mismatch in the past.

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
E.53	International navigation – liquid fuels – general	The ERT noted that data on international marine bunkers between the CRF tables and data reported to the IEA agree closely, except in 2007 (CRF table data are 13% less than IEA data) and 2008–2012 (CRF table data are up to 400% larger than IEA data). Comparison with IEA data shows that during this time period, consumption of residual fuel oil reported in the CRF tables is far higher than that reported to the IEA, while consumption of gas/diesel oil is significantly lower The ERT encourages Turkey to investigate the reasons for the differences between data reported in the CRF tables and IEA data and provide explanations in the NIR, as well as to revise its definitions and estimates, if found necessary	Not an issue	All relevant institutions are working together to eliminate the reasons causing the differences between the CRF tables and IEA data.
E.54	Feedstocks, reductants and other NEU of fuels – gaseous, solid and liquid fuels – CO_2	The ERT noted that there are inconsistencies between the emissions reported as NEU in the energy sector and the emissions reported in the IPPU sector. Emissions from coke and other bituminous coal reported in the energy sector as NEU are higher than CO_2 emissions from iron and steel production in the IPPU sector, CO_2 emissions reported from natural gas in the energy sector as NEU are higher than CO_2 emissions from ammonia production in the IPPU sector and CO_2 emissions from metallurgical coke used in carbide production are not reported in CRF table 1.A(d). Emissions from NEU of bitumen and naphtha are reported in table 1.A(d) as "NA". During the review, the Party explained that emiss ions from bitumen, refinery feedstocks and naphtha are not estimated as there is no methodology provided in the 2006 IPCC Guidelines The ERT recommends that Turkey use appropriate notation keys in CRF table 1.A(d) for emissions from bitumen, refinery feedstocks and naphtha and include relevant explanations in the documentation box of the table for fuels with NEU consumption reported without any associated emissions reported in the inventory. In addition, the ERT recommends that the Party further improve the explanations in the NIR on the reporting of emissions from NEU between the energy sector and the IPPU sector	Yes. Transparency	Notation keys are corrected in this submission.
E.55	1.A.1.a Public electricity and heat production – gaseous, solid and liquid fuels – CO_2, CH_4, N_2O	In its NIR (section 3.2.4.1), Turkey indicates that plant-level data are used for emission estimates in the public electricity and heat production category. During the review, the Party explained that it compares data gathered from plants and that of energy balance tables, examines and reports probable reasons for differences, and, in future submissions, will further improve the comparison of AD from facility-level reporting and its national energy balance The ERT recommends that Turkey include in the NIR a comparison of facility-level energy data and the sectoral totals from its national energy balance, with an aim to ensure transparency of reported estimates	Yes. Transparency	A table that presents the comparison of aggregated facility-level energy data and the sectoral totals from national energy balance tables was included in NIR section 3.2.4.1.

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
E.56	1.A.1.b Petroleum refining – gaseous and liquid fuels – CO_2, CH_4, N_2O	For emission estimation from petroleum refining, the national energy balance was used until the 2015 submission. Petroleum refining was a key category and needed to be estimated using a higher tier. Therefore, as indicated in the NIR (section 3.2.4.2), from the 2015 submission onwards, plant-level AD, NCVs and carbon content have been compiled from all refineries and a tier 2 method has been applied. As a result, there are some differences between the energy balance data and aggregated plant-level data observed. During the review, Turkey informed the ERT that it is coordinating communication between refineries and the energy balance team on these issues, to improve the comparison of AD from facility-level reporting and its national energy balance The ERT recommends that Turkey improve transparency of reporting by including a comparison of facility-level data and the sectoral totals from its national energy balance in its NIR	Yes. Transparency	There is some differences between energy balance tables and aggregated plant level data. We have been communicating both refineries and the energy balance team on this issue. Furthermore, this year there are significant revisions on Energy Balance table and revisions are going on. Therefore, we make an effort to coordinate communication between refineries and the energy balance team on these issues to improve the comparison of AD from facility-level reporting and ours national energy balance.
E.57	1.A.2.a Iron and steel – liquid fuels – CO_2, CH_4, N_2O	The consumption of liquid fuels for the category shows large variations, reaching inter-annual changes of 3 752.5% (2009–2010). The increase between 2013 and 2014 is 161.2%. The trend of N_2O and CH_4 IEF emissions after the constant values used for the 1990–2007 period shows inter-annual changes within the range of −49.5% (2011–2012) to +172.9% (2012–2013) for N_2O and within the range of −35.9% (2011–2012) to +98.8% (2012–2013) for CH_4. During the review, Turkey explained that the fluctuation was caused by the type and share of oil products changing for different years, particularly the share of gas diesel oil and liquid petroleum gas (mainly auxiliary fuels) used in this category The ERT recommends that Turkey improve the transparency of the NIR by including information on significant changes in the trend in AD composition for the different share of oil products, and how these impact the CH_4 and N_2O IEFs	Yes. Transparency	
E.58	1.A.3.d Domestic navigation – liquid fuels – CO_2, CH_4, N_2O	The ERT noted that data on domestic navigation agree (within 2% from 1996 to 2008) with IEA data, but show larger discrepancies for other years. For 2014, the residual oil consumption according to the IEA (9 880 TJ) was 704.3% above the value reported in the CRF tables (1 228 TJ). IEA data for gas/diesel oil (10 352 TJ) was 38.6% below the CRF table value of 16 854.42 TJ. For 2013, the IEA reported 13 320 TJ of residual fuel oil consumption, which was 1 277% above the CRF table value of 967 TJ The ERT encourages Turkey to investigate the reasons for the differences between the CRF tables and IEA data and revise its definitions for domestic and international fuels and estimates, as appropriate	Not an issue	All relevant institutions are working together to eliminate the reasons causing the differences between the CRF tables and IEA data

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
E.59	1.B.1 Solid fuels – solid fuels – CH4	The ERT noted that the CH4 emissions from abandoned mines are reported by Turkey as "NE", explained as due to insufficient data available The ERT recommends that Turkey conduct surveys of abandoned mines to gather AD and estimate CH4 emissions from this mandatory category to ensure completeness of the inventory	Yes. Completeness	Emissions from abondened underground mines were included in this submission in the NIR section 3.3.1
E.60	1.B.2.a Oil – gaseous fuels – CO2 and CH4	The ERT noted that CO2 and CH4 emissions from the category distribution of oil products are reported as "NA" across the time series. According to paragraph 37(c) of the UNFCCC Annex I inventory reporting guidelines, this notation key is appropriate for activities taking place in the country that do not result in emissions. There is no information in the NIR to justify the notation key used Noting that there are no default EFs for the subcategory in the 2006 IPCC Guidelines, the ERT encourages Turkey to attempt to estimate and report relevant CO2 and CH4 emissions. If a notation key is used, the ERT encourages the Party use the notation key "NE" for this non mandatory category	Not an issue	The notation key "NA" was changed as "NE" in accordance with ERT.
IPPU I.46	2. General (IPPU) – general	Turkey has used notation key "C" for reporting AD for all subcategories of chemical industry, such as ammonia production, nitric acid production, calcium carbide production, soda ash production, ethylene production, ethylene dichloride and vinyl chloride monomer, acrylonitrile and carbon black production. Aluminium production is also reported as confidential. However, emissions from all mentioned categories are separated and included in the CRF tables in the appropriate categories and AD trends are presented in the NIR in relative values The ERT commends the Party for the more transparent reporting of the emissions in this sector, allowing the share of the emissions per subcategory and the trend of the emissions across the time series to be checked	Not an issue	Some of the confidential data (Aluminum, ethylene, ethylene dichloride, VCM) are published in 2017 submission by negotiating the plats. Share of the emissions per subcategory and the trend of the emissions across the time series are evaluated.

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
I.47	2.A.2 Lime production – CO_2	AD used for the lime production category includes marketed lime production only, although lime is also produced as an intermediate product in several industries in the country. During the review, Turkey clarified that lime is produced in the sugar industry and the CO_2 is used for refining sugar, and it is assumed that no CO_2 is released to the atmosphere from lime production in sugar production plants. In addition to the 2006 IPCC Guidelines, scientific literature suggests that in sugar refineries, not all CaO is recarbonated to limestone in the refining process As the assumption that 100% of the lime used in the sugar industry is precipitated as $CaCO_3$ has not been supported by any evidence, the ERT recommends that Turkey provide evidence of the 100% CO_2 recovery rate associated with lime use during sugar refining and precipitate production in the NIR (as evidence, the Party can provide any proven and validated methods used to calculate the amount of CO_2 that reacts with lime to re-form $CaCO_3$ or the amount of CO_2 that is not recarbonated to limestone in the refining process). The ERT notes that if Turkey can not demonstrate 100% CO_2 recovery, the CO_2 emissions from the lime produced in sugar mills are to be reported together with the emissions from marketed lime in the lime production category, as described in I.10. In addition, if proven and validated methods are used to calculate the amount of CO_2 that reacts with lime to re-form $CaCO_3$, the ERT encourages the Party to report these CO_2 captured emissions under category other (2H) in line with the 2006 IPCC Guidelines	Yes. Transparency	The activity data was revised and it is found that some of the lime production data was double counted. Besides that the lime produced for sugar refining and synthetic soda ash production is deducted from the national lime production data because the CO_2 is reabsorbed and processed in these industries. However, this "reabsorbing of CO_2" information was given by plants and any scientific justification couldn't be provided. Studies are ongoing on this issue.
I.48	2.A.4 Other process uses of carbonates – CO_2	Turkey reports emissions from ceramics production, other uses of soda ash and non-metallurgical magnesia production under other process uses of carbonates (category 2.A.4). During the review, the Party clarified that dolomitic lime is produced in iron and steel plants in small amounts and used in blast furnaces. Emissions are considered under iron and steel production. Moreover, dolomite is also used as a raw material for ceramic production, and the emissions resulting from the use of dolomite are reported under the ceramics production subcategory The ERT noted that there could be other uses of carbonates in the country (such as dolomite use reported in previous inventories under the lime production category) and recommends that Turkeyundertake limestone and dolomite mass balances to cross-check the estimates in order to increase the accuracy of the inventory	Yes. Accuracy	In the previous inventories dolomit use emissions were reporting under lime production category due to confidentially. It was started to report under the category where it is consumed. Limestone and dolomite mass balance studies have already start by prepearing the producers frame.

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
I.49	2.A.4 Other process uses of carbonates – CO_2	The ERT noted that the AD for non-metallurgical magnesia production are provided only for 2005–2014, due to a lack of data, so emission estimation could not be conducted for the period 1990–2004. Therefore, Turkey assumes that non-metallurgical magnesia production does not occur between 1990 and 2004, and plans to search for any mining sector reports or academic reports regarding the history of magnesite production The ERT commends the Party for its plans to improve the completeness of the estimates and recommends that it either estimate CO_2 emissions from non-metallurgical magnesia production or use the appropriate gap filling procedures suggested by the 2006 IPCC Guidelines to report the complete time series	Yes. Completeness	Emissions from non-metallurgical magnesia production were recalculated. (see 4.2.4.3.)
I.50	2.B Chemical industry – HFCs, PFCs, SF_6	There are no numerical data and no notation keys used to report emissions of F-gases from the chemical industry and the cells are left blank. The NIR (section 4.3.9) indicates the reasons as the absence of fluorochemical production in Turkey The ERT recommends that Turkey include the notation key "NO" for fluorochemical production	Yes. Adherence to UNFCCC Annex I inventory reporting guidelines	
I.51	2.B.1 Ammonia production– CO_2	For ammonia production (category 2.B.1), in order to calculate CO_2 emissions, the total fuel requirement is multiplied by a country-specific carbon content and a carbon oxidation factor according to the tier 2 method of the 2006 IPCC Guidelines. The CO_2 emissions recovered for downstream use are then deducted from the total CO_2 emissions. During the review, the Party clarified that the carbon oxidation factor used is 0.90, the amount of CO_2 recovered for downstream use is not reported separately, and the CO_2 emissions reported subtracted the amount of downstream use for urea production (therefore, only the net amount is reported). In the next inventory submission, the Party is planning to report the amount of CO_2 recovered separately The ERT recommends that Turkey justify the use of a carbon oxidation factor of 0.90 or apply 1.0 as the oxidation factor unless country-specific information is available (table 3.1page 3.15, volume 3, chapter 3 of the 2006 IPCC Guidelines). The ERT further recommends that Turkey clarify if the CO_2 emissions used for urea production are included in category 2.D.3 (other (non energy products from fuels and solvents use)) or in the agriculture sector in line with the 2006 IPCC Guidelines and transparently report the emissions between the two sectors	Yes. Accuracy	Carbon oxidation factor was revised as 1.0 and the emissions were recalculated. The amount of CO_2 recovered for downstream use is not reported separately. (see 4.3.1.)

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
I.52	2.B.5 Carbide production – CO_2	The ERT notes that the CO_2 EF for carbide production (category 2.B.5) is calculated by multiplying metallurgical coke carbon content and a carbon oxidation factor following the tier 1 method of the 2006 IPCC Guidelines. During the review, the Party clarified that the carbon oxidation factor used is 0.90 The ERT recommends that Turkey justify the use of a carbon oxidation factor of 0.90 or apply 1.0 as the oxidation factor unless country-specific information is available in line with the 2006 IPCC Guidelines (table 1.4, volume 2, chapter 1) and check if metallurgical coke is included as NEU in the energy sector and the CO_2 emissions from the feedstock use reported in the IPPU sector are deducted from combustion use in the energy sector, in order to improve the accuracy and comparability of the estimates	Yes. Accuracy	Carbon oxidation factor was revised as 1.0 and the emissions were recalculated. Metallurgical coke is included as NEU in the energy sector and the CO_2 emissions from the feedstock use reported in the IPPU sector are deducted from combustion use in the energy sector.
I.53	2.C.3 Aluminium production – PCFs	The ERT noted that CF_4 and C_2F_6 emissions (by-product emissions) from aluminium production are reported for the 1990–2006 period, and for the following years, notation key "NE" is used. PFC emissions from the single aluminium production plant in Turkey are available following a tier 3 method, but they are confidential from 2007 onwards The ERT recommends that the Party report the estimates as described in I.36 (for instance, by aggregating themed with the PFC emissions of other categories to keep the confidentiality), indicating in the CRF tables "IE" for the category aluminium productiontogether with information on the methodology used on their estimation across the time series in order to increase the transparency of its reporting while keeping the confidentiality of the estimates.	Yes. Transparency	PFCs emissions are not confidential anymore, sincethe company allowed to publish their data.
I.54	2.C.5 Lead production – CO_2	The trend of AD for lead production shows significant inter-annual variations, such as: 2005–2006 (144.9%), 2007–2008 (267.4%), 2008–2009 (−73.9%), 2009–2010 (214.5%), 2011–2012 (−59.9%) and 2012–2013 (75.2%). The Party has indicated that AD for lead production is based on PRODCOM statistics in which lead production data was mixed with the lead trading data thus explaining the outlier trend. In addition, during the review, in response to a question raised by the ERT on the technologies in use for lead production, the Party clarified that it is not possible to separate lead production data by technology in the existing statistics. While analysing the PRODCOM statistics from industry, the Party found that there is no primary lead production in Turkey. However , there is a secondary type of production from the recycling of vehicle accumulators. Waste statistics of the Turkish Statistical Institute provide the amount of batteries recycled in 2012 and 2014. In the next inventory submission, the Party plans to use this data set as the AD for the calculation of secondary lead production estimates The ERT commends the Party for its improvement plans and recommends that the Party report CO_2 emissions estimates based on the current technologies in use in the country in order to improve the accuracy of the inventory	Yes. Accuracy	It is understood that the national data is not lead production data but it is lead ore mining and trading data. Therefore a new approach developed to estimate the lead production in Turkey and emissions are calculated accordingly. (see 4.4.5.)

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
I.55	2.C.6 Zinc production – CO2	The ERT notes that emission estimates for zinc production (category 2.C.6) are calculated assuming that all zinc produced in Turkey comes from primary production. During the review, the Party explained that zinc production data are gathered from PRODCOM. However, it is not possible to separate zinc production data by technology using PRODCOM statistics. While analysing the PRODCOM statistics from industry, the Party found that there is no primary or secondary zinc production in Turkey. In Turkey, zinc is imported and then converted to zinc oxide for use in the chemical industry or it is used for the production of zinc alloys. Therefore, the Party i nformed the ERT that for the next submission,the notation key "NO" will be used for zinc production The ERT recommends that the Party reassess the AD for zinc production, and if it finds that zinc production does not occur in the country, it should use the appropriate notation key, explaining the reasons for the recalculations in the NIR in order to improve the accuracy of the inventory	Yes. Accuracy	It is found that the national data is not zinc production data but it is zinc ore mining data and possibly zinc oxide production data. In Turkey there is no zinc metal production. However in the past there used to be. A new data source has found revealing the zinc productions of Turkey for 1990-1999 and the emission calculation was done accordingly. (see 4.4.6.)
I.56	2.E Electonics Industry – HFCs, PFCs, SF6, NF3	There are no numerical data and no notation keys used to report emissions of F-gases from the electronics industry and the cells are left blank. The NIR (section 4.6) indicates the reasons as the absence of AD for the electronics industry, for which category studies on data collection are ongoing The ERT commends Turkey for its plans to collect data and recommends that the Party provide the resulting estimates of emissions from the electronics industry in its t submission. If Turkey assesses that these emissions are insignificant in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines, it should use the appropriate notation key "NE" for emissions, providing a qualitative and quantitative justification in the NIR	Yes. Completeness	Emissions are estimated for the electronic industry and included in the 2017 inventory submission in the NIR section 4.6
I.57	2.F. Product uses as substitutes for ozone depleting substances – SF6	Emissions of SF6 from fire extinguishers are currently reported under category other product manufacture and use (category 2.G), using assumptions in agreement with the single importing company The ERT recommends that Turkey report these emissions under category 2.F.3 fire protection, in order to increase the comparability and transparency of its reporting	Yes. Comparability	Improvements will be made for the next submissions.

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
I.58	2.G Other product manufacture and use – SF6	Emissions of SF6 from electrical equipment and fire extinguishers and other product use were reported for 2013 in the original 2015 submission. The values are replaced by the notation key "IE" in the 2016 submission. The reporting of SF6 emissions in the category is inconsistent: "NE" is reported for the 1990–1995 period; values are reported for 1996–2012; and the notation key "IE" is reported for 2013 and 2014. During the review, the Party explained that until 2013, there was no official record for SF6 and calculations were conducted according to basic assumptions such as annual growth rates. However, trade data for SF6 are available for the years 2013 and 2014 and the corresponding estimates for these years were reported under category 2.G.4 other categories. The Party indicated that time-series consistency will be ensured from the next submission onwards. The ERT notes that no information is reported in the CRF tables under 2.G.4 and in the NIR The ERT recommends that the Party provide a consistent time series of emissions of SF6 under the appropriate categories of electrical equipment (2.G.1), fire protection (2.F.3) and SF6 and PFCs from other product use (2.G.2)	Yes. Consistency	Improvements will be made for the next submissions.
Agriculture				
A.14	3.B Manure management – CH4, N2O	The ERT noted that while in the previous submission, Turkey did not provide any distribution of nitrogen excretion per MMS, the current submission provides data for solid storage, and dry lot and other MMS. AD for daily spread, pasture range and paddock, and burned for fuel as waste MMSs are reported as "IE". During the review, Turkey presented more detailed data on manure handled in different management systems, including the use of anaerobic lagoons, anaerobic digesters, large amounts of animal manure spread daily and relatively large amounts of burning of animal manure, than previously provided in CRF table 3.B(b) The ERT recommends that Turkey validate AD on manure handled in different MMS and include the relevant information in the NIR and in the CRF tables 3.B(a)s2 and 3.B(b). The ERT further recommends that the Party include further explanation on the sources and assumptions used for deriving the AD including information why all AD and the distribution to the MMS reported for the "Dairy Cattle – Hybrid" category always represent the mean values of the categories "Dairy Cattle – Culture" and "Dairy Cattle – Domestic"	Yes. Accuracy	Provided in this submission. (CRF Table 3.B(a)s2 and 3.B(b), NIR Section 5.2 and 5.3)
A.15	3.D.a.2.b Sewage sludge applied to soils – N2O	Turkey has reported N2O emissions from sewage sludge applied to agricultural soils as "NE". CRF table 9 explains the omission as being due to insufficient AD available The ERT recommends that Turkey collect AD for this source and include the N2O emissions from sewage sludge applied to soils in its submission	Yes. Completeness	May be provided in next submissions provided that activity data will be gathered in order to estimate related emissions reasonably from 1990 onwards.

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
A.16	3.D.a.5 Mineralization / immobilization associated with loss/gain of soil organic matter – N2O	Turkey reports N2O emissions from mineralization/immobilization associated with loss/gain of soil organic matter in CRF table 3.D for the agriculture sector. For the LULUCF sector (CRF table 4.B.2), Turkey reports carbon gains from mineral soils for cropland remaining cropland and loss of carbon in the LULUCF sector due to land-use changes. In CRF table 4(III), "NE" is reported for direct N2O emissions from nitrogen mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils. The omission is explained as due to lack of available data. During the review, the Party explained that for the calculation of the value for agriculture, it uses –28.64 kt carbon in 2014 for net CSC in mineral soils from grassland converted to cropland and applies equation 11.8 from the 2006 IPCC Guidelines (volume 4, chapter 11, page 11.16). The ERT notes that the proper allocation of N2O emissions across the agriculture and LULUCF sectors would be to report N2O emissions from cropland remaining cropland under the agriculture sector and N2O emissions from land-use conversions to cropland under the LULUCF sector (see footnote 2 to CRF table 4(III)) The ERT recommends that Turkey report N2O emissions from land-use changes in the LULUCF sector in CRF table 4(III) and not in the agricultural sector and include N2O emissions in the agriculture sector only from loss of soil carbon from cropland remaining cropland	Yes. Adherence to UNFCCC Annex I inventory reporting guidelines	Resolved in this submission. (CRF Table 3.D, CRF Table 4(III), NIR Section 5.5)
A.17	3.D.a.6 Cultivation of organic soils (i.e. histosols) – N2O	Turkey reports N2O emissions from agricultural organic soils as "NE" and CRF table 9 explains the omission as being due to insufficient AD available. However, the ERT noted that in the LULUCF sector, CRF tables 4.B and 4.C, Turkey reported that organic soils are occurring and CSC is reported The ERT recommends that Turkey make use of available AD on organic soils and include the N2O emissions from agricultural use of organic soils in its submission	Yes. Completeness	Resolved in this submission. (CRF Table 3.D, NIR Section 5.5)
A.18	3.D.b.1 Atmospheric deposition – N2O	The ERT noted that Turkey reports volatilized nitrogen under the Convention on Long-range Transboundary Air Pollution (367.4 kt NH3-N in 2014) and under the UNFCCC (356.3 kt N volatilized), including ammonia and nitrogen oxides. For the inventory, Turkey uses the methodology from the 2006 IPCC Guidelines. During the review, it was clarified that the responsible institution for the Convention on Long-range Transboundary Air Pollution emission estimates in Turkey is the Ministry of Environment and Urbanization. In response to a question raised by the ERT during the review, Turkey informed on a plan for collaboration and coordination of the work on related AD in its next submission. The ERT encourages Turkey to verify and harmonize the AD used under the UNFCCC and the Convention on Long-range Transboundary Air Pollution and commends Turkey for the planned collaboration	Not an issue	Related collaboration work has been started.

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
A.19	3.D.b.2 Nitrogen leaching and run-off – N2O	For estimating indirect N2O emissions from nitrogen leaching from agricultural soils, Turkey uses the default EF from the 2006 IPCC Guidelines combined with a FracLEACH-(H) of 0.3. In the footnote to table 11.3 of the 2006 IPCC Guidelines, there is an estimation methodology for Frac LEACH-(H) for areas where the soil water-holding capacity is not exceeded. Taking into account the dry conditions in Turkey and the use of a FracLEACH-(H) of 0.3, a likely overestimation is taking place The ERT recommends that Turkey investigate the actual leaching conditions in Turkey and estimate the most likely FracLEACH-(H) for its national conditions and include justification of the FracLEACH-(H) value used in its submission	Yes. Accuracy	Necessary steps will be taken to investigate a country-specific FracLEACH-(H) value, though estimating a single value for our wide and heterogenous country regarding climatic conditions is not an uncomplex undertaking.
A.20	3.G Liming – CO2	Turkey reports "NE" for CO2 emissions from liming with justification for the omissions being that there are no data available to estimate the emissions. In addition, the NIR (section 5.8) indicates that the Party plans to estimate emissions from liming The ERT recommends that the Party include estimates for the CO2 emissions from liming in order to improve the completeness of the inventory or justify further the "NE" notation key in case the emissions are assessed to be insignificant, in accordance with decision 24/CP.19, annex, paragraph 37 (b)	Yes. Completeness	Necessary steps will be taken regarding the recommendation in next submissions.
A.21	3.I Other carbon-containing fertilizers – CO2	Turkey reports "NE" for CO2 emissions from other carbon-containing fertilizers. The NIR (section 5.10) indicates that there are insufficient AD available to estimate the emissions The ERT encourages Turkey to investigate the use of other carbon-containing fertilizers in the country with an aim to include the emissions from the category in its inventory	Not an issue	
LULUCF	L.14 4. General (LULUCF)	The ERT noted that Turkey, in several cases, calculates and presents disaggregated data for land uses in its NIR but not in its CRF tables. For example, the NIR (pages 237 and 238) reports about subdividing the country into climatic zones and that calculations have been made separately for these zones. However, in the CRF tables, the categories are reported at an aggregated level. During the review, Turkey explained that the calculations are made at a disaggregated level according to climatic zones for the last four submissions, but did not explain why it does not report by subdivision in the CRF tables The ERT encourages Turkey to report data for subdivisions of land-use categories in the CRF tables when available	Not an issue	This map has derived from IPCC climatic zones and soil map and used for all land uses except forest land. But most of nationa IEF's has been used at national level.

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
L.15	4. General (LULUCF) CO_2, CH_4, N_2O	The ERT noted some improvements in the completeness of reporting (see L.1), but found that the notation key "NE" continues to be used by Turkey for a large number of reporting categories in the LULUCF sector (see annex II). Apart from categories listed in L1 the following mandatory categories where not reported; CSC in DOM, mineral soil and organic soils for forest remaining forest; CSC for cropland converted to forest for biomass, DOM and organic soils, CSC in organic soils for grassland converted to forest land; CSC for all pools for wetland converted to forest land; CSC for all pools for settlements converted to forest; CSC for all pools for other land converted to forest; CSC for biomass for grassland remaining grassland; CSC for all pools for settlements converted to grassland; CSC for all pools for other land converted to grassland; CSC for organic soils from grassland converted to cropland ; CSC for mineral and organic soils for flooded land remaing flooded land, cropland converted to flooded land and grassland converted to flooded land; CSC for all pools for grassland converted to other land; direct nitrous oxide (N_2O) emissions from nitrogen inputs to forest land remaing forest land and land converted to forest land; emissions from biomass burning (CO_2, CH_4, N_2O) for cropland remaining cropland and land converted to cropland and for grassland remaing grassland and land converted to grassland; direct nitrous oxide (N_2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter for all land-use categories apart from cropland remaining cropland which is reported under Agriculture. In the NIR (section 6.1, page 240) Turkey provides brief comments on the completeness of the LULUCF sector with an explanation of the reasons for the omissions. However, many categories for which "NE" has been used are not mentioned in the section and the listed categories are not included with their CRF category identifications and with all relevant pools. Further, in the NIR (annex 5, table A7), a comprehensive compilation of not estimated categories is made but without explaining why the "NE" notation key is used. In CRF table 9, 69 instances of the use of "NE" are explained, but the list is not complete. The ERT underlines that, according to paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines, when the notation key "NE" is used, Parties shall indicate in both the NIR and the CRF completeness table why such emissions or removals have not been estimated. During the review, Turkey responded that it aims to increase the completeness of the inventory in the next submission and that it will add all the notation keys to the completeness table The ERT recommends that Turkey improve the completeness of the reporting by providing, in addition to the categories listed in L.1, estimates for the land -use categories and transitions listed above that occur in the country and for which there are default IPCC methods. The ERT recommends, in cases where the notation key "NE" is used, that Turkey indicate in both the NIR and the CRF completeness table why the emissions and removals have not been estimated consistently with the provisions in paragraph 37 of the UNFCCC Annex I inventory reporting guidelines.	Yes. Completeness	Direct N_2O emissions from N mineralization/immobilization has been in Agriculture (CRF Category 3.) sector, as of this year it is reported in Cropland section. Sections where we use notation key "NE" are planned to report in the NIR.

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
L.16	Land representation area	The ERT commends Turkey for improving the description of land-use categories and for reporting more land-use transition classes than in previous submissions (see L.5). Thus, the ERT noted that in CRF table 4.1 (land transition matrix), Turkey reports areas for forest land remaining forest land, cropland remaining cropland, forest land converted to grassland, grassland converted to forest land, cropland converted to grassland, cropland converted to settlements and grassland converted to settlements. However, all other land-use or land-use transition classes are reported as "NE" or "NO". Further, there are inconsistencies in reported areas, for example: cropland remaining cropland in CRF table 4.B(548.23 kha) is not the total cropland area for the category but only a small fraction of the area (see NIR, p. 265); and the overall country area reported in CRF table 4.1 differs between years (e.g. 22 902.40 kha in 2013 versus 23 074.05 kha in 2014) and is less than a third of Turkey's total land area. The ERT also noted that Turkey, in table 6.20 in the NIR, provides two detailed land-use transition matrices for 1990–2000 and 2000–2006 for all land-use categories except forest land, demonstrating the availability of the land-use information needed to improve the land-use matrix further. The ERT has also taken note of the problems of integration of the data from ENVANIS[c] for forest land and the data from the CORINE[d] land-cover maps covering other land uses Consistent reporting of areas for all land uses and land-use transitions in the CRF tables and in the NIR is mandatory and essential for the completeness and transparency of the LULUCF reporting. Therefore, the ERT recommends that Turkey treat with priority the issue of land representation in the LULUCF sector and provide a complete land-use matrix for the entire time series (see also L.5 above). The ERT welcomes the information that the integration of ENVANIS and CORINE is included in the improvement plans of Turkey and recommends that the Party prioritize integration of the data sources and include information on the progress with the integration and data validation in the submission	Yes. Completeness	Land use matrix has been established by using ENVANIS, Corine maps and national data for 2017 National Inventory Report

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
L.17	4.A Forest land CO_2	Forest land is the second most important key category in Turkey, amounting to 10.2% of the total emissions/removals and constituted a net removal of CO_2 of 54 458.43 kt CO_2 eq in 2014. In its NIR (section 6.2), Turkey provides a detailed presentation of changes in forested area and biomass stock for the entire reporting period (1990–2014). The ERT commends Turkey for the significant improvements in detail and transparency made in the NIR for the forest land category since the 2014 submission. The data are compiled from two national forest inventories (1972 and 1999) and since 2004 the ENVANIS database has been used for the estimates. The ERT noted that the underlying data and calculations made before 2004 and after that using the ENVANIS database are not transparently described in the NIR. The NIR is limited in information on how data were collected in the forest management plans that were used to compile the forest inventories (e.g. how data for these records were sampled and which variables were collected) and how these data have been aggregated into the information that has been used in the final biomass stock calculations presented in the NIR tables. Since 2004 , Turkey reports that forest biomass stock, forest biomass increment and forest area have been calculated annually in ENVANIS, but it is also unclear how the data records are updated: are they updated through annual submissions of forest management plans or by extrapolation of older records? During the reviewTurkey declared an ambition to further explain the ENVANIS system in the next submission The ERT recommends that Turkey continue its efforts to improve transparency for underlying forest data and the methods used for determination and calculation of forest stock and increment as well as data on removals in the ENVANIS system	Yes. Transparency	There will be more information on the ENVANIS database in the next submission (2017)
L.18	4.A.2.2 Grassland converted to forest land CO_2	The ERT noted that the value reported in 2014 for the implied CSC factor for mineral soils (2.41 t C/ha) (range of 2.37–2.41 t C/ha over the time series) from grassland converted to forest is the highest reported by Parties (range of −1.27 to +2.41 t C/ha). During the review, Turkey replied to a question regarding this issue that it used the national soil carbon stock values to calculate the EF. However, the calculation is not described in the NIR. Values on soil carbon stocks for pasture provided in NIR table 6.21 suggest that the IEF could be considerably lower than the one used for reporting The ERT recommends that Turkey verify the accuracy of the estimates for mineral soil net CSC and apply a recalculation if deemed necessary. The ERT further recommends that Turkey include in the NIR a section on grassland land converted to forest land under section 6.4, report in the NIR the background data used for the calculation of net emission/removals from soil and further document the country-specific values used	Yes. Accuracy	There will be more information on the calculation of Grassland converted to Forest and category in the next submission (2017)

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
L.19	4.B Cropland areas	The ERT noted that, for 1990–2014, the area for cropland (category 4.B. total cropland) is reported to be in the range of 970.35 kha (in 1990) to 769.32 kha (in 2014), of which cropland remaining cropland ranges from 724.75 kha (in 1990) to 548.23 kha (in 2014). These values are not in accordance with the text in the NIR (page 265), where the total cropland area for 1990 is given as 31 259.93 ha, and in the graph presented in figure 6.4, where the area of cropland is given as about 32 000 kha for 1990. During the review, Turkey clarified that the area reported as cropland remaining cropland is just a fraction of the total cropland. The ERT recommends that Turkey, as part of its QA/QC routines, check that data presented in the NIR in tables, text and figures are consistent and match the latest data reported in the CRF tables	Yes. Adherence to UNFCCC Annex I inventory reporting guidelines	Cropland Data is uptated.
L.20	2.B Cropland CO2	Page 264 of the 2016 NIR states that "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 text does not identify the "last" submission and the ERT noted that the reported values in the original submission of 2015 and the 2016 submission for the year 2013 are identical, with no changes in emissions or uptake and there is no recalculation reported for cropland in the section on recalculation for the sector (page 282). There is a change between the 2014 and 2016 submissions (430.77 kt net CO2 removals in the 2014 submission and 47.63 kt net CO2 removals in the 2016 submission from cropland in 1990). A check of the original 2015 NIR submission shows the same text included, but no further details on the recalculations implemented for the category The ERT recommends that Turkey clearly explain the rationale and impact of any performed recalculation and provide clear numerical information of such recalculation in the NIR In addition, the ERT recommends that the Party check that the NIR text is updated to reflect the content of the present year's reporting in the CRF tables with a view to ensuring consistency of reported information between the CRF tables and the NIR	Yes. Transparency	Result of there calculation is reported in NIR.
L.21	4.G Harvested wood products CO2	Turkey provides a time series used for HWP calculations in CRF table4.Gs2. However, the time series is not complete, and starts from 1990 instead of containing data at least from 1960. Additionally, the values for production of sawn wood (4 658.43 m3) and wood panels (5 780.89 m3) for 2014 are well below the values for the other years of the reported time series (ranges of 2 659 911.48–6 909 736.79 m3 and 696 726.76–5 825 342.00 m3 , respectively, excluding 2014), which indicates that they might be incorrect The ERT recommends that Turkey check that data presented in the CRF tables for HWP are complete and correct and report a corrected time series for the category in the next submission	Yes. Accuracy	Time series of HWP is completed and the incorrect value is corrected.

Table 10.4 Additional findings made during the 2016 technical review of the inventory submission of Turkey (cont'd)

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue? If yes, classify by type	Party Comment/Action
Waste				
W.16	5.A Solid waste disposal on land – CH4	The ERT noted that Turkey reports AD of annual waste at solid waste disposal sites for managed and unmanaged disposal sites separately. However, the CH4 emissions of unmanaged waste disposal sites are reported as "IE" and are included together with the managed waste disposal sites. During the review, Turkey informed the ERT that disaggregated emissions can be provided in the next submission The ERT recommends that Turkey ensure comparability of reporting and provide emissions of unmanaged waste disposal sites and managed waste disposal sites disaggregated	Yes. Comparability	Turkey reported CH_4 emissions of unmanaged waste disposal sites and managed waste disposal sites disaggregated for 2017 submission.
W.17	5.C.2 Open burning of waste – CO2	The ERT notes that in the NIR (page 313), it is stated that the CO2 emissions from open burning of waste are estimated on the basis of waste types/material (e.g. paper, wood and plastics) in the waste open-burned as given in equation 5.2 of the 2006 IPCC Guidelines, volume 5, chapter 5. During the review, in response to a request by the ERT, the Party provided the calculation spreadsheets for open burning of waste. The ERT concluded that equation 5.2 of the 2006 IPCC Guidelines is misapplied. Dry matter content, total carbon content and fossil carbon fraction in municipal solid waste are calculated using equations 5.8, 5.9 and 5.10, respectively, as given in the 2006 IPCC Guidelines. However, the calculation does not take into account that equations 5.8, 5.9 and 5.10 are part of equation 5.2, and the fraction of components in the municipal solid waste (WFj) in equation 5.2 is cubed. As a result, the emissions for the entire time series are underestimated The ERT recommends that Turkey improve the accuracy of reporting and recalculate CO2 emissions, correctly applying equation 5.2 of the 2006 IPCC Guidelines	Yes. Accuracy	Turkey corrected the aggregation error and recalculated CO_2 emissions from open burning of waste for the entire time series in the 2017 submission.
W.18	5.D.1 Domestic wastewater – N2O	The ERT noted that Turkey used a constant value (36.83 kg/person/year) of protein consumption for the whole time series. The constant value of protein consumption is the average of the available data for the periods 1990–1992, 1995–1997, 2000–2002 and 2005–2007, provided by FAO. During the review, Turkey informed the ERT that as country-specific information is not available, the Party has applied an average value for the years from the FAO data set The ERT recommends that Turkey improve the accuracy of reporting using available data from the FAO Country Profile: Food Security Indicators for Turkey for corresponding years of the inventory and IPCC gap filling techniques for the years with missing data, while country-specific information is not available	Yes. Accuracy	Turkey reported N_2O emissions by using annual per capita protein consumption data originates from the *FAOSTAT (Food Balance Sheets)* as described in the Methodological Issues for N_2O emissions under Section 7.5. Wastewater Treatment and Discharge (Category 5.D) of the NIR 2017.

Annex 1: Key Categories

This annex presents the use of an IPCC T1 key category analysis and results for Turkish'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 green-house 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 over-all 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 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 category.

Level contribution each source or sink is calculated according to Equation 4.1. in 2006 IPCC Guideline while trend assessment is calculated according to the Equation 4.2. and 4.3.

In 2015 inventory key source analysis, there were 35 key source categories shown in Table A1 below

Table A1 Key category analysis summary, 2015

KEY CATEGORIES OF EMISSIONS AND REMOVALS	Gas	Criteria used for key source identification		Key category excluding LULUCF	Key category including LULUCF
		L	T		
1.A.1 Energy Industries - Liquid Fuels	CO_2	X	X	X	X
1.A.1 Energy Industries - Solid Fuels	CO_2	X	X	X	X
1.A.1 Energy Industries - Gaseous Fuels	CO_2	X	X	X	X
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	X	X	X	X
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	X	X	X	X
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	X	X	X	X
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2		X	X	
1.A.3.b Road Transportation	CO_2	X	X	X	X
1.A.4 Other Sectors - Liquid Fuels	CO_2	X	X	X	X
1.A.4 Other Sectors - Solid Fuels	CO_2	X	X	X	X
1.A.4 Other Sectors - Solid Fuels	CH_4		X	X	X
1.A.4 Other Sectors - Gaseous Fuels	CO_2	X	X	X	X
1.A.4 Other Sectors - Biomass	CH_4		X	X	X
1.B.1 Fugitive emissions from Solid Fuels	CH_4		X	X	X
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	X	X	X	X
2.A.1 Cement Production	CO_2	X	X	X	X
2.A.2 Lime Production	CO_2	X	X	X	X
2.C.1 Iron and Steel Production	CO_2	X	X	X	X
2.C.3 Aluminium Production	PFCs		X	X	
2.F.6 Other Applications	Aggregate F-gases	X	X	X	X
2.G Other Product Manufacture and Use	Aggregate F-gases		X	X	X
3.A Enteric Fermentation	CH_4	X	X	X	X
3.B Manure Management	CH_4	X	X	X	X
3.B Manure Management	N_2O	X		X	X

Table A1 Key category analysis summary, 2015 (cont'd)

KEY CATEGORIES OF EMISSIONS AND REMOVALS	Gas	Criteria used for key source identification		Key category excluding LULUCF	Key category including LULUCF
		L	T		
3.D.1 Direct N2O Emissions From Managed Soils	N_2O	X	X	X	X
3.D.2 Indirect N2O Emissions From Managed Soils	N_2O	X	X	X	X
4.A.1 Forest Land Remaining Forest Land	CO_2	X	X		X
4.A.2 Land Converted to Forest Land	CO_2	X	X		X
4.B.2 Land Converted to Cropland	CO_2		X		X
4.C.2 Land Converted to Grassland	CO_2	X	X		X
4.D.2 Land Converted to Wetlands	CO_2		X		X
4.G Harvested Wood Products	CO_2	X	X		X
5.A Solid Waste Disposal	CH_4	X	X	X	X
5.D Wastewater Treatment and Discharge	CH_4	X	X	X	X
5.D Wastewater Treatment and Discharge	N_2O	X		X	

Note: L = Level assessment; T = Trend assessment.

Table A1.2 shows the 1990 key categories identified from level assessment without LULUCF.

Table A2 Key category analysis level assessment with LULUCF, 2015

	Sector	Fuel	GAS	2015 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.1.	Energy industries	Solid fuels	CO_2	81 459.15	81 459.15	14.95	14.95
1.A.3.b.	Road Transportation		CO2	67 889.31	67 889.31	12.46	27.41
1.A.1.	Energy industries	Gaseous fuels	CO2	46 891.27	46 891.27	8.61	36.02
4.A.1.	Forest Land Remaining Forest Land		CO2	-35 188.41	35 188.41	6.46	42.48
2.A.1.	Cement Production (Mineral Products)		CO2	32 618.66	32 618.66	5.99	48.46
1.A.4.	Other sectors	Gaseous fuels	CO2	27 679.90	27 679.90	5.08	53.54
3.A.	Enteric fermentation		CH4	26 888.01	26 888.01	4.94	58.48
1.A.4.	Other sectors	Solid fuels	CO2	23 845.39	23 845.39	4.38	62.85
4.A.2.	Land Converted to Forest Land		CO2	-21 486.81	21 486.81	3.94	66.80
1.A.2.	Manufacturing industries and construction	Solid fuels	CO2	20 185.62	20 185.62	3.70	70.50
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CO2	19 618.52	19 618.52	3.60	74.10
3.D.a.	Direct N2O emissions from managed soils		N2O	17 427.90	17 427.90	3.20	77.30
1.A.2.	Manufacturing industries and construction	Liquid fuels	CO2	16 000.94	16 000.94	2.94	80.24
5.A.	Solid waste disposal		CH4	12 455.27	12 455.27	2.29	82.53
2.C.1.	Iron and Steel Production		CO2	11 452.26	11 452.26	2.10	84.63
1.A.4.	Other sectors	Liquid fuels	CO2	11 159.19	11 159.19	2.05	86.68
4.G.	Harvested Wood Products		CO2	-10 227.40	10 227.40	1.88	88.55
1.A.1.	Energy industries	Liquid fuels	CO2	7 210.29	7 210.29	1.32	89.88
3.D.b.	Indirect N2O Emissions from managed soils		N2O	5 449.64	5 449.64	1.00	90.88
2.F.6.	Other applications		HFC	4 678.31	4 678.31	0.86	91.74
1.A.3.a.	Domestic Aviation		CO2	4 161.93	4 161.93	0.76	92.50
3.B.	Manure management		CH4	3 159.66	3 159.66	0.58	93.08
3.B.	Manure management		N2O	3 144.12	3 144.12	0.58	93.66
2.A.2.	Lime Production (Mineral Products)		CO2	2 628.30	2 628.30	0.48	94.14
4.C.2.	Land Converted to Grassland		CO2	2 593.58	2 593.58	0.48	94.61
5.D.	Wastewater treatment and discharge		CH4	2 371.23	2 371.23	0.44	95.05
5.D.	Wastewater treatment and discharge		N2O	2 032.56	2 032.56	0.37	95.42
1.B.2.b	Natural Gas		CH4	1 998.51	1 998.51	0.37	95.79
2.G.1.	Electrical equipment		SF6	1 984.85	1 984.85	0.36	96.15

Table A2 Key category analysis level assessment with LULUCF, 2015 (cont'd)

	Sector	Fuel	GAS	2015 Emission	ABS (Emission)	Cont. (%)	Cumulative
2.A.4.	Other process uses of carbonates		CO2	1 967.73	1 967.73	0.36	96.52
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CO2	1 605.75	1 605.75	0.29	96.81
2.B.1.	Ammonia Production		CO2	1 466.26	1 466.26	0.27	97.08
2.B.2.	Nitric acid production		N2O	1 415.20	1 415.20	0.26	97.34
1.B.1	Solid fuels		CH4	1 236.30	1 236.30	0.23	97.57
2.B.8.	Petrochemical and carbon black production		CO2	1 104.58	1 104.58	0.20	97.77
1.A.3.b.	Road Transportation		N2O	1 061.12	1 061.12	0.19	97.96
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO2	1 021.36	1 021.36	0.19	98.15
1.A.4.	Other sectors	Liquid fuels	N2O	1 008.74	1 008.74	0.19	98.34
3.H.	Urea application		CO2	810.59	810.59	0.15	98.48
1.A.4.	Other sectors	Biomass	CH4	801.49	801.49	0.15	98.63
1.A.4.	Other sectors	Solid fuels	CH4	686.01	686.01	0.13	98.76
1.A.3.e.	Other transportation		CO2	646.74	646.74	0.12	98.88
1.A.1.	Energy industries	Gaseous fuels	N2O	604.52	604.52	0.11	98.99
1.A.1.	Energy industries	Solid fuels	N2O	534.52	534.52	0.10	99.09
2.A.3.	Glass Production		CO2	493.25	493.25	0.09	99.18
1.B.2.c	Venting and flaring		CH4	469.88	469.88	0.09	99.26
1.A.3.c.	Railways		CO2	429.41	429.41	0.08	99.34
1.A.3.b.	Road Transportation		CH4	358.58	358.58	0.07	99.41
1.B.2.a	Oil		CH4	270.67	270.67	0.05	99.46
3.F.	Field burning of agricultural residues		CH4	261.63	261.63	0.05	99.50
2.D.1.	Lubricant Use		CO2	254.71	254.71	0.05	99.55
4.B.1.	Cropland Remaining Cropland		CO2	207.02	207.02	0.04	99.59
1.A.1.	Energy industries	Other fossil fuels	CO2	206.08	206.08	0.04	99.63
3.C.	Rice cultivation		CH4	199.71	199.71	0.04	99.66
1.B.2.c	Venting and flaring		CO2	148.13	148.13	0.03	99.69

Table A2 Key category analysis level assessment with LULUCF, 2015 (cont'd)

	Sector	Fuel	GAS	2015 Emission	ABS (Emission)	Cont. (%)	Cumulative
2.B.7.	Soda ash production		CO2	134.27	134.27	0.02	99.72
1.A.4.	Other sectors	Biomass	N2O	127.38	127.38	0.02	99.74
2.F.3.	Fire protection		HFC	126.64	126.64	0.02	99.76
2.C.3.	Aluminium Production		PFC	120.08	120.08	0.02	99.78
2.C.2.	Ferroalloys Production		CO2	118.48	118.48	0.02	99.81
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO2	114.17	114.17	0.02	99.83
1.A.4.	Other sectors	Solid fuels	N2O	111.37	111.37	0.02	99.85
1.A.2.	Manufacturing industries and construction	Solid fuels	N2O	90.17	90.17	0.02	99.86
3.F.	Field burning of agricultural residues		N2O	80.85	80.85	0.01	99.88
2.C.3.	Aluminium Production		CO2	74.69	74.69	0.01	99.89
4.E.2.	Land Converted to Settlements		CO2	64.29	64.29	0.01	99.90
1.A.4.	Other sectors	Gaseous fuels	CH4	61.72	61.72	0.01	99.92
1.A.2.	Manufacturing industries and construction	Solid fuels	CH4	50.52	51.72	0.01	99.92
1.A.3.c.	Railways		N2O	49.86	49.86	0.01	99.93
2.B.8.	Petrochemical and carbon black production		CH4	42.33	42.33	0.01	99.94
1.A.3.a.	Domestic Aviation		N2O	41.98	41.98	0.01	99.95
1.A.2.	Manufacturing industries and construction	Liquid fuels	N2O	30.25	30.25	0.01	99.96
1.A.1.	Energy industries	Gaseous fuels	CH4	30.14	30.14	0.01	99.96
1.A.4.	Other sectors	Liquid fuels	CH4	17.72	17.72	0.00	99.96
2.C.1.	Iron and Steel Production		CH4	14.99	14.99	0.00	99.97
1.A.4.	Other sectors	Gaseous fuels	N2O	14.71	14.71	0.00	99.97
1.A.1.	Energy industries	Solid fuels	CH4	14.31	14.31	0.00	99.97
1.A.2.	Manufacturing industries and construction	Other fossil fuels	N2O	13.54	13.54	0.00	99.97
1.A.2.	Manufacturing industries and construction	Liquid fuels	CH4	12.76	12.76	0.00	99.98
2.B.5.	Carbide production		CO2	11.56	11.56	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	N2O	10.43	10.43	0.00	99.98
4.C.1.	Grassland Remaining Grassland		CO2	10.38	10.38	0.00	99.98
5.B.	Biological treatment of solid waste		CH4	9.34	9.34	0.00	99.98
1.A.1.	Energy industries	Liquid fuels	N2O	8.95	8.95	0.00	99.99

Table A2 Key category analysis level assessment with LULUCF, 2015 (cont'd)

	Sector	Fuel	GAS	2015 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CH4	8.75	8.75	0.00	99.99
2.C.5.	Lead Production		CO2	8.57	8.57	0.00	99.99
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CH4	8.52	8.52	0.00	99.99
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N2O	8.28	8.28	0.00	99.99
5.B.	Biological treatment of solid waste		N2O	6.68	6.68	0.00	99.99
4.B.2.	Land Converted to Cropland		CO2	6.12	6.12	0.00	99.99
1.A.1.	Energy industries	Liquid fuels	CH4	3.99	3.99	0.00	100.00
1.A.1.	Energy industries	Biomass	N2O	3.93	3.93	0.00	100.00
1.B.2.a	Oil		CO2	3.92	3.92	0.00	100.00
1.B.2.b	Natural Gas		CO2	2.72	2.72	0.00	100.00
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH4	2.44	2.44	0.00	100.00
2.D.2.	Paraffin Wax Use		CO2	2.36	2.36	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	N2O	1.72	1.72	0.00	100.00
1.A.3.a.	Domestic Aviation		CH4	1.44	1.44	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	CH4	1.08	1.08	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	N2O	0.86	0.86	0.00	100.00
5.C.	Incineration and open burning of waste		CH4	0.70	0.70	0.00	100.00
1.B.2.c	Venting and flaring		N2O	0.62	0.62	0.00	100.00
1.A.3.c.	Railways		CH4	0.61	0.61	0.00	100.00
5.C.	Incineration and open burning of waste		CO2	0.54	0.54	0.00	100.00
1.A.1.	Energy industries	Biomass	CH4	0.36	0.36	0.00	100.00
1.A.3.e.	Other transportation		N2O	0.35	0.35	0.00	100.00
1.A.3.e.	Other transportation		CH4	0.29	0.29	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH4	0.26	0.26	0.00	100.00
1.C.	CO2 Transport and storage		CO2	0.13	0.13	0.00	100.00

Table A2 Key category analysis level assessment with LULUCF, 2015 (cont'd)

	Sector	Fuel	GAS	2015 Emission	ABS (Emission)	Cont. (%)	Cumulative
5.C.	Incineration and open burning of waste		N2O	0.12	0.12	0.00	100.00
2.E.5.	Other		HFC	0.09	0.09	0.00	100.00
2.E.5.	Other		SF6	0.04	0.04	0.00	100.00
1.A.2.	Manufacturing industries and construction	Biomass	N2O	0.04	0.04	0.00	100.00
1.A.2.	Manufacturing industries and construction	Biomass	CH4	0.02	0.02	0.00	100.00
4.B.2.	Land Converted to Cropland		N2O	0.02	0.02	0.00	100.00
2.E.5.	Other		PFC	0.01	0.01	0.00	100.00
4.A.1.	Forest Land Remaining Forest Land		CH4	0.01	0.01	0.00	100.00
4.A.1.	Forest Land Remaining Forest Land		N2O	0.01	0.01	0.00	100.00
	Total			**411 035.21**	**544 840.43**	100.00	

Table A3 Key category analysis level assessment without LULUCF, 2015

	Sector	Fuel	GAS	2015 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.1.	Energy industries	Solid fuels	CO2	81 459.15	81 459.15	17.15	17.15
1.A.3.b.	Road Transportation		CO2	67 889.31	67 889.31	14.29	31.44
1.A.1.	Energy industries	Gaseous fuels	CO2	46 891.27	46 891.27	9.87	41.31
2.A.1.	Cement Production (Mineral Products)		CO2	32 618.66	32 618.66	6.87	48.17
1.A.4.	Other sectors	Gaseous fuels	CO2	27 679.90	27 679.90	5.83	54.00
3.A.	Enteric fermentation		CH4	26 888.01	26 888.01	5.66	59.66
1.A.4.	Other sectors	Solid fuels	CO2	23 845.39	23 845.39	5.02	64.68
1.A.2.	Manufacturing industries and construction	Solid fuels	CO2	20 185.62	20 185.62	4.25	68.93
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CO2	19 618.52	19 618.52	4.13	73.06
3.D.a.	Direct N2O emissions from managed soils		N2O	17 427.90	17 427.90	3.67	76.73
1.A.2.	Manufacturing industries and construction	Liquid fuels	CO2	16 000.94	16 000.94	3.37	80.10
5.A.	Solid waste disposal		CH4	12 455.27	12 455.27	2.62	82.72
2.C.1.	Iron and Steel Production		CO2	11 452.26	11 452.26	2.41	85.13
1.A.4.	Other sectors	Liquid fuels	CO2	11 159.19	11 159.19	2.35	87.48
1.A.1.	Energy industries	Liquid fuels	CO2	7 210.29	7 210.29	1.52	89.00
3.D.b.	Indirect N2O Emissions from managed soils		N2O	5 449.64	5 449.64	1.15	90.14
2.F.6.	Other applications		HFC	4 678.31	4 678.31	0.98	91.13
1.A.3.a.	Domestic Aviation		CO2	4 161.93	4 161.93	0.88	92.00
3.B.	Manure management		CH4	3 159.66	3 159.66	0.67	92.67
3.B.	Manure management		N2O	3 144.12	3 144.12	0.66	93.33
2.A.2.	Lime Production (Mineral Products)		CO2	2 628.30	2 628.30	0.55	93.88
5.D.	Wastewater treatment and discharge		CH4	2 371.23	2 371.23	0.50	94.38
5.D.	Wastewater treatment and discharge		N2O	2 032.56	2 032.56	0.43	94.81
1.B.2.b	Natural Gas		CH4	1 998.51	1 998.51	0.42	95.23
2.G.1.	Electrical equipment		SF6	1 984.85	1 984.85	0.42	95.65
2.A.4.	Other process uses of carbonates		CO2	1 967.73	1 967.73	0.41	96.06
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CO2	1 605.75	1 605.75	0.34	96.40
2.B.1.	Ammonia Production		CO2	1 466.26	1 466.26	0.31	96.71
2.B.2.	Nitric acid production		N2O	1 415.20	1 415.20	0.30	97.01

Table A3 Key category analysis level assessment without LULUCF, 2015 (cont'd)

	Sector	Fuel	GAS	2015 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.B.1	Solid fuels		CH4	1 236.30	1 236.30	0.26	97.27
2.B.8.	Petrochemical and carbon black production		CO2	1 104.58	1 104.58	0.23	97.50
1.A.3.b.	Road Transportation		N2O	1 061.12	1 061.12	0.22	97.72
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO2	1 021.36	1 021.36	0.21	97.94
1.A.4.	Other sectors	Liquid fuels	N2O	1 008.74	1 008.74	0.21	98.15
3.H.	Urea application		CO2	810.59	810.59	0.17	98.32
1.A.4.	Other sectors	Biomass	CH4	801.49	801.49	0.17	98.49
1.A.4.	Other sectors	Solid fuels	CH4	686.01	686.01	0.14	98.64
1.A.3.e.	Other transportation		CO2	646.74	646.74	0.14	98.77
1.A.1.	Energy industries	Gaseous fuels	N2O	604.52	604.52	0.13	98.90
1.A.1.	Energy industries	Solid fuels	N2O	534.52	534.52	0.11	99.01
2.A.3.	Glass Production		CO2	493.25	493.25	0.10	99.12
1.B.2.c	Venting and flaring		CH4	469.88	469.88	0.10	99.21
1.A.3.c.	Railways		CO2	429.41	429.41	0.09	99.30
1.A.3.b.	Road Transportation		CH4	358.58	358.58	0.08	99.38
1.B.2.a	Oil		CH4	270.67	270.67	0.06	99.44
3.F.	Field burning of agricultural residues		CH4	261.63	261.63	0.06	99.49
2.D.1.	Lubricant Use		CO2	254.71	254.71	0.05	99.55
1.A.1.	Energy industries	Other fossil fuels	CO2	206.08	206.08	0.04	99.59
3.C.	Rice cultivation		CH4	199.71	199.71	0.04	99.63
1.B.2.c	Venting and flaring		CO2	148.13	148.13	0.03	99.66
2.B.7.	Soda ash production		CO2	134.27	134.27	0.03	99.69
1.A.4.	Other sectors	Biomass	N2O	127.38	127.38	0.03	99.72
2.F.3.	Fire protection		HFC	126.64	126.64	0.03	99.74
2.C.3.	Aluminium Production		PFC	120.08	120.08	0.03	99.77
2.C.2.	Ferroalloys Production		CO2	118.48	118.48	0.02	99.79
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO2	114.17	114.17	0.02	99.82
1.A.4.	Other sectors	Solid fuels	N2O	111.37	111.37	0.02	99.84
1.A.2.	Manufacturing industries and construction	Solid fuels	N2O	90.17	90.17	0.02	99.86
3.F.	Field burning of agricultural residues		N2O	80.85	80.85	0.02	99.88

Table A3 Key category analysis level assessment without LULUCF, 2015 (cont'd)

	Sector	Fuel	GAS	2015 Emission	ABS (Emission)	Cont. (%)	Cumulative
2.C.3.	Aluminium Production		CO2	74.69	74.69	0.02	99.89
1.A.4.	Other sectors	Gaseous fuels	CH4	61.72	61.72	0.01	99.91
1.A.2.	Manufacturing industries and construction	Solid fuels	CH4	50.52	51.72	0.01	99.92
1.A.3.c.	Railways		N2O	49.86	49.86	0.01	99.93
2.B.8.	Petrochemical and carbon black production		CH4	42.33	42.33	0.01	99.94
1.A.3.a.	Domestic Aviation		N2O	41.98	41.98	0.01	99.95
1.A.2.	Manufacturing industries and construction	Liquid fuels	N2O	30.25	30.25	0.01	99.95
1.A.1.	Energy industries	Gaseous fuels	CH4	30.14	30.14	0.01	99.96
1.A.4.	Other sectors	Liquid fuels	CH4	17.72	17.72	0.00	99.96
2.C.1.	Iron and Steel Production		CH4	14.99	14.99	0.00	99.97
1.A.4.	Other sectors	Gaseous fuels	N2O	14.71	14.71	0.00	99.97
1.A.1.	Energy industries	Solid fuels	CH4	14.31	14.31	0.00	99.97
1.A.2.	Manufacturing industries and construction	Other fossil fuels	N2O	13.54	13.54	0.00	99.97
1.A.2.	Manufacturing industries and construction	Liquid fuels	CH4	12.76	12.76	0.00	99.98
2.B.5.	Carbide production		CO2	11.56	11.56	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	N2O	10.43	10.43	0.00	99.98
5.B.	Biological treatment of solid waste		CH4	9.34	9.34	0.00	99.98
1.A.1.	Energy industries	Liquid fuels	N2O	8.95	8.95	0.00	99.99
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CH4	8.75	8.75	0.00	99.99
2.C.5.	Lead Production		CO2	8.57	8.57	0.00	99.99
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CH4	8.52	8.52	0.00	99.99
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N2O	8.28	8.28	0.00	99.99
5.B.	Biological treatment of solid waste		N2O	6.68	6.68	0.00	99.99
1.A.1.	Energy industries	Liquid fuels	CH4	3.99	3.99	0.00	99.99
1.A.1.	Energy industries	Biomass	N2O	3.93	3.93	0.00	100.00
1.B.2.a	Oil		CO2	3.92	3.92	0.00	100.00
1.B.2.b	Natural Gas		CO2	2.72	2.72	0.00	100.00

Table A3 Key category analysis level assessment without LULUCF, 2015 (cont'd)

	Sector	Fuel	GAS	2015 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH4	2.44	2.44	0.00	100.00
2.D.2.	Paraffin Wax Use		CO2	2.36	2.36	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	N2O	1.72	1.72	0.00	100.00
1.A.3.a.	Domestic Aviation		CH4	1.44	1.44	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	CH4	1.08	1.08	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	N2O	0.86	0.86	0.00	100.00
5.C.	Incineration and open burning of waste		CH4	0.70	0.70	0.00	100.00
1.B.2.c	Venting and flaring		N2O	0.62	0.62	0.00	100.00
1.A.3.c.	Railways		CH4	0.61	0.61	0.00	100.00
5.C.	Incineration and open burning of waste		CO2	0.54	0.54	0.00	100.00
1.A.1.	Energy industries	Biomass	CH4	0.36	0.36	0.00	100.00
1.A.3.e.	Other transportation		N2O	0.35	0.35	0.00	100.00
1.A.3.e.	Other transportation		CH4	0.29	0.29	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH4	0.26	0.26	0.00	100.00
1.C.	CO2 Transport and storage		CO2	0.13	0.13	0.00	100.00
5.C.	Incineration and open burning of waste		N2O	0.12	0.12	0.00	100.00
2.E.5.	Other		HFC	0.09	0.09	0.00	100.00
2.E.5.	Other		SF6	0.04	0.04	0.00	100.00
1.A.2.	Manufacturing industries and construction	Biomass	N2O	0.04	0.04	0.00	100.00
1.A.2.	Manufacturing industries and construction	Biomass	CH4	0.02	0.02	0.00	100.00
2.E.5.	Other		PFC	0.01	0.01	0.00	100.00
	Total			**475 056.40**	**475 056.40**	100.00	

Table A4 Key category analysis trend assessment with LULUCF, 2015

	Sector	Fuel	Gas	2015	1990	Trend	Cont	Cum.
1.A.1.	Energy industries	Gaseous fuels	CO2	46 891.27	5 024.67	0.15	11.11	11.11
4.A.1.	Forest Land Remaining Forest Land		CO2	-35 188.41	-23 910.51	0.13	9.81	20.92
1.A.1.	Energy industries	Solid fuels	CO2	81 459.15	25 957.84	0.13	9.53	30.45
1.A.4.	Other sectors	Gaseous fuels	CO2	27 679.90	93.85	0.11	8.19	38.64
1.A.3.b.	Road Transportation		CO2	67 889.31	24 142.97	0.09	6.52	45.16
4.A.2.	Land Converted to Forest Land		CO2	-21 486.81	-4 412.36	0.08	6.27	51.44
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CO2	19 618.52	1 557.09	0.07	4.96	56.40
1.A.4.	Other sectors	Liquid fuels	CO2	11 159.19	14 436.34	0.07	4.87	61.26
3.A.	Enteric fermentation		CH4	26 888.01	22 314.09	0.06	4.65	65.92
1.A.2.	Manufacturing industries and construction	Solid fuels	CO2	20 185.62	17 435.82	0.05	3.88	69.80
2.A.1.	Cement Production (Mineral Products)		CO2	32 618.66	10 444.54	0.05	3.79	73.59
4.G.	Harvested Wood Products		CO2	-10 227.40	-4 368.20	0.04	2.92	76.51
1.A.2.	Manufacturing industries and construction	Liquid fuels	CO2	16 000.94	13 232.02	0.04	2.74	79.25
3.D.a.	Direct N2O emissions from managed soils		N2O	17 427.90	13 162.98	0.03	2.28	81.53
1.A.1.	Energy industries	Liquid fuels	CO2	7 210.29	6 878.52	0.02	1.76	83.29
2.F.6.	Other applications		HFC	4 678.31		0.02	1.39	84.68
1.A.4.	Other sectors	Solid fuels	CO2	23 845.39	14 713.62	0.02	1.25	85.93
1.A.4.	Other sectors	Biomass	CH4	801.49	2 263.35	0.01	1.05	86.97
1.B.1	Solid fuels		CH4	1 236.30	2 458.50	0.01	1.03	88.00
4.D.2.	Land Converted to Wetlands		CO2		1 741.74	0.01	0.99	88.99
5.D.	Wastewater treatment and discharge		CH4	2 371.23	2 789.04	0.01	0.88	89.86
3.D.b.	Indirect N2O Emissions from managed soils		N2O	5 449.64	4 365.13	0.01	0.85	90.72
4.C.2.	Land Converted to Grassland		CO2	2 593.58	66.49	0.01	0.73	91.45
1.A.3.a.	Domestic Aviation		CO2	4 161.93	913.74	0.01	0.72	92.17
2.G.1.	Electrical equipment		SF6	1 984.85		0.01	0.59	92.77
4.B.2.	Land Converted to Cropland		CO2	6.12	929.02	0.01	0.53	93.29
2.A.2.	Lime Production (Mineral Products)		CO2	2 628.30	2 290.53	0.01	0.52	93.81
1.B.2.b	Natural Gas		CH4	1 998.51	143.70	0.01	0.51	94.32
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CO2	1 605.75		0.01	0.48	94.80
3.B.	Manure management		CH4	3 159.66	2 352.09	0.01	0.39	95.19
1.A.4.	Other sectors	Solid fuels	CH4	686.01	1 022.28	0.01	0.38	95.57
2.A.4.	Other process uses of carbonates		CO2	1 967.73	377.87	0.00	0.37	95.94
4.E.2.	Land Converted to Settlements		CO2	64.29	683.21	0.00	0.37	96.31
2.C.3.	Aluminium Production		PFC	120.08	692.77	0.00	0.36	96.67
1.A.3.c.	Railways		CO2	429.41	651.19	0.00	0.24	96.91

Table A4 Key category analysis trend assessment with LULUCF, 2015 (cont'd)

	Sector	Fuel	Gas	2015	1990	Trend	Cont	Cum.
5.D.	Wastewater treatment and discharge		N2O	2 032.56	1 447.24	0.00	0.22	97.12
2.C.1.	Iron and Steel Production		CO2	11 452.26	6 371.36	0.00	0.20	97.33
2.B.2.	Nitric acid production		N2O	1 415.20	1 063.63	0.00	0.18	97.51
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO2	1 021.36	220.75	0.00	0.18	97.69
1.A.1.	Energy industries	Gaseous fuels	N2O	604.52	2.57	0.00	0.18	97.87
1.A.3.e.	Other transportation		CO2	646.74	39.29	0.00	0.17	98.04
1.A.4.	Other sectors	Biomass	N2O	127.38	359.72	0.00	0.17	98.20
2.B.8.	Petrochemical and carbon black production		CO2	1 104.58	838.08	0.00	0.15	98.35
1.B.2.a	Oil		CH4	270.67	399.44	0.00	0.15	98.50
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO2	114.17	282.87	0.00	0.13	98.62
5.A.	Solid waste disposal		CH4	12 455.27	6 729.60	0.00	0.11	98.73
1.A.1.	Energy industries	Solid fuels	N2O	534.52	95.53	0.00	0.10	98.84
1.A.4.	Other sectors	Liquid fuels	N2O	1 008.74	692.17	0.00	0.09	98.93
4.B.1.	Cropland Remaining Cropland		CO2	207.02	- 976.65	0.00	0.09	99.02
2.B.1.	Ammonia Production		CO2	1 466.26	919.87	0.00	0.09	99.10
1.B.2.c	Venting and flaring		CO2	148.13	217.58	0.00	0.08	99.18
1.B.2.c	Venting and flaring		CH4	469.88	126.99	0.00	0.07	99.25
3.B.	Manure management		N2O	3 144.12	1 759.39	0.00	0.06	99.31
1.A.1.	Energy industries	Other fossil fuels	CO2	206.08		0.00	0.06	99.38
3.F.	Field burning of agricultural residues		CH4	261.63	243.61	0.00	0.06	99.44
1.A.3.b.	Road Transportation		CH4	358.58	96.49	0.00	0.05	99.49
2.B.5.	Carbide production		CO2	11.56	83.33	0.00	0.04	99.53
2.B.7.	Soda ash production		CO2	134.27		0.00	0.04	99.57
5.C.	Incineration and open burning of waste		CH4	0.70	67.31	0.00	0.04	99.61
2.F.3.	Fire protection		HFC	126.64		0.00	0.04	99.65
2.A.3.	Glass Production		CO2	493.25	198.14	0.00	0.03	99.68
2.C.3.	Aluminium Production		CO2	74.69	99.16	0.00	0.03	99.72
1.A.3.c.	Railways		N2O	49.86	68.71	0.00	0.02	99.74
2.D.1.	Lubricant Use		CO2	254.71	175.11	0.00	0.02	99.76
2.C.6.	Zinc Production		CO2		37.84	0.00	0.02	99.78
3.H.	Urea application		CO2	810.59	459.95	0.00	0.02	99.80
3.F.	Field burning of agricultural residues		N2O	80.85	75.28	0.00	0.02	99.82
1.A.4.	Other sectors	Gaseous fuels	CH4	61.72	0.21	0.00	0.02	99.84
5.C.	Incineration and open burning of waste		CO2	0.54	27.40	0.00	0.02	99.86
1.A.2.	Manufacturing industries and construction	Solid fuels	N2O	90.17	71.72	0.00	0.01	99.87
1.A.4.	Other sectors	Liquid fuels	CH4	17.72	30.81	0.00	0.01	99.88
1.A.3.b.	Road Transportation		N2O	1 061.12	537.71	0.00	0.01	99.89

Table A4 Key category analysis trend assessment with LULUCF, 2015 (cont'd)

	Sector	Fuel	Gas	2015	1990	Trend	Cont	Cum.
1.A.2.	Manufacturing industries and construction	Liquid fuels	N2O	30.25	30.08	0.00	0.01	99.90
1.A.1.	Energy industries	Gaseous fuels	CH4	30.14	2.16	0.00	0.01	99.91
3.C.	Rice cultivation		CH4	199.71	91.36	0.00	0.01	99.92
1.A.3.a.	Domestic Aviation		N2O	41.98	8.88	0.00	0.01	99.92
1.A.2.	Manufacturing industries and construction	Solid fuels	CH4	50.52	40.14	0.00	0.01	99.93
4.C.1.	Grassland Remaining Grassland		CO2	10.38	18.00	0.00	0.01	99.94
5.C.	Incineration and open burning of waste		N2O	0.12	10.78	0.00	0.01	99.94
4.B.2.	Land Converted to Cropland		N2O	0.02	10.48	0.00	0.01	99.95
1.A.1.	Energy industries	Liquid fuels	N2O	8.95	14.70	0.00	0.01	99.96
1.A.4.	Other sectors	Gaseous fuels	N2O	14.71	0.05	0.00	0.00	99.96
1.A.2.	Manufacturing industries and construction	Other fossil fuels	N2O	13.54		0.00	0.00	99.96
2.B.8.	Petrochemical and carbon black production		CH4	42.33	28.36	0.00	0.00	99.97
5.B.	Biological treatment of solid waste		CH4	9.34	10.95	0.00	0.00	99.97
1.A.2.	Manufacturing industries and construction	Liquid fuels	CH4	12.76	12.65	0.00	0.00	99.98
2.C.2.	Ferroalloys Production		CO2	118.48	66.87	0.00	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	N2O	10.43	0.83	0.00	0.00	99.98
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CH4	8.52		0.00	0.00	99.98
5.B.	Biological treatment of solid waste		N2O	6.68	7.83	0.00	0.00	99.99
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CH4	8.75	0.70	0.00	0.00	99.99
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N2O	8.28	1.79	0.00	0.00	99.99
1.A.4.	Other sectors	Solid fuels	N2O	111.37	60.93	0.00	0.00	99.99
2.C.5.	Lead Production		CO2	8.57	2.20	0.00	0.00	99.99
1.A.1.	Energy industries	Biomass	N2O	3.93		0.00	0.00	99.99
1.A.1.	Energy industries	Solid fuels	CH4	14.31	5.62	0.00	0.00	99.99
1.A.1.	Energy industries	Liquid fuels	CH4	3.99	3.93	0.00	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	N2O	0.86	2.15	0.00	0.00	100.00
1.B.2.b	Natural Gas		CO2	2.72	0.25	0.00	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	N2O	1.72		0.00	0.00	100.00
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH4	2.44	0.53	0.00	0.00	100.00
1.B.2.c	Venting and flaring		N2O	0.62	0.91	0.00	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	CH4	1.08		0.00	0.00	100.00
1.A.3.c.	Railways		CH4	0.61	0.86	0.00	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH4	0.26	0.63	0.00	0.00	100.00
1.A.3.a.	Domestic Aviation		CH4	1.44	0.31	0.00	0.00	100.00
2.D.2.	Paraffin Wax Use		CO2	2.36	1.65	0.00	0.00	100.00
1.B.2.a	Oil		CO2	3.92	2.38	0.00	0.00	100.00
1.A.1.	Energy industries	Biomass	CH4	0.36		0.00	0.00	100.00

Table A4 Key category analysis trend assessment with LULUCF, 2015 (cont'd)

	Sector	Fuel	Gas	2015	1990	Trend	Cont	Cum.
1.A.3.e.	Other transportation		N2O	0.35	0.02	0.00	0.00	100.00
1.A.3.e.	Other transportation		CH4	0.29	0.02	0.00	0.00	100.00
1.C.	CO2 Transport and storage		CO2	0.13	0.13	0.00	0.00	100.00
2.E.5.	Other		HFC	0.09		0.00	0.00	100.00
4.A.1.	Forest Land Remaining Forest Land		CH4	0.01	0.03	0.00	0.00	100.00
2.E.5.	Other		SF6	0.04		0.00	0.00	100.00
2.C.1.	Iron and Steel Production		CH4	14.99	7.89	0.00	0.00	100.00
1.A.2.	Manufacturing industries and construction	Biomass	N2O	0.04		0.00	0.00	100.00
4.A.1.	Forest Land Remaining Forest Land		N2O	0.01	0.02	0.00	0.00	100.00
1.A.2.	Manufacturing industries and construction	Biomass	CH4	0.02		0.00	0.00	100.00
2.E.5.	Other		PFC	0.01		0.00	0.00	100.00
	Total			**411 035.2**	**183 753.2**	**1.3**	**100**	

Table A5 Key category analysis trend assessment without LULUCF, 2015

	Sector	Fuel	Gas	2015	1990	Trend	Cont	Cum.
1.A.1.	Energy industries	Gaseous fuels	CO2	46 891.3	5 024.7	0.15	14.20	14.20
1.A.1.	Energy industries	Solid fuels	CO2	81 459.2	25 957.8	0.13	12.18	26.38
1.A.4.	Other sectors	Gaseous fuels	CO2	27 679.9	93.8	0.11	10.46	36.84
1.A.3.b.	Road Transportation		CO2	67 889.3	24 143.0	0.09	8.33	45.17
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CO2	19 618.5	1 557.1	0.07	6.34	51.50
1.A.4.	Other sectors	Liquid fuels	CO2	11 159.2	14 436.3	0.07	6.22	57.72
3.A.	Enteric fermentation		CH4	26 888.0	22 314.1	0.06	5.94	63.67
1.A.2.	Manufacturing industries and construction	Solid fuels	CO2	20 185.6	17 435.8	0.05	4.96	68.63
2.A.1.	Cement Production (Mineral Products)		CO2	32 618.7	10 444.5	0.05	4.84	73.47
1.A.2.	Manufacturing industries and construction	Liquid fuels	CO2	16 000.9	13 232.0	0.04	3.50	76.97
3.D.a.	Direct N2O emissions from managed soils		N2O	17 427.9	13 163.0	0.03	2.91	79.88
1.A.1.	Energy industries	Liquid fuels	CO2	7 210.3	6 878.5	0.02	2.24	82.12
2.F.6.	Other applications		HFC	4 678.3		0.02	1.78	83.90
1.A.4.	Other sectors	Solid fuels	CO2	23 845.4	14 713.6	0.02	1.59	85.50
1.A.4.	Other sectors	Biomass	CH4	801.5	2 263.4	0.01	1.34	86.83
1.B.1	Solid fuels		CH4	1 236.3	2 458.5	0.01	1.31	88.14
5.D.	Wastewater treatment and discharge		CH4	2 371.2	2 789.0	0.01	1.12	89.26
3.D.b.	Indirect N2O Emissions from managed soils		N2O	5 449.6	4 365.1	0.01	1.09	90.35
1.A.3.a.	Domestic Aviation		CO2	4 161.9	913.7	0.01	0.92	91.28
2.G.1.	Electrical equipment		SF6	1 984.9		0.01	0.76	92.03
2.A.2.	Lime Production (Mineral Products)		CO2	2 628.3	2 290.5	0.01	0.66	92.69
1.B.2.b	Natural Gas		CH4	1 998.5	143.7	0.01	0.66	93.35
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CO2	1 605.8		0.01	0.61	93.96
3.B.	Manure management		CH4	3 159.7	2 352.1	0.01	0.50	94.46
1.A.4.	Other sectors	Solid fuels	CH4	686.0	1 022.3	0.01	0.48	94.94
2.A.4.	Other process uses of carbonates		CO2	1 967.7	377.9	0.00	0.47	95.42
2.C.3.	Aluminium Production		PFC	120.1	692.8	0.00	0.46	95.87
1.A.3.c.	Railways		CO2	429.4	651.2	0.00	0.31	96.18
5.D.	Wastewater treatment and discharge		N2O	2 032.6	1 447.2	0.00	0.28	96.46
2.C.1.	Iron and Steel Production		CO2	11 452.3	6 371.4	0.00	0.26	96.72
2.B.2.	Nitric acid production		N2O	1 415.2	1 063.6	0.00	0.23	96.95
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO2	1 021.4	220.8	0.00	0.23	97.18
1.A.1.	Energy industries	Gaseous fuels	N2O	604.5	2.6	0.00	0.23	97.41
1.A.3.e.	Other transportation		CO2	646.7	39.3	0.00	0.22	97.62
1.A.4.	Other sectors	Biomass	N2O	127.4	359.7	0.00	0.21	97.84
2.B.8.	Petrochemical and carbon black production		CO2	1 104.6	838.1	0.00	0.19	98.02
1.B.2.a	Oil		CH4	270.7	399.4	0.00	0.19	98.21

Table A5 Key category analysis trend assessment without LULUCF, 2015 (cont'd)

	Sector	Fuel	Gas	2015	1990	Trend	Cont	Cum.
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO2	114.2	282.9	0.00	0.16	98.37
5.A.	Solid waste disposal		CH4	12 455.3	6 729.6	0.00	0.14	98.51
1.A.1.	Energy industries	Solid fuels	N2O	534.5	95.5	0.00	0.13	98.65
1.A.4.	Other sectors	Liquid fuels	N2O	1 008.7	692.2	0.00	0.12	98.76
2.B.1.	Ammonia Production		CO2	1 466.3	919.9	0.00	0.11	98.87
1.B.2.c	Venting and flaring		CO2	148.1	217.6	0.00	0.10	98.97
1.B.2.c	Venting and flaring		CH4	469.9	127.0	0.00	0.09	99.06
3.B.	Manure management		N2O	3 144.1	1 759.4	0.00	0.08	99.14
1.A.1.	Energy industries	Other fossil fuels	CO2	206.1		0.00	0.08	99.22
3.F.	Field burning of agricultural residues		CH4	261.6	243.6	0.00	0.08	99.30
1.A.3.b.	Road Transportation		CH4	358.6	96.5	0.00	0.07	99.36
2.B.5.	Carbide production		CO2	11.6	83.3	0.00	0.06	99.42
2.B.7.	Soda ash production		CO2	134.3		0.00	0.05	99.47
5.C.	Incineration and open burning of waste		CH4	0.7	67.3	0.00	0.05	99.52
2.F.3.	Fire protection		HFC	126.6		0.00	0.05	99.57
2.A.3.	Glass Production		CO2	493.2	198.1	0.00	0.04	99.61
2.C.3.	Aluminium Production		CO2	74.7	99.2	0.00	0.04	99.65
1.A.3.c.	Railways		N2O	49.9	68.7	0.00	0.03	99.68
2.D.1.	Lubricant Use		CO2	254.7	175.1	0.00	0.03	99.71
2.C.6.	Zinc Production		CO2		37.8	0.00	0.03	99.74
3.H.	Urea application		CO2	810.6	459.9	0.00	0.02	99.77
3.F.	Field burning of agricultural residues		N2O	80.9	75.3	0.00	0.02	99.79
1.A.4.	Other sectors	Gaseous fuels	CH4	61.7	0.2	0.00	0.02	99.81
5.C.	Incineration and open burning of waste		CO2	0.5	27.4	0.00	0.02	99.83
1.A.2.	Manufacturing industries and construction	Solid fuels	N2O	90.2	71.7	0.00	0.02	99.85
1.A.4.	Other sectors	Liquid fuels	CH4	17.7	30.8	0.00	0.02	99.87
1.A.3.b.	Road Transportation		N2O	1 061.1	537.7	0.00	0.01	99.88
1.A.2.	Manufacturing industries and construction	Liquid fuels	N2O	30.3	30.1	0.00	0.01	99.89
1.A.1.	Energy industries	Gaseous fuels	CH4	30.1	2.2	0.00	0.01	99.90
3.C.	Rice cultivation		CH4	199.7	91.4	0.00	0.01	99.91
1.A.3.a.	Domestic Aviation		N2O	42.0	8.9	0.00	0.01	99.92
1.A.2.	Manufacturing industries and construction	Solid fuels	CH4	50.5	40.1	0.00	0.01	99.93
5.C.	Incineration and open burning of waste		N2O	0.1	10.8	0.00	0.01	99.94
1.A.1.	Energy industries	Liquid fuels	N2O	9.0	14.7	0.00	0.01	99.94
1.A.4.	Other sectors	Gaseous fuels	N2O	14.7	0.1	0.00	0.01	99.95
1.A.2.	Manufacturing industries and construction	Other fossil fuels	N2O	13.5		0.00	0.01	99.96
2.B.8.	Petrochemical and carbon black production		CH4	42.3	28.4	0.00	0.00	99.96

Table A5 Key category analysis trend assessment without LULUCF, 2015 (cont'd)

	Sector	Fuel	Gas	2015	1990	Trend	Cont	Cum.
5.B.	Biological treatment of solid waste		CH4	9.3	11.0	0.00	0.00	99.96
1.A.2.	Manufacturing industries and construction	Liquid fuels	CH4	12.8	12.6	0.00	0.00	99.97
2.C.2.	Ferroalloys Production		CO2	118.5	66.9	0.00	0.00	99.97
1.A.2.	Manufacturing industries and construction	Gaseous fuels	N2O	10.4	0.8	0.00	0.00	99.98
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CH4	8.5		0.00	0.00	99.98
5.B.	Biological treatment of solid waste		N2O	6.7	7.8	0.00	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CH4	8.7	0.7	0.00	0.00	99.98
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N2O	8.3	1.8	0.00	0.00	99.99
1.A.4.	Other sectors	Solid fuels	N2O	111.4	60.9	0.00	0.00	99.99
2.C.5.	Lead Production		CO2	8.6	2.2	0.00	0.00	99.99
1.A.1.	Energy industries	Biomass	N2O	3.9		0.00	0.00	99.99
1.A.1.	Energy industries	Solid fuels	CH4	14.3	5.6	0.00	0.00	99.99
1.A.1.	Energy industries	Liquid fuels	CH4	4.0	3.9	0.00	0.00	99.99
1.A.3.d.	Domestic Navigation	Residual fuel oil	N2O	0.9	2.1	0.00	0.00	100.00
1.B.2.b	Natural Gas		CO2	2.7	0.3	0.00	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	N2O	1.7		0.00	0.00	100.00
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH4	2.4	0.5	0.00	0.00	100.00
1.B.2.c	Venting and flaring		N2O	0.6	0.9	0.00	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	CH4	1.1		0.00	0.00	100.00
1.A.3.c.	Railways		CH4	0.6	0.9	0.00	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH4	0.3	0.6	0.00	0.00	100.00
1.A.3.a.	Domestic Aviation		CH4	1.4	0.3	0.00	0.00	100.00
2.D.2.	Paraffin Wax Use		CO2	2.4	1.7	0.00	0.00	100.00
1.B.2.a	Oil		CO2	3.9	2.4	0.00	0.00	100.00
1.A.1.	Energy industries	Biomass	CH4	0.4		0.00	0.00	100.00
1.A.3.e.	Other transportation		N2O	0.3	0.0	0.00	0.00	100.00
1.A.3.e.	Other transportation		CH4	0.3	0.0	0.00	0.00	100.00
1.C.	CO2 Transport and storage		CO2	0.1	0.1	0.00	0.00	100.00
2.E.5.	Other		HFC	0.1		0.00	0.00	100.00
2.E.5.	Other		SF6	0.0		0.00	0.00	100.00
2.C.1.	Iron and Steel Production		CH4	15.0	7.9	0.00	0.00	100.00
1.A.2.	Manufacturing industries and construction	Biomass	N2O	0.0		0.00	0.00	100.00
1.A.2.	Manufacturing industries and construction	Biomass	CH4	0.0		0.00	0.00	100.00
2.E.5.	Other		PFC	0.0		0.00	0.00	100.00
	Total			**475 056.4**	**213 971.9**	**1.0**	**100**	

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 calculation of uncertainty, 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),

Table A6. shows the uncertainty assessment of Turkish GHG emissions inventory. According to the calculations; total uncertainty of the inventory is 9.15 (with LULUCF) while this value is 6.42 without LULUCF.

Table A6 Uncertainty assessment

Source Category		Fuel	Gas	1990 Gg CO2eq	2015 Gg CO2eq	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	CO2	3650.2	3040.8	6.0	4.1	7.27	0.05	0.00	0.14	-0.11	0.18	0.03
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CO2	24147.7	80325.6	1.0	3.4	3.50	0.68	0.47	0.62	0.48	0.78	0.61
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CO2	5024.7	44856.3	3.0	1.1	3.20	0.35	0.12	1.04	0.20	1.06	1.11
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	CO2		206.1	0.9	7.0	7.06	0.00	0.00	0.00	0.01	0.01	0.00
1.A.1.b.	Petroleum Refining	Liquid fuels	CO2	3228.3	4169.5	2.0	7.0	7.28	0.07	0.01	0.06	-0.12	0.13	0.02
1.A.1.b.	Petroleum Refining	Gaseous fuels	CO2		2034.9	2.0	7.0	7.28	0.04	0.00	0.03	0.08	0.08	0.01
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CO2	1810.1	1133.5	2.0	7.0	7.28	0.02	0.00	0.02	-0.11	0.11	0.01
1.A.2.a.	Iron and Steel Production	Liquid fuels	CO2	1823.3	23.3	10.0	7.0	12.21	0.00	0.00	0.00	-0.15	0.15	0.02
1.A.2.a.	Iron and Steel Production	Solid fuels	CO2	112.4	531.4	10.0	7.0	12.21	0.02	0.00	0.04	0.01	0.04	0.00
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CO2		2688.5	10.0	7.0	12.21	0.08	0.01	0.21	0.10	0.23	0.05
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CO2	926.4	11.5	21.2	7.0	22.33	0.00	0.00	0.00	-0.08	0.08	0.01
1.A.2.b.	Non-Ferrous Metals	Solid fuels	CO2	156.9	156.5	21.2	7.0	22.33	0.01	0.00	0.03	-0.01	0.03	0.00
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	CO2		1037.0	21.2	7.0	22.33	0.06	0.00	0.17	0.04	0.17	0.03
1.A.2.c.	Chemicals	Liquid fuels	CO2	2588.1	19.0	15.8	7.0	17.29	0.00	0.00	0.00	-0.22	0.22	0.05
1.A.2.c.	Chemicals	Solid fuels	CO2	1342.6	1407.8	15.8	7.0	17.29	0.06	0.00	0.17	-0.06	0.18	0.03
1.A.2.c.	Chemicals	Gaseous fuels	CO2	944.2	4707.6	15.8	7.0	17.29	0.20	0.04	0.57	0.10	0.58	0.34
1.A.2.c.	Chemicals	Other fossil fuels	CO2		7.8	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	CO2		33.1	18.0	7.0	19.31	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.d.	Pulp. Paper and Print	Solid fuels	CO2		499.0	18.0	7.0	19.31	0.02	0.00	0.07	0.02	0.07	0.01
1.A.2.d.	Pulp. Paper and Print	Gaseous fuels	CO2		430.4	18.0	7.0	19.31	0.02	0.00	0.06	0.02	0.06	0.00
1.A.2.e.	Food Processing. Beverages and Tobacco	Liquid fuels	CO2	420.7	215.5	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	CO2	2473.0	2239.8	18.0	7.0	19.31	0.11	0.01	0.31	-0.13	0.33	0.11
1.A.2.e.	Food Processing. Beverages and Tobacco	Gaseous fuels	CO2		1900.7	14.1	7.0	15.78	0.07	0.01	0.21	0.07	0.22	0.05
1.A.2.f.	Non metalic minerals	Liquid fuels	CO2	2613.3	13686.2	27.8	7.0	28.67	0.95	0.91	2.93	0.30	2.94	8.66
1.A.2.f.	Non metalic minerals	Solid fuels	CO2	5561.5	11627.8	25.5	7.0	26.44	0.75	0.56	2.28	-0.03	2.28	5.21
1.A.2.f.	Non metalic minerals	Gaseous fuels	CO2	1.9	3647.8	29.2	7.0	30.03	0.27	0.07	0.82	0.14	0.83	0.69
1.A.2.f.	Non metalic minerals	Other fossil fuels	CO2		1598.0	2.0	7.0	7.28	0.03	0.00	0.02	0.06	0.07	0.00
1.A.2.g.	Other Industries	Liquid Fuels	CO2	4860.2	2012.4	70.7	7.0	71.06	0.35	0.12	1.10	-0.34	1.15	1.31
1.A.2.g.	Other Industries	Solid Fuels	CO2	7789.4	3723.3	70.7	7.0	71.06	0.64	0.41	2.03	-0.52	2.09	4.38
1.A.2.g.	Other Industries	Gaseous Fuels	CO2	611.0	5206.5	70.7	7.0	71.06	0.90	0.81	2.83	0.15	2.84	8.05
1.A.3.a.	Domestic Aviation	Jet kerosene	CO2	913.7	4161.9	5.5	5.0	7.42	0.08	0.01	0.18	0.06	0.18	0.03
1.A.3.b.	Road Transportation	Gasoline	CO2	8377.4	6296.0	10.0	5.0	11.18	0.17	0.03	0.48	-0.34	0.59	0.35

Table A6 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	1990	2015	AD Unc.	EF Unc.	A(1)	B(2)	C(3)	D(4)	E(5)	F(6)	G(7)
				Gg CO2eq	**Gg CO2eq**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
1.A.3.b.	Road Transportation	Diesel oil	CO2	15765.5	52272.0	10.0	5.0	11.18	1.42	2.02	4.02	0.46	4.05	16.40
1.A.3.b.	Road Transportation	LPG	CO2		9157.8	10.0	5.0	11.18	0.25	0.06	0.70	0.25	0.75	0.56
1.A.3.b.	Road Transportation	Gaseous fuels	CO2		163.5	10.0	7.0	12.21	0.00	0.00	0.01	0.01	0.01	0.00
1.A.3.c.	Railways	Liquid fuels	CO2	589.5	429.4	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	CO2	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	CO2	282.9	114.2	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	CO2	220.8	1021.4	15.0	1.5	15.07	0.04	0.00	0.12	0.00	0.12	0.01
1.A.3.e.	Pipeline Transportation	Gaseous fuels	CO2	39.3	646.7	5.0	7.0	8.60	0.01	0.00	0.02	0.02	0.03	0.00
1.A.4.a.	Commercial/institutional	Liquid fuels	CO2		1704.3	7.1	7.0	9.97	0.04	0.00	0.09	0.06	0.11	0.01
1.A.4.a.	Commercial/institutional	Solid fuels	CO2		15289.6	14.1	7.0	15.74	0.59	0.34	1.66	0.58	1.76	3.09
1.A.4.a.	Commercial/institutional	Gaseous fuels	CO2		6120.5	5.0	7.0	8.60	0.13	0.02	0.24	0.23	0.33	0.11
1.A.4.b.	Residential	Liquid fuels	CO2	8666.7	913.8	7.1	7.0	9.97	0.02	0.00	0.05	-0.70	0.71	0.50
1.A.4.b.	Residential	Solid fuels	CO2	14713.6	8555.8	14.1	7.0	15.74	0.33	0.11	0.93	-0.93	1.31	1.72
1.A.4.b.	Residential	Gaseous fuels	CO2	93.8	21301.4	5.0	7.0	8.60	0.45	0.20	0.82	0.80	1.15	1.32
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CO2	5769.6	8541.0	200.0	5.0	200.06	4.16	17.28	13.15	-0.12	13.15	172.85
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	CO2		258.0	7.0	7.0	9.90	0.01	0.00	0.01	0.01	0.02	0.00
1.B.2.a.	Oil		CO2	2.4	3.9	7.0	334.0	334.07	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2.b.	Natural gas		CO2	0.3	2.7	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		CO2	217.6	148.1	7.0	334.0	334.07	0.12	0.01	0.01	-0.62	0.62	0.38
1.C	Transport of CO2		CO2	0.1	0.1	2.0	200.0	200.01	0.00	0.00	0.00	0.00	0.00	0.00
2.A.1.	Cement Production (Mineral Products)		CO2	10444.5	32618.7	5.0	2.0	5.39	0.43	0.18	1.26	0.10	1.26	1.59
2.A.2.	Lime Production (Mineral Products)		CO2	2290.5	2628.3	10.0	10.0	14.14	0.09	0.01	0.20	-0.14	0.24	0.06
2.A.3.	Glass Production		CO2	198.1	493.2	5.0	2.0	5.39	0.01	0.00	0.02	0.00	0.02	0.00
2.A.4.	Other process uses of carbonates		CO2	377.9	1967.7	30.0	2.0	30.07	0.14	0.02	0.45	0.01	0.45	0.21
2.B.1.	Ammonia Production		CO2	919.9	1466.3	2.0	5.0	5.39	0.02	0.00	0.02	-0.02	0.03	0.00
2.B.5.	Carbide production		CO2	83.3	11.6	5.0	20.0	20.62	0.00	0.00	0.00	-0.02	0.02	0.00
2.B.7.	Soda ash production		CO2		134.3	5.0	1.0	5.10	0.00	0.00	0.01	0.00	0.01	0.00
2.B.8.	Petrochemical and carbon black production		CO2	838.1	1104.6	10.0	10.0	14.14	0.04	0.00	0.09	-0.04	0.09	0.01
2.C.1.	Iron and Steel Production		CO2	6371.4	11452.3	10.0	25.0	26.93	0.75	0.56	0.88	-0.38	0.96	0.92
2.C.2.	Ferroalloys Production		CO2	66.9	118.5	5.0	25.0	25.50	0.01	0.00	0.00	0.00	0.01	0.00
2.C.3.	Aluminium Production		CO2	99.2	74.7	1.0	5.0	5.10	0.00	0.00	0.00	0.00	0.00	0.00
2.C.5.	Lead Production		CO2	2.2	8.6	25.0	20.0	32.02	0.00	0.00	0.00	0.00	0.00	0.00

Table A6 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	1990 Gg CO2eq	2015 Gg CO2eq	AD Unc. %	EF Unc. %	A(1) %	B(2) %	C(3) %	D(4) %	E(5) %	F(6) %	G(7) %
2.C.6.	Zinc Production		CO2	37.8		20.0	50.0	53.85	0.00	0.00	0.00	-0.02	0.02	0.00
2.D.1.	Lubricant Use		CO2	175.1	254.7	25.0	50.0	55.90	0.03	0.00	0.05	-0.04	0.06	0.00
2.D.2.	Paraffin Wax Use		CO2	1.7	2.4	25.0	100.0	103.08	0.00	0.00	0.00	0.00	0.00	0.00
3.H.	Urea application		CO2	459.9	810.6	10.0	50.0	50.99	0.10	0.01	0.06	-0.06	0.09	0.01
4.A.	Forest land		CO2	-28322.9	-56675.2	23.5	4.5	23.93	-3.30	10.88	-10.25	0.16	10.25	105.10
4.B.	Cropland		CO2	-47.6	213.1	23.5	4.5	23.93	0.01	0.00	0.04	0.01	0.04	0.00
4.C.	Grassland		CO2	84.5	2604.0	23.5	4.5	23.93	0.15	0.02	0.47	0.06	0.47	0.23
4.D.	Wetlands		CO2	1741.7		23.5	4.5	23.93	0.00	0.00	0.00	-0.10	0.10	0.01
4.E.	Settlements		CO2	683.2	64.3	23.5	4.5	23.93	0.00	0.00	0.01	-0.04	0.04	0.00
4.G.	Harvested wood products		CO2	-4368.2	-10227.4	23.5	4.5	23.93	-0.60	0.35	-1.85	-0.01	1.85	3.42
5.C.2	Open burning of waste		CO2	27.4	0.5	30.4	40.0	50.24	0.00	0.00	0.00	-0.01	0.01	0.00
TOTAL	**TOTAL CO2**			**117 966**	**319 406**					**5.97**				**18.43**
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	CH4	1.2	1.4	6.0	25.0	25.71	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CH4	5.3	13.9	1.0	25.0	25.02	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CH4	2.2	29.2	3.0	25.0	25.18	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	CH4		1.1	0.9	25.0	25.02	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.a.	Public Electricity and Heat Production	Biomass	CH4		0.4	0.9	25.0	25.02	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.b.	Petroleum Refining	Liquid fuels	CH4	2.7	2.6	2.0	100.0	100.02	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.b.	Petroleum Refining	Gaseous fuels	CH4		0.9	2.0	100.0	100.02	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CH4	0.3	0.4	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	CH4	1.8	0.0	10.0	100.0	100.50	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.a.	Iron and Steel Production	Solid fuels	CH4	0.1	0.3	10.0	100.0	100.50	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CH4		1.2	10.0	100.0	100.50	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CH4	0.9	0.0	21.2	100.0	102.22	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.b.	Non-Ferrous Metals	Solid fuels	CH4	0.3	0.4	21.2	100.0	102.22	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	CH4		0.5	21.2	100.0	102.22	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.c.	Chemicals	Liquid fuels	CH4	2.5	0.0	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	CH4	2.9	3.7	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	CH4	0.4	2.1	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	CH4		0.0	2.0	100.0	100.02	0.00	0.00	0.00	0.00	0.00	0.00

Table A6 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	1990	2015	AD Unc.	EF Unc.	A(1)	B(2)	C(3)	D(4)	E(5)	F(6)	G(7)
				Gg CO2eq	Gg CO2eq	%	%	%	%	%	%	%	%	%
1.A.2.d.	Pulp. Paper and Print	Liquid fuels	CH4		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	CH4		1.2	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	CH4		0.2	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	CH4	0.4	0.2	5.0	100.0	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.e.	Food Processing. Beverages and Tobacco	Solid fuels	CH4	5.5	5.4	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	Gaseous fuels	CH4		0.8	14.1	100.0	100.99	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.f.	Non metalic minerals	Liquid fuels	CH4	2.3	10.6	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	CH4	13.5	30.6	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	CH4	0.0	1.6	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	CH4		8.5	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	CH4		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	CH4	4.7	1.9	70.7	100.0	122.47	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.g.	Other Industries	Solid Fuels	CH4	17.7	9.0	70.7	100.0	122.47	0.00	0.00	0.00	-0.02	0.02	0.00
1.A.2.g.	Other Industries	Gaseous Fuels	CH4	0.3	2.3	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	CH4	0.3	1.4	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	CH4	75.6	56.8	10.0	250.0	250.20	0.03	0.00	0.00	-0.15	0.15	0.02
1.A.3.b.	Road Transportation	Diesel oil	CH4	20.9	69.4	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	CH4		225.1	10.0	250.0	250.20	0.14	0.02	0.02	0.31	0.31	0.09
1.A.3.b.	Road Transportation	Gaseous fuels	CH4		6.8	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	CH4		0.5	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	CH4	0.8	0.6	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	CH4	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	CH4	0.6	0.3	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	CH4	0.5	2.4	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	CH4	0.0	0.3	5.0	100.0	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.a.	Commercial/institutional	Liquid fuels	CH4	0.0	3.4	7.1	100.0	100.25	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.a.	Commercial/institutional	Solid fuels	CH4	0.0	40.8	14.1	100.0	100.99	0.01	0.00	0.00	0.02	0.02	0.00
1.A.4.a.	Commercial/institutional	Gaseous fuels	CH4	0.0	13.6	5.0	100.0	100.12	0.00	0.00	0.00	0.01	0.01	0.00
1.A.4.b.	Residential	Liquid fuels	CH4	22.5	2.1	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	CH4	1022.3	645.2	14.1	100.0	100.99	0.16	0.03	0.07	-0.89	0.90	0.80
1.A.4.b.	Residential	Gaseous fuels	CH4	0.2	47.5	5.0	100.0	100.12	0.01	0.00	0.00	0.03	0.03	0.00
1.A.4.b.	Residential	Biomass	CH4	2263.4	801.5	300.0	100.0	316.23	0.62	0.38	1.85	-2.32	2.97	8.80

Table A6 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	1990 Gg CO2eq	2015 Gg CO2eq	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	CH4	8.3	12.3	200.0	250.0	320.16	0.01	0.00	0.02	-0.01	0.02	0.00
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	CH4		0.6	7.0	100.0	100.24	0.00	0.00	0.00	0.00	0.00	0.00
1.B.1.a.	Coal mining and handling		CH4	2458.5	1236.3	16.6	557.0	557.25	1.68	2.81	0.16	-12.92	12.92	166.97
1.B.2.a.	Oil		CH4	399.4	270.7	7.0	356.0	356.07	0.23	0.05	0.01	-1.21	1.21	1.46
1.B.2.b.	Natural gas		CH4	143.7	1998.5	7.0	356.0	356.07	1.73	3.00	0.11	3.25	3.25	10.57
1.B.2.c.	Venting and flaring		CH4	127.0	469.9	7.0	356.0	356.07	0.41	0.17	0.03	0.36	0.36	0.13
2.B.8.	Petrochemical and carbon black production		CH4	28.4	42.3	10.0	30.0	31.62	0.00	0.00	0.00	0.00	0.00	0.00
2.C.1.	Iron and Steel Production		CH4	7.9	15.0	10.0	5.0	11.18	0.00	0.00	0.00	0.00	0.00	0.00
3.A.	Enteric fermentation		CH4	22314.1	26888.0	12.4	12.1	17.27	1.13	1.28	2.56	-1.51	2.97	8.82
3.B.	Manure management		CH4	2352.1	3159.7	14.1	30.0	33.15	0.25	0.06	0.34	-0.34	0.49	0.24
3.C.	Rice cultivation		CH4	91.4	199.7	5.0	33.0	33.38	0.02	0.00	0.01	0.00	0.01	0.00
3.F.	Field burning of agricultural residues		CH4	243.6	261.6	50.0	50.0	70.71	0.05	0.00	0.10	-0.08	0.13	0.02
4.A.	Forest land		CH4	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		CH4		3437.8	10.0	30.8	32.38	0.27	0.07	0.26	0.58	0.63	0.40
5.A.2.	Unmanaged waste disposal sites		CH4	6729.6	9017.5	30.0	38.1	48.49	1.06	1.13	2.08	-1.25	2.43	5.90
5.B.1	Composting		CH4	11.0	9.3	10.0	20.0	22.36	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2	Open burning of waste		CH4	67.3	0.7	30.4	100.0	104.52	0.00	0.00	0.00	-0.08	0.08	0.01
5.D.1	Domestic wastewater		CH4	2579.8	1895.7	5.0	37.7	38.03	0.18	0.03	0.07	-0.79	0.80	0.64
5.D.2	Industrial wastewater		CH4	209.2	475.6	11.2	39.1	40.67	0.05	0.00	0.04	0.00	0.04	0.00
Total	**Total CH4**			**41244**	**51440**					**3.01**				**14.31**
	Cumulative CO2 and CH4			**159 209**	**370 846**					**6.69**				**23.34**
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	N2O	8.49	4.39	6.0	75.0	75.24	0.00	0.00	0.00	-0.01	0.01	0.00
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	N2O	95.18	534.06	1.0	75.0	75.01	0.10	0.01	0.00	0.13	0.13	0.02
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	N2O	2.57	603.41	3.0	75.0	75.06	0.11	0.01	0.01	0.24	0.24	0.06
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	N2O		1.72	0.9	75.0	75.01	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.a.	Public Electricity and Heat Production	Biomass	N2O		3.93	0.9	75.0	75.01	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.b.	Petroleum Refining	Liquid fuels	N2O	6.21	4.56	2.0	100.0	100.02	0.00	0.00	0.00	-0.01	0.01	0.00
1.A.1.b.	Petroleum Refining	Gaseous fuels	N2O		1.11	2.0	100.0	100.02	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.c.	Manufacture of solid fuels	Solid fuels	N2O	0.35	0.46	2.0	100.0	100.02	0.00	0.00	0.00	0.00	0.00	0.00

Table A6 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	1990 Gg CO2eq	2015 Gg CO2eq	AD Unc. %	EF Unc. %	A(1) %	B(2) %	C(3) %	D(4) %	E(5) %	F(6) %	G(7) %
1.A.2.a.	Iron and Steel Production	Liquid fuels	N2O	4.24	0.06	10.0	100.0	100.50	0.00	0.00	0.00	-0.01	0.01	0.00
1.A.2.a.	Iron and Steel Production	Solid fuels	N2O	0.08	0.30	10.0	100.0	100.50	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.a.	Iron and Steel Production	Gaseous fuels	N2O		1.43	10.0	100.0	100.50	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	N2O	2.11	0.03	21.2	100.0	102.22	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.b.	Non-Ferrous Metals	Solid fuels	N2O	0.62	0.65	21.2	100.0	102.22	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	N2O		0.55	21.2	100.0	102.22	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.c.	Chemicals	Liquid fuels	N2O	6.08	0.05	15.8	100.0	101.24	0.00	0.00	0.00	-0.01	0.01	0.00
1.A.2.c.	Chemicals	Solid fuels	N2O	5.26	6.54	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	N2O	0.50	2.50	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	N2O		0.07	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	N2O		0.08	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	N2O		2.15	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	N2O		0.23	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	N2O	0.98	0.38	5.0	100.0	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.e.	Food Processing. Beverages and Tobacco	Solid fuels	N2O	9.92	9.68	18.0	100.0	101.61	0.00	0.00	0.00	-0.01	0.01	0.00
1.A.2.e.	Food Processing. Beverages and Tobacco	Gaseous fuels	N2O		1.01	14.1	100.0	100.99	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.f.	Non metalic minerals	Liquid fuels	N2O	5.60	25.20	27.8	100.0	103.79	0.01	0.00	0.01	0.01	0.01	0.00
1.A.2.f.	Non metalic minerals	Solid fuels	N2O	24.15	54.70	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	N2O	0.00	1.94	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	N2O		13.47	2.0	100.0	100.02	0.00	0.00	0.00	0.01	0.01	0.00
1.A.2.f.	Non metalic minerals	Biomass	N2O		0.04	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	N2O	11.08	4.46	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	N2O	31.69	16.15	70.7	100.0	122.47	0.00	0.00	0.01	-0.03	0.03	0.00
1.A.2.g.	Other Industries	Gaseous Fuels	N2O	0.33	2.77	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	N2O	8.88	41.98	5.5	85.0	85.18	0.01	0.00	0.00	0.01	0.01	0.00
1.A.3.b.	Road Transportation	Gasoline	N2O	288.20	216.59	10.0	250.0	250.20	0.13	0.02	0.02	-0.58	0.58	0.34
1.A.3.b.	Road Transportation	Diesel oil	N2O	249.52	827.34	10.0	250.0	250.20	0.50	0.25	0.06	0.37	0.37	0.14
1.A.3.b.	Road Transportation	LPG	N2O		8.64	10.0	250.0	250.20	0.01	0.00	0.00	0.01	0.01	0.00
1.A.3.b.	Road Transportation	Gaseous fuels	N2O		2.65	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	N2O		5.90	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	N2O	68.42	49.86	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	N2O	0.29		5.0	150.0	150.08	0.00	0.00	0.00	0.00	0.00	0.00

Table A6 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	1990 Gg CO2eq	2015 Gg CO2eq	AD Unc. %	EF Unc. %	A(1) %	B(2) %	C(3) %	D(4) %	E(5) %	F(6) %	G(7) %
1.A.3.d.	Domestic Navigation	Residual fuel oil	N2O	2.15	0.86	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	N2O	1.79	8.28	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	N2O	0.02	0.35	5.0	100.0	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.a.	Commercial/institutional	Liquid fuels	N2O	0.00	0.81	7.1	100.0	100.25	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.a.	Commercial/institutional	Solid fuels	N2O	0.00	72.92	14.1	100.0	100.99	0.02	0.00	0.01	0.04	0.04	0.00
1.A.4.a.	Commercial/institutional	Gaseous fuels	N2O	0.00	3.25	5.0	100.0	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.b.	Residential	Liquid fuels	N2O	11.83	0.80	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	N2O	60.93	38.46	14.1	100.0	100.99	0.01	0.00	0.00	-0.05	0.05	0.00
1.A.4.b.	Residential	Gaseous fuels	N2O	0.05	11.32	5.0	100.0	100.12	0.00	0.00	0.00	0.01	0.01	0.00
1.A.4.b.	Residential	Biomass	N2O	359.72	127.38	300.0	100.0	316.23	0.10	0.01	0.29	-0.37	0.47	0.22
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	N2O	680.34	1007.14	14.1	250.0	250.40	0.61	0.38	0.11	-0.70	0.71	0.50
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	N2O		0.14	7.0	100.0	100.24	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2.c.	Venting and flaring		N2O	0.91	0.62	7.0	224.0	224.11	0.00	0.00	0.00	0.00	0.00	0.00
2.B.2.	Nitric acid production		N2O	1063.63	1415.20	2.0	20.0	20.10	0.07	0.00	0.02	-0.10	0.11	0.01
3.B.	Manure management		N2O	1759.39	3144.12	14.1	50.0	51.95	0.40	0.16	0.34	-0.22	0.40	0.16
3.D.	Agricultural soils		N2O	17528.11	22877.54	55.2	96.0	110.70	6.16	37.97	9.72	-8.52	12.93	167.06
3.F.	Field burning of agricultural residues		N2O	75.28	80.85	50.0	50.0	70.71	0.01	0.00	0.03	-0.02	0.04	0.00
4.A.	Forest land		N2O	0.02	0.01	23.5	0.9	23.52	0.00	0.00	0.00	0.00	0.00	0.00
4.B.	Cropland		N2O	10.48	0.02	23.5	4.5	23.93	0.00	0.00	0.00	0.00	0.00	0.00
5.B.1	Composting		N2O	7.83	6.68	10.0	20.0	22.36	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2	Open burning of waste		N2O	10.78	0.12	30.4	100.0	104.52	0.00	0.00	0.00	-0.01	0.01	0.00
5.D.1	Domestic wastewater		N2O	1447.24	2032.56	30	42.4	51.94	0.26	0.07	0.47	-0.28	0.55	0.30
	Total N2O			**23851**	**33280**					**6.23**				**12.99**
	Cumulative CO2. CH4. N2O. HFC			**183060.44**	**404126**					**10.92**				**32.45**

Table A6 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	1990	2015	AD Unc.	EF Unc.	A(1)	B(2)	C(3)	D(4)	E(5)	F(6)	G(7)
				Gg CO2eq	Gg CO2eq	%	%	%	%	%	%	%	%	%
2.C.3.	Aluminium Production		PFC	692.8	120.1	25.0	5.0	25.50	0.01	0.00	0.02	-0.04	0.05	0.00
2.E.5.	Other		HFC		0.1	25.0	5.0	25.50	0.00	0.00	0.00	0.00	0.00	0.00
2.E.5.	Other		PFC		0.0	25.0	5.0	25.50	0.00	0.00	0.00	0.00	0.00	0.00
2.E.5.	Other		SF6		0.0	25.0	5.0	25.50	0.00	0.00	0.00	0.00	0.00	0.00
2.F.3.	Fire protection		HFC		126.6	25.0	5.0	25.50	0.01	0.00	0.02	0.00	0.02	0.00
2.F.6.	Other applications		HFC		4678.3	25.0	5.0	25.50	0.29	0.08	0.90	0.13	0.91	0.83
2.G.1.	Electrical equipment		SF6		1984.9	25.0	5.0	25.50	0.12	0.02	0.38	0.05	0.39	0.15
Total	**Total HFC. PFC & SF6**			**693**	**6910**					**0.32**				**0.99**
	Total all gases			**183753.21**	**411 035.21**									
						Overall Uncertainty in Emissions			**9.15**		**Trend Unc.**		**26.73**	

(1) Combined Uncertainty
(2) Combined Uncertainty as % of Emissions in 2015
(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 Content Determination

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.

Table 1 Gas densities under normal conditions (0 °C, i.e. 273.15 K; 101.325 kPa)

Gas	Formula	M_r [g/mol]	$\rho^{*)}$ [kg/m³]
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 1990-2015 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) G= E*F
A	B	% C	D	E=C*D	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
						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)	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 MİKTARI		(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 3302 TS 4744	25,45				25,99							
ENDÜSTRİYEL ANALİZ (%) * Ortam Sıcaklığı/Nem : 24 °C % 18	ASTM D 7582												
NEM *		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	6065	0	0	0	0
ELEMENTEL ANALİZ(%) Ortam Sıcaklığı/Nem : 23,9 °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	29,33	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 : 28 °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.

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TERMİK SANTRALLAR DAİRE BAŞKANLIĞI
TEKNİK KONTROL ve LABORATUVARLAR İŞLETME MÜDÜRLÜĞÜ

YAKIT LABORATUVARI ANALİZ RAPORU

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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 (12/278 C)	KÜL (12/278 D)
	2,64	2,05

DENEYİ YAPAN	RAPOR VEREN		KONTROL EDEN	ONAY
Kimya Baştekniisyeni	Kimyager	Teknik Şef	İşl.Md. Yrd (Teknik)	Şükrü DEMİR İşletme Müdürü Y.

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 oxidation 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 integrated 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

DISTRUBITIONS OF ENERGY SUPPLY	Hard Coal	Lignite	Asphaltite	Coke	Derivative Gases	Blast Furnace Gas	Coke Oven Gas	BOF Gas	Coal Tar	Oil	Oil Products	Petroleum Coke
Domestic Production (+)	875	11,505	414							2,641		
Import (+)	21,815			369						26,319	23,782	3,388
Export (-)	93			2					77		7,467	226
Bunkers (-)											4,417	
Stock Changes (+/-)	-271	110	85	-68					-3	-946	-675	-176
Primary Energy Supply	**22,326**	**11,616**	**499**	**299**	**0**	**0**	**0**	**0**	**-79**	**28,015**	**11,223**	**2,986**
--Statistical Difference (+/-)--	**91**	**58**	**0**	**32**	**0**	**0**	**0**	**0**	**0**	**0**	**-117**	**42**
Transformation Sector	**-13,893**	**-8,746**	**-238**	**2,849**	**504**	**69**	**291**	**144**	**141**	**-28,015**	**26,637**	**385**
Electricity Production	-9,314	-8,367	-238		-951	-707	-244				-559	
Electricity Plants	-8,291	-8,241	-238		-951	-707	-244				-552	
Autoproducers	-1,022	-126									-7	
Heat Production	-6	-370									-184	
Coke Ovens	-4,409			2,940	781		781		141			
Blast Furnaces					1,539	1,373		166				
Petroleum Refinery										-27,828	28,979	385
Own Use and Loses	-164	-9		-91	-865	-597	-246	-22		-187	-1,600	
Total Final Energy Consumption	**8,433**	**2,870**	**262**	**3,148**	**504**	**69**	**291**	**144**	**62**	**0**	**37,860**	**3,371**
Sectors Total	**8,342**	**2,812**	**262**	**3,117**	**504**	**69**	**291**	**144**	**62**	**0**	**37,977**	**3,329**
Industry Consumption	**3,769**	**1,582**	**145**	**3,086**	**504**	**69**	**291**	**144**	**62**	**0**	**4,145**	**3,329**
Mining and Quarrying (07,08,09)	**12**	**40**									**389**	
Food,beverages,tobacco products production (10,11,12)	**151**	**334**		**32**							**70**	**5**
Manufacture of food products (10)	149	276									37	5
Manufacture of beverages (11)											5	
Manufacture of tobacco products (12)												
Manufacture of sugar (10)	2	59		32							28	
Textile, leather production (13,14,15)	**234**	**462**									**20**	
Manufacture of textiles (13)	210	429									20	
Manufacture of wearing apparel(14)	24	32									1	
Manufacture of leather and related products(15)		1										
Manufacture of wood and of products of wood and cork(16)	**11**	**11**									**17**	
Manufacture of paper and paper products(17,18)	**29**	**86**									**11**	
Manufacture of chemicals and chemical products(20,21,22)	**261**	**138**									**18**	
Manufacture of chemicals and chemical products(20)	261	88									5	
Fertilizer(20)												
of basic pharmaceutical products and pharmaceutical preparations(21)											1	
Manufacture of rubber and plastic products(22)		50									12	
Manufacture of other non-metallic mineral products(23)	**2,308**	**470**	**145**								**3,369**	**3,323**
Manufacture of Glass(23)											5	
Manufacture of ceramics(23)	109	64	145								52	43
Manufacture of cement(23)	2,199	406									3,311	3,280
Manufacture of basic metals(24,25)	**760**	**29**		**3,054**	**504**	**69**	**291**	**144**	**62**		**56**	
Manufacture of iron and steel(24)	754			3,025	504	69	291	144	62		8	
Manufacute of non-ferrous metals(24)	6			29							4	
Manufacture of fabricated metal product(25)		29									44	
MAchinery,Electricity,Electronics Products Production(26,27,	**2**	**7**									**9**	
Manufacture of motor vehicles(29,30)		**3**									**33**	
Manufacture of motor vehicles, trailers and semi-trailers(29)											12	
Manufacture of other transport equipment(30)		3									21	
Manufacture of furniture and other (31,32)											**1**	
Construction (41,42,43)	**1**	**1**									**153**	
Other Industry												
TRANSPORT	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**24,375**	**0**
Railways											140	
Domestic Navigation											189	
Domestic Aviation											1,405	
Pipelines											0	
Road											22,641	
OTHER SECTORS	**4,573**	**1,230**	**117**	**31**	**0**	**0**	**0**	**0**	**0**	**0**	**3,805**	**0**
Residential	1,021	886	117	31							337	
Commercial and Services	3,552	344									645	
Agriculture and Livestock											2,822	
NON ENERGY CONSUMPTION											**5,652**	
Petrochemicals Feedstock											**1,990**	
SUPPLY BASIS FOR TOTAL ENERGY CONSUMPTION	**22,326**	**11,616**	**499**	**299**	**0**	**0**	**0**	**0**	**-79**	**28,015**	**8,895**	2,986

DISTRUBITIONS OF ENERGY SUPPLY	Fuel Oil	Gas diesel Oil	Gasoline	LPG	Refinery Gas	Jet Kerosene	Kerosen	Naphta	Byproduct	Base Oil	White Spirit	Bitumen
Domestic Production (+)												
Import (+)	883	12,301		3,912		192		1,724	1,303			
Export (-)	943	28	3,334	292		298			425			
Bunkers (-)						3,703			0			
Stock Changes (+/-)	88	-181	46	-90		-85		-16	-257	-3		-5
Primary Energy Supply	28	12,092	-3,288	3,530	0	-3,895	0	1,708	620	-3	0	-5
--Statistical Difference (+/-)--	1	52	13	31	0	51	0	0	0	0	0	0
Transformation Sector	29	8,561	5,471	1,016	0	5,351	61	282	-133	125	10	2,762
Electricity Production	-312	-247										
Electricity Plants	-307	-245										
Autoproducers	-5	-2										
Heat Production	-184											
Coke Ovens												
Blast Furnaces												
Petroleum Refinery	525	8,808	5,471	1,016	1,600	5,351	61	282	-133	125	10	2,762
Own Use and Loses					-1,600							
Total Final Energy Consumption	57	20,653	2,183	4,546	0	1,456	61	1,990	487	122	10	2,757
Sectors Total	56	20,600	2,170	4,515	0	1,405	61	1,990	487	122	10	2,757
Industry Consumption	56	636	0	124	0	0	0	0	0	0	0	0
Mining and Quarrying (07,08,09)		389										
Food,beverages,tobacco products production (10,11,12)	36	6		23								
Manufacture of food products (10)	7	4		20								
Manufacture of beverages (11)	0	2		2								
Manufacture of tobacco products (12)												
Manufacture of sugar (10)	28											
Textile, leather production (13,14,15)		7		14								
Manufacture of textiles (13)		6		14								
Manufacture of wearing apparel(14)		1										
Manufacture of leather and related products(15)												
Manufacture of wood and of products of wood and cork(16)		17										
Manufacture of paper and paper products(17,18)		10		1								
Manufacture of chemicals and chemical products(20,21,22)	3	5		10								
Manufacture of chemicals and chemical products(20)	2	3										
Fertilizer(20)												
of basic pharmaceutical products and pharmaceutical preparations(21)	1											
Manufacture of rubber and plastic products(22)		1		10								
Manufacture of other non-metallic mineral products (23)	17	25		3								
Manufacture of Glass(23)		2		3								
Manufacture of ceramics(23)		9										
Manufacture of cement(23)	17	13										
Manufacture of basic metals(24,25)		14		42								
Manufacture of iron and steel(24)		8										
Manufacute of non-ferrous metals(24)		4										
Manufacture of fabricated metal product(25)		2		42								
MAchinery,Electricity,Electronics Products Production(26,27,28)		3		6								
Manufacture of motor vehicles(29,30)		7		26								
Manufacture of motor vehicles, trailers and semi-trailers(29)		5		7								
Manufacture of other transport equipment(30)		2		19								
Manufacture of furniture and other (31,32)		1										
Construction (41,42,43)		153										
Other Industry												
TRANSPORT	0	17,142	2,170	3,468	0	1,405	0	0	0	0	0	0
Railways		140										
Domestic Navigation												
Domestic Aviation						1,405						
Pipelines												
Road		17,003	2,170	3,468								
OTHER SECTORS	0	2,822	0	922	0	0	61	0	0	0	0	0
Residential				277			61					
Commercial and Services				645								
Agriculture and Livestock		2,822										
NON ENERGY CONSUMPTION								1,990	487	122	10	2,757
Petrochemicals Feedstock								1,990				
SUPPLY BASIS FOR TOTAL ENERGY CONSUMPTION	28	12,092	-3,288	3,530	0	-3,895	0	0	0	-3	0	-5

DISTRUBITIONS OF ENERGY SUPPLY	Other	Navigation Diesel Oil	Navigation Fuel	Nat. Gas	Biofuels and Waste	Hydro	Wind	Electricity	Geothermal Heat	Solar	Total
Domestic Production (+)				314	2,972	5,775	1,002		4,805	828	31,131
Import (+)			79	39,952				614			112,851
Export (-)		115	1,806	515				275			8,427
Bunkers (-)			713								4,417
Stock Changes (+/-)	-5	-5	15	-101	-7						-1,870
Primary Energy Supply	-5	-120	-2,425	39,651	2,964	5,775	1,002	339	4,805	828	129,267
--Statistical Difference (+/-)--	0	-7	-300	150	0	0	0	0	0	0	
Transformation Sector	292	113	2,314	-19,001	-264	-5,775	-1,002	18,349	-1,783	-17	-30,295
Electricity Production				-16,677	-231	-5,775	-1,002	22,513	-2,945	-17	-23,611
Electricity Plants				-14,804	-199	-5,775	-1,002	21,271	-2,945	-17	-21,743
Autoproducers				-1,873	-32			1,243			-1,868
Heat Production				-578	-33				1,162		0
Coke Ovens											-547
Blast Furnaces											1,539
Petroleum Refinery	292	113	2,314	-1,440				-129			-417
Own Use and Loses				-307				-4,035			-7,258
Total Final Energy Consumption	287	-7	-111	20,650	2,700	0	0	18,688	3,022	811	98,973
Sectors Total	287	0	189	20,499	2,700	0	0	18,688	3,022	811	98,811
Industry Consumption	0	0	0	8,358	0	0	0	8,878	1,162	283	31,974
Mining and Quarrying (07,08,09)				108				880			1,428
Food,beverages,tobacco products production (10,11,12)				810				669	112		2,178
Manufacture of food products (10)				553				618			1,633
Manufacture of beverages (11)				25				31			61
Manufacture of tobacco products (12)				18				11			29
Manufacture of sugar (10)				214				9	112		455
Textile, leather production (13,14,15)				989				2,066	146		3,916
Manufacture of textiles (13)				894				2,029	146		3,728
Manufacture of wearing apparel (14)				76				34			167
Manufacture of leather and related products (15)				18				3			22
Manufacture of wood and of products of wood and cork (16)				168				95			301
Manufacture of paper and paper products (17,18)				183				346	121		776
Manufacture of chemicals and chemical products (20,21,22)				2,137				692	124		3,370
Manufacture of chemicals and chemical products (20)				1,199				118	124		1,795
Fertilizer (20)				774				12			786
of basic pharmaceutical products and pharmaceutical preparations (21)				32				260			293
Manufacture of rubber and plastic products (22)				131				315			508
Manufacture of other non-metallic mineral products (23)				1,554				1,568	68		9,482
Manufacture of Glass (23)				543				124			672
Manufacture of ceramics (23)				807				109			1,286
Manufacture of cement (23)				204				1,335	68		7,523
Manufacture of basic metals (24,25)				1,697				1,802	570		8,534
Manufacture of iron and steel (24)				1,145				1,469	430		7,397
Manufacute of non-ferrous metals (24)				442				205	140		825
Manufacture of fabricated metal product (25)				110				128			312
MAchinery,Electricity,Electronics Products Production (26,27,28)				57				138			213
Manufacture of motor vehicles (29,30)				147				164			348
Manufacture of motor vehicles, trailers and semi-trailers (29)				124				154			290
Manufacture of other transport equipment (30)				23				10			58
Manufacture of furniture and other (31,32)				22				10			33
Construction (41,42,43)				297				48			500
Other Industry				190				402	21	283	895
TRANSPORT	0	0	189	349	121	0	0	17	0	0	24,740
Railways								17			157
Domestic Navigation			189								189
Domestic Aviation											1,405
Pipelines				278							278
Road				71	121						22,712
OTHER SECTORS	0	0	0	11,792	2,579	0	0	9,793	1,860	528	36,445
Residential				9,075	2,579			4,127	280	528	19,117
Commercial and Services				2,608				5,205	1,000		13,354
Agriculture and Livestock				110				461	580		3,974
NON ENERGY CONSUMPTION	287										5,652
Petrochemicals Feedstock											1,990
SUPPLY BASIS FOR TOTAL ENERGY CONSUMPTION	-5	-120	-2,425	39,651	2,964	5,775	1,002	339	4,805	828	126,939

Energy balance sheets for 1972-2015 are available on the MENR website (http://www.eigm.gov.tr/en-US/Balance-Sheets?page=1).

Annex 5: Completeness

Table A7.1 Completeness, Sources and sinks not estimated ("NE")

GHG	Sector	Source/sink category[(2)]
CH4	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
CH4	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
CH4	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
CH4	LULUCF	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Controlled Burning
CH4	LULUCF	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Wildfires
CH4	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
CH4	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
CH4	LULUCF	4.C Grassland/4.C.1 Grassland Remaining Grassland/4(V) Biomass Burning/Controlled Burning
CH4	LULUCF	4.C Grassland/4.C.1 Grassland Remaining Grassland/4(V) Biomass Burning/Wildfires
CH4	LULUCF	4.C Grassland/4.C.2 Land Converted to Grassland/4(V) Biomass Burning/Wildfires
CH4	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
CH4	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
CH4	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
CH4	LULUCF	4.F Other Land/4(V) Biomass Burning 4.F Other Land
CH4	LULUCF	4.H Other (please specify)
CO2	Agriculture	3.G Liming/3.G.1 Limestone CaCO3
CO2	Agriculture	3.G Liming/3.G.2 Dolomite CaMg(CO3)2
CO2	Agriculture	3.I Other Carbon-containing Fertilizers
CO2	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
CO2	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

Table A7.1 Completeness, Sources and sinks not estimated ("NE")(cont'd)

GHG	Sector	Source/sink category[(2)]
CO2	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
CO2	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
CO2	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
CO2	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
CO2	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
CO2	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
CO2	LULUCF	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Controlled Burning
CO2	LULUCF	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Wildfires
CO2	LULUCF	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Controlled Burning
CO2	LULUCF	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Wildfires
CO2	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
CO2	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
CO2	LULUCF	4.C Grassland/4.C.1 Grassland Remaining Grassland/4(V) Biomass Burning/Controlled Burning
CO2	LULUCF	4.C Grassland/4.C.1 Grassland Remaining Grassland/4(V) Biomass Burning/Wildfires
CO2	LULUCF	4.C Grassland/4.C.2 Land Converted to Grassland/4(V) Biomass Burning/Wildfires
CO2	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
CO2	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
CO2	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
CO2	LULUCF	4.F Other Land/4(V) Biomass Burning 4.F Other Land
CO2	LULUCF	4.H Other (please specify)
N2O	Agriculture	3.D Agricultural Soils/3.D.1 Direct N2O Emissions From Managed Soils/3.D.1.2 Organic N Fertilizers/3.D.1.2.b Sewage Sludge Applied to Soils
N2O	LULUCF	4(IV) Indirect N2O Emissions from Managed Soils/Atmospheric Deposition

Table A7.1 Completeness, Sources and sinks not estimated ("NE")(cont'd)

GHG	Sector	Source/sink category[2]
N2O	LULUCF	4(IV) Indirect N2O Emissions from Managed Soils/Nitrogen Leaching and Run-off
N2O	LULUCF	4.A Forest Land 4.A Forest Land/4.A.1 Forest Land Remaining Forest Land/4(III) Direct N2O Emissions from N Mineralization/Immobilization
N2O	LULUCF	4.A Forest Land/4.A.1 Forest Land Remaining Forest Land/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers
N2O	LULUCF	4.A Forest Land/4.A.1 Forest Land Remaining Forest Land/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers
N2O	LULUCF	4.A Forest Land/4.A.2 Land Converted to Forest Land/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers
N2O	LULUCF	4.A Forest Land/4.A.2 Land Converted to Forest Land/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers
N2O	LULUCF	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Controlled Burning
N2O	LULUCF	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Wildfires
N2O	LULUCF	4.C Grassland 4.C Grassland/4.C.1 Grassland Remaining Grassland/4(III) Direct N2O Emissions from N Mineralization/Immobilization
N2O	LULUCF	4.C Grassland/4.C.1 Grassland Remaining Grassland/4(V) Biomass Burning/Controlled Burning
N2O	LULUCF	4.C Grassland/4.C.1 Grassland Remaining Grassland/4(V) Biomass Burning/Wildfires
N2O	LULUCF	4.C Grassland/4.C.2 Land Converted to Grassland/4(V) Biomass Burning/Wildfires
N2O	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
N2O	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
N2O	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
N2O	LULUCF	4.D Wetlands/4.D.1 Wetlands Remaining Wetlands/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers
N2O	LULUCF	4.D Wetlands/4.D.1 Wetlands Remaining Wetlands/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers
N2O	LULUCF	4.D Wetlands/4.D.1 Wetlands Remaining Wetlands/4(III) Direct N2O Emissions from N Mineralization/Immobilization 4.D Wetlands
N2O	LULUCF	4.D Wetlands/4.D.2 Land Converted to Wetlands/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers
N2O	LULUCF	4.D Wetlands/4.D.2 Land Converted to Wetlands/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers
N2O	LULUCF	4.D Wetlands/4.D.2 Land Converted to Wetlands/4(III) Direct N2O Emissions from N Mineralization/Immobilization 4.D Wetlands
N2O	LULUCF	4.E Settlements 4.E Settlements/4.E.1 Settlements Remaining Settlements/4(III) Direct N2O Emissions from N Mineralization/Immobilization

Table A7.1 Completeness, Sources and sinks not estimated ("NE")(cont'd)

GHG	Sector	Source/sink category[(2)]
N2O	LULUCF	4.E Settlements/4.E.1 Settlements Remaining Settlements/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers
N2O	LULUCF	4.E Settlements/4.E.1 Settlements Remaining Settlements/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers
N2O	LULUCF	4.E Settlements/4.E.2 Land Converted to Settlements/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers
N2O	LULUCF	4.E Settlements/4.E.2 Land Converted to Settlements/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers
N2O	LULUCF	4.F Other Land/4(III) Direct N2O Emissions from N Mineralization/Immobilization 4.F Other Land
N2O	LULUCF	4.F Other Land/4(V) Biomass Burning 4.F Other Land
N2O	LULUCF	4.H Other (please specify)

Table A7.2 Completeness, Sources and sinks reported elsewhere ("IE")

GHG	Source/sink category	Allocation as per IPCC Guidelines	Explanation
CH4	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Biomass	Included under "1.A.3.e Other Transportation"
CH4	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Diesel Oil	Included under "1.A.3.e Other Transportation"
CH4	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Gasoline	Included under "1.A.3.e Other Transportation"
CH4	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Liquefied Petroleum Gases (LPG)	Included under "1.A.3.e Other Transportation"
CH4	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Gasoline	Included under "1.A.3.e Other Transportation"
CH4	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks	Included under "1.A.3.e Other Transportation"

Table A7.2 Completeness, Sources and sinks reported elsewhere ("IE") (cont'd)

GHG	Source/sink category	Allocation as per IPCC Guidelines	Explanation
CH4	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Diesel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks	Included under "1.A.3.e Other Transportation"
CH4	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses/Biomass	Included under "1.A.3.e Other Transportation"
CH4	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses/Diesel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses	Included under "1.A.3.e Other Transportation"
CH4	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Gasoline	Included under "1.A.3.e Other Transportation"
CH4	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles	Included under "1.A.3.e Other Transportation"
CH4	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Diesel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles	Included under "1.A.3.e Other Transportation"
CH4	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing 1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing/Gas/Diesel Oil	Included under 1.A.4.c.i
CH4	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing 1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing/Gasoline	Included under 1.A.4.c.i
CH4	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing/Residual Fuel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing	Included under 1.A.4.c.i
CH4	LULUCF	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Controlled Burning	Report under 3.F. section

Table A7.2 Completeness, Sources and sinks reported elsewhere ("IE") (cont'd)

GHG	Source/sink category	Allocation as per IPCC Guidelines	Explanation
CH4	LULUCF	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Wildfires	Report under 3.F. section
CH4	WASTE	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.1 Biogenic/5.C.1.1.b Other (please specify)/Clinical Waste	Emissions from 5.C.1.1.b Clinical Waste are included in 1.A.1.a
CH4	WASTE	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.1 Biogenic/5.C.1.1.b Other (please specify)/Industrial Solid Wastes	Emissions from 5.C.1.1.b Industrial Solid Wastes are included in 1.A.1.a, 1.A.2.c and 1.A.2.g
CH4	WASTE	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.2 Non-biogenic/5.C.1.2.b Other (please specify)/Clinical Waste	Emissions from 5.C.1.2.b Clinical Waste are included in 1.A.1.a
CH4	WASTE	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.2 Non-biogenic/5.C.1.2.b Other (please specify)/Industrial Solid Wastes	Emissions from 5.C.1.2.b Industrial Solid Wastes are included in 1.A.1.a, 1.A.2.c and 1.A.2.g
CO2	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Biomass	Included under "1.A.3.e Other Transportation"
CO2	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Diesel Oil	Included under "1.A.3.e Other Transportation"
CO2	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Gasoline	Included under "1.A.3.e Other Transportation"
CO2	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Liquefied Petroleum Gases (LPG)	Included under "1.A.3.e Other Transportation"
CO2	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Gasoline	Included under "1.A.3.e Other Transportation"
CO2	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks	Included under "1.A.3.e Other Transportation"
CO2	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Diesel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks	Included under "1.A.3.e Other Transportation"

Table A7.2 Completeness, Sources and sinks reported elsewhere ("IE") (cont'd)

GHG	Source/sink category	Allocation as per IPCC Guidelines	Explanation
CO2	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses	Included under "1.A.3.e Other Transportation"
CO2	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses/Diesel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses	Included under "1.A.3.e Other Transportation"
CO2	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Gasoline	Included under "1.A.3.e Other Transportation"
CO2	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles	Included under "1.A.3.e Other Transportation"
CO2	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Diesel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles	Included under "1.A.3.e Other Transportation"
CO2	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing 1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing/Gas/Diesel Oil	Included under 1.A.4.c.i
CO2	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing 1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing/Gasoline	Included under 1.A.4.c.i
CO2	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing/Residual Fuel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing	Included under 1.A.4.c.i
CO2	IPPU	2.C Metal Industry/2.C.1 Iron and Steel Production/2.C.1.b Pig Iron	CO2 emissions from pig iron production is included in emissions from steel production
CO2	LULUCF	4.A Forest Land/4.A.1 Forest Land Remaining Forest Land/4(V) Biomass Burning/Wildfires/Forest land remaining forest land	calculated in stock change in biomass (losses section)

Table A7.2 Completeness, Sources and sinks reported elsewhere ("IE") (cont'd)

GHG	Source/sink category	Allocation as per IPCC Guidelines	Explanation
CO2	LULUCF	4.A Forest Land/4.A.2 Land Converted to Forest Land/4(V) Biomass Burning/Wildfires	All emissions are sourced from wildfires estimated at the Forestland remaining forestland section
CO2	LULUCF	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.1 Biogenic/5.C.1.1.b Other (please specify)/Clinical Waste	Emissions from 5.C.1.1.b Clinical Waste are included in 1.A.1.a
CO2	LULUCF	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.1 Biogenic/5.C.1.1.b Other (please specify)/Industrial Solid Wastes	Emissions from 5.C.1.1.b Industrial Solid Wastes are included in 1.A.1.a, 1.A.2.c and 1.A.2.g
CO2	LULUCF	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.2 Non-biogenic/5.C.1.2.b Other (please specify)/Clinical Waste	Emissions from 5.C.1.2.b Clinical Waste are included in 1.A.1.a
CO2	LULUCF	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.2 Non-biogenic/5.C.1.2.b Other (please specify)/Industrial Solid Wastes	Emissions from 5.C.1.2.b Industrial Solid Wastes are included in 1.A.1.a, 1.A.2.c and 1.A.2.g
HFC-134a	IPPU	2.F Product Uses as Substitutes for ODS/2.F.6 Other Applications/2.F.6.a Emissive/HFC-134a	All emissions caused by HFC-134a is given in this section due to lack of disaggregated data. Emission estimates are made by tier 1 and default emission factor.
N2O	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Biomass	Included under "1.A.3.e Other Transportation"
N2O	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Diesel Oil	Included under "1.A.3.e Other Transportation"
N2O	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Liquefied Petroleum Gases (LPG)	Included under "1.A.3.e Other Transportation"
N2O	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Gasoline	Included under "1.A.3.e Other Transportation"
N2O	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks	Included under "1.A.3.e Other Transportation"

Table A7.2 Completeness, Sources and sinks reported elsewhere ("IE") (cont'd)

GHG	Source/sink category	Allocation as per IPCC Guidelines	Explanation
N2O	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses/Biomass	Included under "1.A.3.e Other Transportation"
N2O	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Gasoline	Included under "1.A.3.e Other Transportation"
N2O	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles	Included under "1.A.3.e Other Transportation"
N2O	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing 1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing/Gas/Diesel Oil	Included under 1.A.4.c.i
N2O	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing 1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing/Gasoline	Included under 1.A.4.c.i
N2O	ENERGY	1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing/Residual Fuel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing	Included under 1.A.4.c.i
N2O	LULUCF	4.A Forest Land/4.A.2 Land Converted to Forest Land/4(V) Biomass Burning/Wildfires	All emissions are sourced from wildfires estimated at the Forestland remaining forestland section
N2O	LULUCF	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Controlled Burning	Report under 3.F. section
N2O	LULUCF	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Wildfires	Report under 3.F. section
N2O	WASTE	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.1 Biogenic/5.C.1.1.b Other (please specify)/Clinical Waste	Emissions from 5.C.1.1.b Clinical Waste are included in 1.A.1.a

Table A7.2 Completeness, Sources and sinks reported elsewhere ("IE") (cont'd)

GHG	Source/sink category	Allocation as per IPCC Guidelines	Explanation
N2O	WASTE	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.1 Biogenic/5.C.1.1.b Other (please specify)/Industrial Solid Wastes	Emissions from 5.C.1.1.b Industrial Solid Wastes are included in 1.A.1.a, 1.A.2.c and 1.A.2.g
N2O	WASTE	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.2 Non-biogenic/5.C.1.2.b Other (please specify)/Clinical Waste	Emissions from 5.C.1.2.b Clinical Waste are included in 1.A.1.a
N2O	WASTE	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.2 Non-biogenic/5.C.1.2.b Other (please specify)/Industrial Solid Wastes	Emissions from 5.C.1.2.b Industrial Solid Wastes are included in 1.A.1.a, 1.A.2.c and 1.A.2.g
N2O	WASTE	5.D Wastewater Treatment and Discharge/5.D.2 Industrial Wastewater	Emissions from 5.D.2 are included in 5.D.1

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